FUTURE OF THE FINNISH ENGINEERING EDUCATION
– A COLLABORATIVE STAKEHOLDER APPROACH

Kati Korhonen-Yrjänheikki

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Kati Korhonen-Yrjänheikki

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Author Kati Korhonen-Yrjänheikki

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Supervisor	Professor Paul Lillrank
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Abstract

The dissertation sheds light on how to develop the Finnish engineering education to face the anticipated challenges of the future based primarily on the views of the key stakeholders. The research questions are: What kind of a framework can be developed for selecting participants for a group communication process of key stakeholders when aiming at capturing future prospects and enhancing development of engineering education nationally, in this case in the context of Finland (RQ 1)? What are the future prospects and development proposals for the Finnish engineering education based on the views of the key stakeholders on the past, present and future, as well as literature and statistics describing the long-term development and present (RQ 2)?

The study can be regarded as a strategic prospective foresight study, the subsequent focus being on option and commitment reasonability. The primary sources of knowledge are three stakeholder group communication processes: an anonymous Argument Delphi, an Open Futures Search event, and the work process of the National Collaboration Group for the Finnish Engineering Education.

The theoretical discussion for developing the participant selection framework consists of stakeholder concept and identification, creation of knowledge, and member and group characteristics. By combining this with empirical experiences gathered during stakeholder processes, the researcher develops a framework for participant selection. The key findings of the study regarding future prospects of the Finnish engineering education and key proposals for action are summarized in eight statements. The researcher argues that the most severe skills shortages of engineering graduates compared to future needs are in collaborative learning skills. The study contains a proposal for a conceptual model for enhancing the collaborative learning skills of graduates.

The study suggests that face-to-face group communication has potential for providing several benefits over anonymous group communication in futures studies. The researcher claims that the most important advantage is the possibility to mobilize both individual- and collective-driven social learning cycles through face-to-face dialogue that enables grasping of tacit knowledge, and through presencing the emerging self-transcending knowledge. However, because of the problem of groupthink, the researcher maintains that anonymous group communication is a useful additional tool in initiating change and bringing potentially conflicting and delicate issues up to discussion, and thereby improving identification of different options for the future.

The research contribution of the study is three-fold. First, the results of the study have high practical value for the development of the Finnish engineering education. Second, the framework developed for participant selection and the experiences gathered during the three group communication processes with stakeholders, are useful in developing engineering education also outside Finland. Third, the researcher contributes to the development of futures research methodologies by discussing the differences in knowledge creation between anonymous and face-to-face group communication methodologies.

Keywords engineering education, future prospects, stakeholders, collaborative learning, group communication

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Tiivistelmä

Tutkimuksessa selvitetään miten suomalaista tekniikan korkeakoulutusta tulisi kehittää ennakoituihin tulevaisuuden haasteisiin vastaamiseksi perustuen pääasiassa keskeisten sidosryhmien näkemyksiin. Tutkimuskysymykset ovat: (1) Minkälainen toimintamalli voidaan luoda osallistujien valitsemiseksi keskeisistä sidosryhmistä koostuvaan ryhmäkommunikaatioprosessiin, jonka tavoitteena on edistää tekniikan korkeakoulutuksen kehittymistä kansallisesti, tässä tapauksessa Suomessa? (2) Mitkä ovat suomalaisen tekniikan korkeakoulutuksen tulevaisuudennäkymät, ja toimenpide-ehdotukset alan koulutuksen kehittämiseksi, perustuen keskeisten sidosryhmien näkemyksiin menneisyydestä, nykyhetkestä ja tulevaisuudesta sekä kirjallisuuteen ja tilastoihin pidemmän aikajänteen kehityksestä ja nykytilasta?

Väitöskirja on luonteeltaan strateginen ennakointitutkimus, jonka painopisteenä on vaihtoehtoisten tulevaisuuksien kartoittaminen ja sitouttaminen tulevaisuuden tekemiseen. Ensisijaisena tutkimusaineistona on kolme sidosryhmien kommunikaatioprosessia: anonyymi Argument Delphi -paneeli, Open Futures Search -työpaja sekä tekniikan korkeakoulutuksen kansallisen yhteistyöryhmän työprosessi.

Osallistujien valintamallin teoriaperusta koostuu kolmesta näkökulmasta: sidosryhmä-konsepti ja sidosryhmien tunnistaminen, tiedon luominen sekä ryhmän ja sen jäsenten ominaisuudet. Yhdistämällä teoriaperusta sidosryhmäprosessien kautta saatuihin empiirisiin kokemuksiin tutkija luo mallin osallistujien valitsemiseksi. Tulokset suomalaisen tekniikan korkeakoulutuksen tulevaisuudennäkymistä toimenpide-ehdotuksineen on tiivistetty kahdeksaan väitteeseen. Tutkijan näkemyksen mukaan vastavalmistuneiden insinöörien ja diplomi-insinöörien osaamisen vakavimmat puutteet suhteessa tulevaisuuden ennakoituihin tarpeisiin liittyvät yhteisöllisen oppimisen taitoihin. Osana tutkimuksen tuloksia on esitetty käsitteellinen viitekehys yhteisöllisen oppimisen taitojen kehittymisen edistämiseksi.

Väitöskirjassa esitetään, että tulevaisuustutkimuksessa kasvokkaisella ryhmäkommunikaatiolla on anonyymiin verrattuna useita mahdollisia etuja. Tutkijan mukaan keskeisimpänä etuna on tilaisuus käynnistää samanaikaisesti sekä yksilölähtöinen että yhteisöllinen oppimisprosessi. Yhteisöllinen oppimisprosessi mahdollistaa dialogin avulla hiljaisen tiedon luomisen ja autenttisen yhteisöllisen läsnäolon kautta muotoutumassa olevan tulevaisuustiedon tavoittamisen. Ryhmäajattelun -ongelmasta johtuen tutkija esittää kuitenkin, että anonyymi ryhmäkommunikaatio on hyödyllinen lisäkeino parantaa vaihtoehtoisten tulevaisuuksien tunnistamista helpottamalla arkaluonteisten ja ristiriitaa herättävien aiheiden esiin nostamista sekä muutoksen käynnistämistä.

Tutkimuksen tuloksia voidaan hyödyntää laajasti suomalaisen tekniikan korkeakoulutuksen kehittämisessä. Luotu toimintamalli osallistujien valitsemiseksi ja sidosryhmäkommunikaatioprosessien kokemukset ovat käyttökelpoisia myös Suomen ulkopuolella. Lisäksi anonyymin ja kasvokkain ryhmässä tapahtuvan kommunikaation tiedon luomisen erojen analysointi tuo lisäarvoa tulevaisuustutkimuksen metodologioiden kehittämiseen.

Asiasanat tekniikan korkeakoulutus, tulevaisuudennäkymät, sidosryhmät, yhteisöllinen oppiminen, ryhmäkommunikaatio	
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To deeply know a thing is to love it. Behind the motivation to conduct this research lies a twofold belief. First, engineering education can make a difference in enhancing the well-being of people and the environment, and therefore, it is important to take action to develop it. And second, an enormous potential for collaborative learning lies in the application of participative working methods to intensifying the stakeholder co-operation in higher education, in this case engineering education.

This study is a result of almost ten years of research during 2001 – 10, when I worked first as a Futurist, and since May 2007 as Director of educational and employment affairs at Academic Engineers and Architects in Finland – TEK. Several talented and helpful people have enabled this study and it is a pleasure to be able to acknowledge and thank for their contribution.

I would like to thank my instructor Docent Osmo Kuusi and supervisor Professor Paul Lillrank for all the guidance, comments and support during the research process. The discussions with you Osmo, especially on futures research methodologies, were crucial for this study. And Paul, I admire your ability to counsel by posing sharp questions that encourage your mentee to consider other, also unconventional, alternatives.

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The third stakeholder process of this study, the Collaboration Group, involved a large project team that enabled the process. Everybody in my team at TEK that functioned as a Secretariat of the Collaboration Group had an important and irreplaceable role.

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I would like to thank my colleague Sari Taukojärvi for the enthusiastic discussions during past ten years especially on enhancing the continuing professional development of engineers. Thank you, Johanna Naukkarinen and Minna Takala, for your great contribution in the FuturEng-project that the first stakeholder process described in this study, the Argument Delphi, was part of. Thank you, Hannu Saarikangas, for co-operation in developing the Finnish engineering education. Thank you, Pepe Nummi, for your advice and guidance in facilitating participative workshops. Also other people from TEK and elsewhere where involved in organizing and documenting the Open Futures Search event and some of the workshops of the Collaboration Group – thank you so much for the great work.

I also want to thank all the participants of the three stakeholder processes: Argument Delphi, Open Futures Search and Collaboration Group. Without your efforts this dissertation would not exist. I want to especially acknowledge the members of the Collaboration Group that invested a lot of time and effort in numerous workshops during two years: Marita Aho, Kalevi Ekman, Riikka Heikinheimo, Antti Joensuu, Jari Jokinen, Maarit Jääskeläinen, Mervi Karikorpi, Tommi Kemppainen, Risto Kimari, Markku Kivikoski, Timo Knuutila, Riitta Konkola, Markku Lahtinen, Kari Lehtomäki, Kauko Leiviskä, Susan Linko, Matti Linna, Matti Lähdeniemi, Olli Mertanen, Jukka Mäkelä, Anneli Pirttilä, Ilkka Pöyhönen, Hannu Saarikangas, Henrik Saxen, Mikko Torvela, Pertti Törmälä, Ilkka Virtanen and Anu Yanar. Thank you also for Petteri Kauppinen and Tarmo Mykkänen who were the contact persons of the Collaboration Group at the Ministry of Education and Culture, as well as Sari Sarkomaa and Heljä Misukka that were in the management of the Ministry and supported the Collaboration Group initiative.

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For the professional layout of this publication I am in debt for Juhani Mykkänen who has done the layout for all the publications in the Open Futures Search and Collaboration Group. It is a joy to work with you. For the language check of this dissertation I would like to acknowledge the great work of Pia Lappalainen. You are a true professional and also a wonderful person.

For the ability to love, strong self-confidence, and life-time support I am extremely thankful to my parents. Thank you, my sister Nina and my friends, for all your support through out this research process and all of my life. My children Iina and Joona have lived with this dissertation all of their lives. Thank you, my precious ones, for keeping me present in everyday life. I have learned from you what the most important thing in life is, and I hope you have learned that whatever you decide to do in life, you need to have passion for it. And finally, thank you Markku for walking with me through heaven and hell. You are the light of my life.

Kirkkonummi, March 2011

Kati Korhonen-Yrjänheikki

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1 INTRODUCTION

Nobody can force change on anyone else. It has to be experienced. Unless we invent ways where paradigm shifts can be experienced by large number of people, then change will remain a myth.
–Eric Trist[1]

1.1 BACKGROUND

In the agricultural economy the key factors of production were land and labor. In the 19th and most part of the 20th century the wealth was associated with command over energy resources. The key factors of production in the industrial economy were capital and labor. Increasing application of knowledge and intelligence led to the fast development of technologies as well as new ways of organizing production. Knowledge assets became a critical determinant of the production function, and therefore, the present society may be called the knowledge economy (Boisot 1998).

As knowledge assets play a key role in society, it becomes increasingly important to define what is knowledge, and how knowledge is created. The primary consequence of the societal change to a knowledge society is the need to speed up the creation and application of knowledge (Nonaka & Takeuchi 1995, Boisot 1998, Scharmer 2009). As illustrated in Figure 1.1., in the knowledge economy there is a growing need not only for evolutionary type of learning to substitute data for physical resources, but also for economizing the consumption of both.

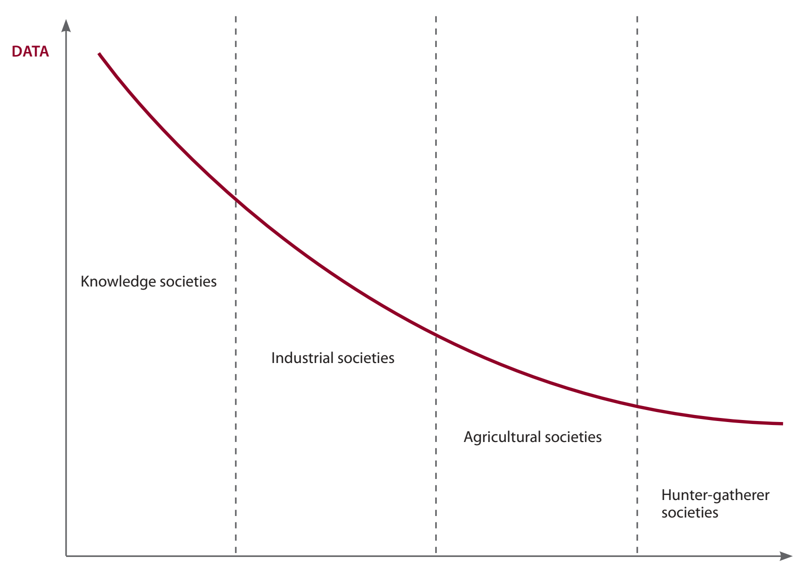

Figure 1.1 Evolution of societies in the evolutionary production function[2] *(Applied from Boisot 1998).*

1 In Holman & Devane (1999, 43)

2 Boisot (1998) argues that the neoclassical approach to production function is not as such applicable to the knowledge economy, where knowledge assets are a critical determinant of production function. Labour and capital as dimensions are made up of entities that have both physical and information attributes. There is a need to use a production function that operates at a higher level of abstraction. Boisot (1998) suggests that energy, space and time could be grouped into an attribute called physical factors. Information itself cannot be a factor of production, because it already contains a factor saving. Knowledge builds on information that is extracted from data, and therefore, Boisot (1998) suggests that knowledge and information could be grouped into a factor called data.

Nonaka & Takeuchi (1995), Boisot (1998) and Scharmer (2009) argue for the dynamic nature of knowledge and that knowledge has an explicit and tacit component. Nonaka et al. (2000) & Scharmer (2009) suggest that, in fact, there is also a third component, the shared context "Ba" (Nonaka et al. 2000) representing the emerging self-transcending knowledge (Scharmer 2009) that is a result of collaborative learning. Also Boisot (1998) implicitly brings up the third knowledge component when he discusses discontinuous emergent learning.

Scharmer (2009) suggests that as a result of the increasing emerging complexity in the knowledge society it is not clear who are the key stakeholders. Increasing social complexity implies that we can rely less on experts in policy-making and need to apply a multi-stakeholder approach including a wide variety of perceptions in order to increase chances that uncodified threats and opportunities will be spotted an acted upon. Often not only the solution to a problem is unknown, but the problem definition itself is unfolding. Also Emery & Purser (1996) maintain that increasing turbulence and uncertainty of environment means that expert-driven planning is inappropriate. And furthermore, increasing interdependence of system subcomponents – dynamic complexity – calls for whole-system approach to problem solving (Scharmer 2009). Figure 1.2 illustrates components of increasing complexity and its implications defined by Scharmer (2009).

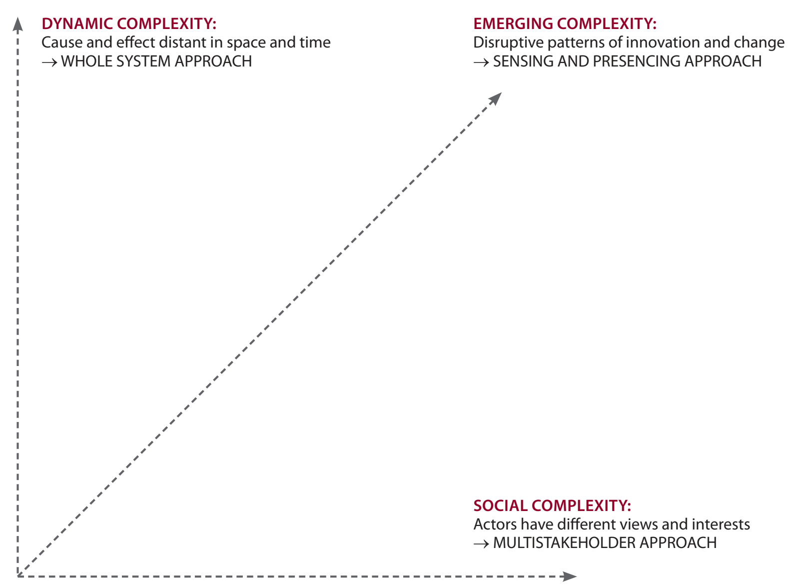

Figure 1.2 Three types of increasing complexity in society and how to deal with them (Scharmer 2009, 60).

The traditional Humboldtian model of a university is based on the assumption that universities are independent from the economic, social and political interests, and the state controls universities, protecting them from third parties intervening in the institution's mission and internal affairs (Magālhaes and Amaral 2000). The researcher argues that this model of ivory tower in creating new knowledge does not fit into the present knowledge society, as proposed for example by Clark (1998), Chesbrough (2003b), van Vught (2004) and Weber & Duderstadt (2004).

One of the core reasons for this is the opening up of the innovation environment (Chesbrough 2003 a, b). The creation, application and distribution of knowledge are increasingly intertwined and simultaneous processes that appear in integrated networks, and universities can not function as entities separate from society (Chesbrough 2003b, Van Vught 2004). The need for intensifying co-operation with industry, in particular, is brought up also in the modernization agenda of universities in Europe (European Commission 2006, 2009) and as a weakness of European universities compared to universities in the US (van Vught 2004).

Different disciplines provided by universities are not identical in their relationship with external stakeholders (Clark 1998). The relationship of engineering with the labor market has varied throughout the course of time from extremely narrow to somewhat more distant (Hautala et al. 1995, Crawley et al. 2007). It also varies between countries (see for example Hautala et al. 1995) and is dependent on the field of engineering (Naukkarinen 2006, Jørgensen 2007). However, due to the nature of the engineering discipline in-between theory and practice and emphasis on practical usability (Niiniluoto 1984, Hendricks et al. 2000, Heikkerö 2009), it is evident that the relationship between external stakeholders – especially industry – is and has been exceptionally close compared to most other disciplines. Also Clark (1998, 141) states that "Science and technology departments commonly become entrepreneurial first and most fully." Engineering (Stokes 1997, Allenby et al. 2009) and medicine (Stokes 1997) are examples of professions that reflect more than most professions the immediate environment within which they operate.

Countries representing the dual system of providing engineering at universities and polytechnics, like Finland, Germany and the Netherlands, are characterized by an especially close relationship with industry in the discipline of engineering (Hautala et al. 1995). Tight co-operation with industry is strongly embedded in the culture of the Finnish engineering education[3] (Hautala et al. 1995, Orelma 1996, Michelsen 1999, Allt 2002, Aunesluoma 2004, Korhonen-Yrjänheikki & Allt 2004). Hautala et al. (1995) even argue that the Finnish engineering education has been historically more connected to industry than to the educational system. This is also supported by findings of Michelsen (1999) regarding the formation of the engineering profession in Finland. The researcher suggests that one key factor also behind the process of establishing Aalto University in 2010, as a result of the merger of Helsinki University of Technology, Helsinki School of Economics and University of Art and Design, was the long tradition of industrial co-operation in the engineering discipline in Finland.

The role of engineers as contributors to society has evolved through the past 150 years. While in 19th century engineers were regarded as heroic constructors with social responsibility, early in the 20th century this image was changed into servants of industry (Jørgensen 2007). Since 1980s the conception of engineers as servants of public safety, health, and well-being has increased, and it is accepted as the mission of engineering education (Heikkerö 2009; See for example Crawley et al. 2007, Academic Engineers and Architects in Finland TEK Code of Ethics[4]).

The role of engineering education and research in combating climate change and more widely in enhancing sustainable development may be regarded as remarkable, although it alone is not enough (Mulder 2006, Isoaho & Pohjola 2007). The tension between serving the immediate needs of industry versus the public good – including sustainable development - is evident in a profession where most of its representatives are employed by the private sector (Heikkerö 2009). In Finland 80% of M.Sc.(Tech.) professionals and 87% of B.Eng professionals work in the private sector (TEK 2010b and UIL 2010).

The studies of EVA (Haavisto & Kiljunen 2009) and Technology barometer of TEK (Lehtoranta et al. 2007) regarding the values and attitudes of Finns towards technology indicate that belief of people that

3 See for the discussion and statistics in Chapter 5.1.
4 See databank of ethics in engineering maintained by TEK (in Finnish) http://www.tek.fi/tekniikanetiikka/saanto/saanto.htm

science and technology would be able to solve problems of the society is decreasing. Especially young people are unsure of the role of technology in solving societal problems.

A national strategy for the Finnish engineering education does not exist, although its necessity has been brought up by Estola (2002) and by the researcher (Korhonen-Yrjänheikki[5] 2004). Hämäläinen & Heiskala (2004) claim that in general in the present business environment it is necessary that organizations in the public sector[6] learn to operate more as a network and carry out collaborative vision and strategy processes. Despite the somewhat advanced external stakeholder co-operation characterized by the Finnish engineering education, also problems exist.

Conclusively, the researcher argues that an open systematic on-going dialogue enabling collaborative learning of the key stakeholders of the Finnish engineering education would be needed to face the challenges of the globalized knowledge society: value creation in an open innovation environment, fast and sometimes surprising changes, and solving of complex transdisciplinary problems, such as combating climate change. The whole system approach and application of participative group communication methodologies enable grasping future prospects of the Finnish engineering education and impacting future development.

1.2 RESEARCH QUESTIONS AND CONTRIBUTION

The overall research problem of the study is: ***How to develop the Finnish engineering education to face the anticipated challenges of the future primarily on the basis of the views of key stakeholders during the three group communication processes of the study*?**

As illustrated in Figure 1.3, the Research Questions underlying the overall research problem are:

1. *What kind of a framework can be developed for selecting participants for a group communication process of key stakeholders when aiming at capturing future prospects and enhancing development of engineering education nationally, in this case in the context of Finland?*

2. *What are the future prospects and development proposals for the Finnish engineering education based on the views of the key stakeholders on the past, present and future, as well as literature and statistics describing the long-term development and present?*

5 The researcher found as a result of an Argument Delphi panel within the decision makers of the Finnish engineering education that Finnish engineering education lacks national vision. See Chapter 3.2 for the description of the Argument Delphi panel.
6 Degree-oriented higher education in Finland is almost fully publicly funded. It is by law free of charge (Act on Polytechnics 351/2003 and Universities Act 558/2009) despite some exceptions for non-EU residents. As an example in 2009 only 8% of funding of the provided teaching man years in engineering programs at universities became external to the state budget (Finnish Ministry of Education KOTA-database).

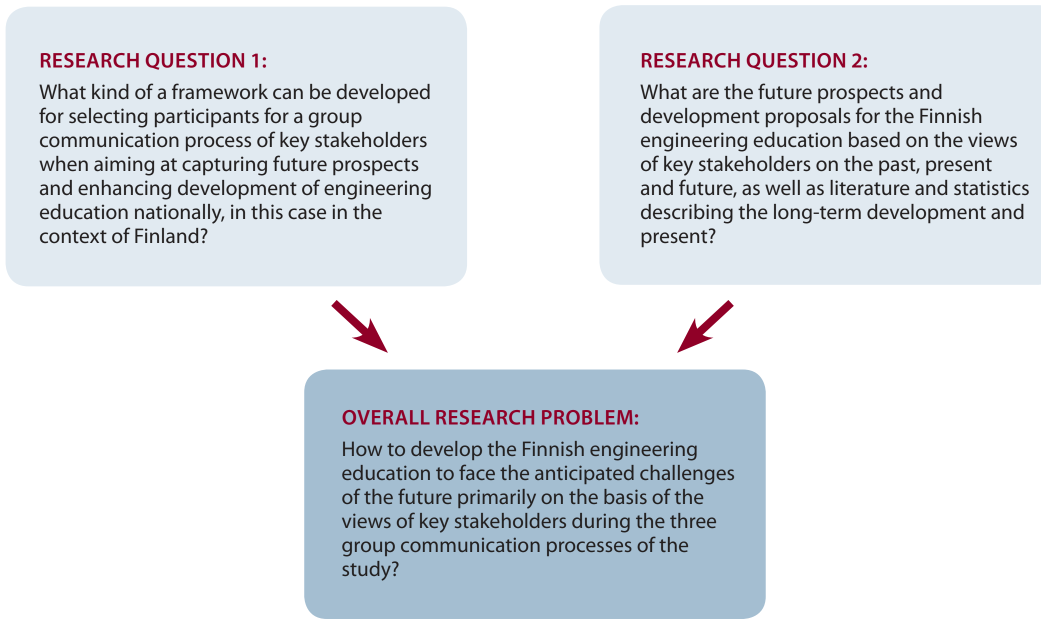

Figure 1.3 The Research Questions of the study.

Research Question 1: What kind of a framework can be developed for selecting participants for a group communication process of key stakeholders when aiming at capturing future prospects and enhancing development of engineering education nationally, in this case in the context of Finland?

In order to frame the future prospects of the Finnish engineering education based on key stakeholders' views, there is a need to define who are the key stakeholders, and how to select participants representing these key stakeholder groups in a group communication process. The research design for solving the Research Question 1 is presented in Figure 1.4.

The selection of individuals with the right mix of knowledge and capabilities is one of the key issues from the knowledge creation point of view (Nonaka et al. 2000, Scharmer 2009). It is one of the core challenges of all group communications processes (Linstone & Turoff 1975, Bunker & Alban 1997, see for example Weisbord & Janoff 2000 in the case of Future Search, Owen 2008 concerning Open Space, Emery & Purser 1996 in the case of Search Conference and Brown & Isaacs 2005 concerning World Café and Kuusi 1999, 2003 and Gordon 2009a concerning the Delphi method).

The theoretical discussion for developing the framework consists of three parts: stakeholder concept and identification (Chapter 2.1), creation of knowledge (Chapter 2.2) and member and group characteristics (Chapter 2.3). The nature of the engineering discipline, especially the role of practice and relation to society affecting stakeholder approach in general is discussed based on literature in Chapter 4. The specific role of industry in the context of Finnish engineering education is discussed in Chapter 5.1.

Combining these three aspects with empirical experiences gathered through participant selection for the Argument Delphi panel (Chapter 3.2.1), Open Futures Search event (Chapter 3.3.1) and the National Collaboration Group for the Finnish Engineering Education (Chapter 3.4.1), a framework for participant selection is developed. This framework can be applied in the selection of participants for a group communication process when aiming at capturing future prospects and enhancing the development of engineering education nationally, in this case in the context of Finland. Conclusions and discussion regarding Research Question 1 is presented in Chapter 7.2.

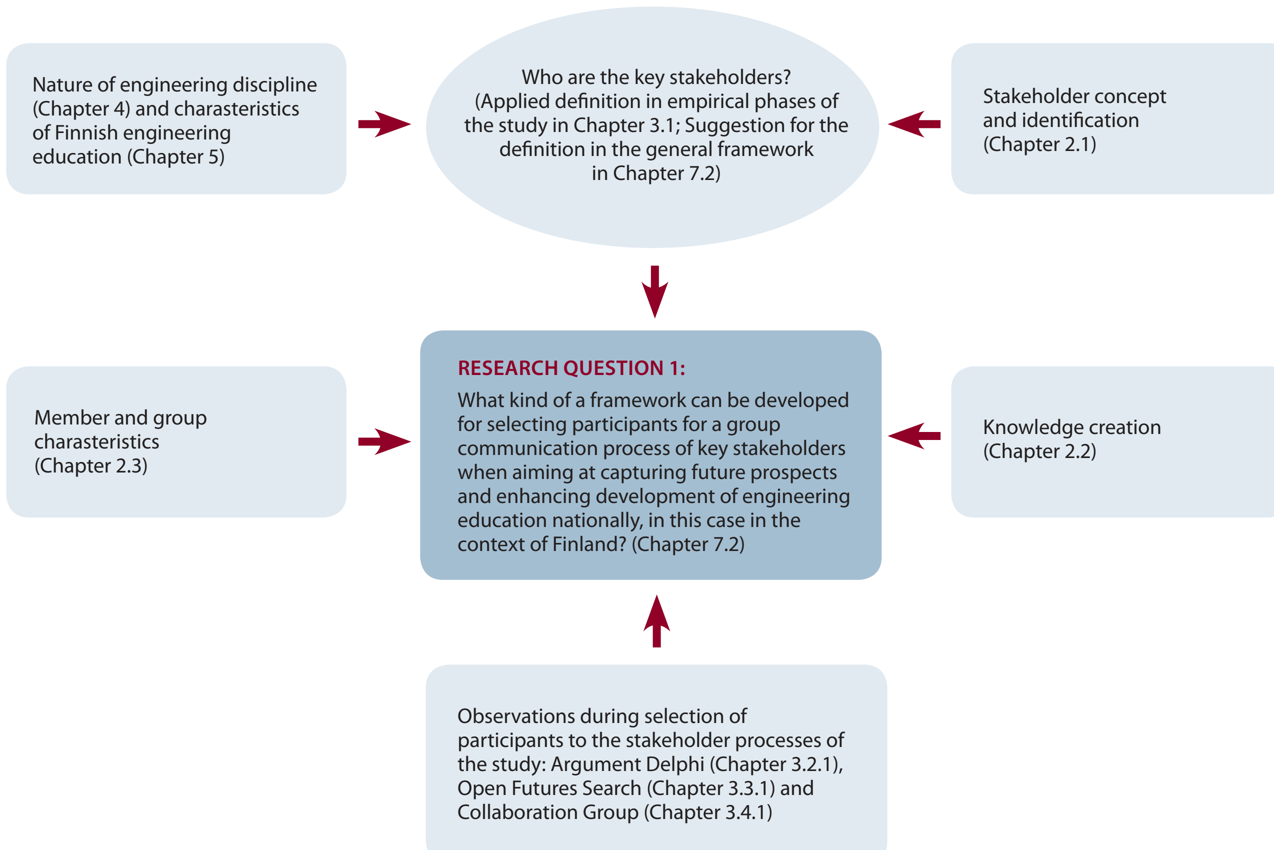

Figure 1.4 The research design for solving Research Question 1.

Research Question 2: What are the future prospects and development proposals for the Finnish engineering education based on the views of the key stakeholders on the past, present and future, as well as literature and statistics describing the long-term development and present?

The research design for solving Research Question 2 is presented in Figure 1.5. Solving of the Research Question 2 is divided into two parts.

First, there is a need to analyze the nature of the engineering discipline and long-term development and present of the Finnish engineering education. Chapter 4 provides an overview of the nature of the engineering discipline. Chapter 4.1 deals with epistemology of engineering education. Engineering education in the changing society and changing skill needs are discussed in Chapter 4.2. The learning context and stakeholder approach are elaborated on in Chapter 4.3.

The long-term development of the Finnish engineering education is analyzed through a literature review (Chapters 5.1 – 5.2), statistics (Chapter 5.4) and historical analysis of the Finnish engineering education carried out by stakeholders at the Open Futures Search event (Chapter 5.5). The key sources of the brief literature review on the history of the Finnish engineering education are Hautala et al. (1995), Orelma (1996), Michelsen (1999) and Aunesluoma (2004). The present state of the Finnish engineering education is analyzed on the basis of statistics (Chapter 5.4), and the results of the three stakeholder processes of the study: the Argument Delphi panel, the Open Futures Search event and the work process of the Collaboration Group (Chapter 5.6). Summary of the analysis of the long-term development and present of the Finnish engineering education is presented in Chapter 5.7.

The main sources of the statistics describing the long-term development and present of the Finnish engineering education are Statistics Finland, the KOTA-database that contains statistics on the Finnish universities and AMKOTA-database focused on the statistics of the polytechnics in Finland. The KOTA and AMKOTA databases are provided by the Finnish Ministry of Education and Culture.

Second, there is a need to find out what are the future prospects and proposals for action for the Finnish engineering education framed by the key stakeholders in the group communication processes of the study: the Argument Delphi panel, the Open Futures Search event and the work process of the National Collaboration Group for the Finnish Engineering Education.

The key factors in the business environment impacting the future of the Finnish engineering education are examined using results of the three stakeholder processes of the study: the Argument Delphi panel, the Open Futures Search event and the Collaboration Group. This is presented in Chapter 6.1.

The vision of the Finnish engineering education is framed by the Open Futures Search event as well as the Collaboration Group. These are presented in Chapter 6.2. Scenarios for the Finnish engineering education are framed by the Argument Delphi, and the Collaboration Group. The scenarios are presented in Chapter 6.3.

Future prospects framed by the stakeholders are analyzed through nine aspects (Chapter 6.4):

- structure of the system, functions and specialization
- co-operation with stakeholders
- professional management of higher education institutions
- funding system
- anticipation and quality assurance
- recruitment and role of technology in society
- degree system
- curriculum, teaching and learning
- post-graduate and continuing education

Conclusions and discussion regarding Research Question 2 is presented in Chapter 7.1.

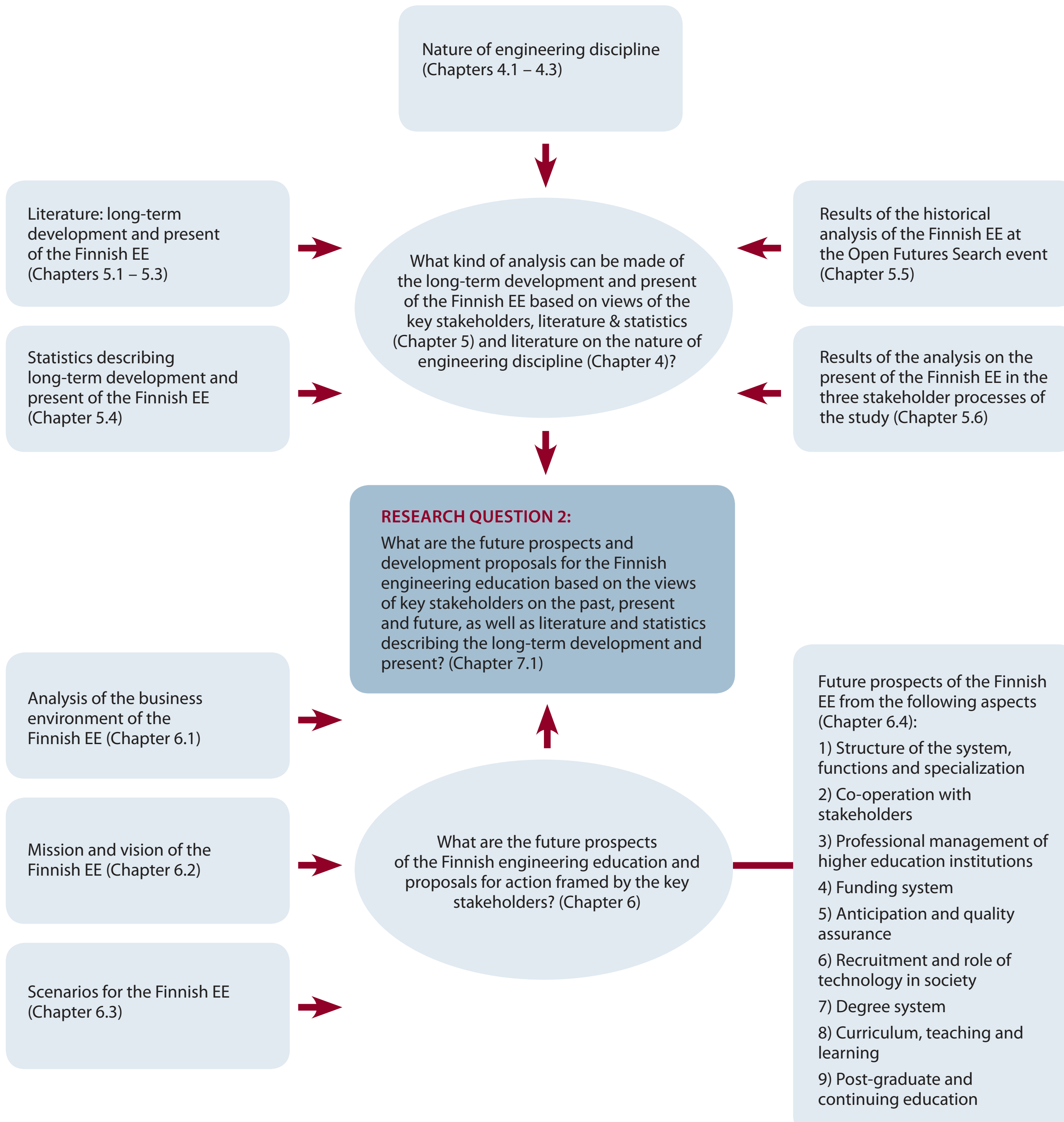

Figure 1.5 The research design for solving Research Question 2.

1) The research contribution of the study is three-fold: The researcher aims at framing future prospects of the Finnish engineering education and development proposals for action, as well as involving key stakeholders in a dialogue for realizing the future they find desirable. The results

of the study should have high practical value for the development of the Finnish engineering education (See Chapter 7.1 for the results and discussion).

2) The researcher develops a proposal for the framework for participant selection for a group communication process aiming at capturing future prospects and enhancing the development of engineering education nationally, in this case in the context of Finland (See Chapter 7.2 for the results and discussion).
3) The researcher discusses differences between knowledge creation in anonymous Argument Delphi and face-to-face group communication methodologies in futures studies based on experiences gathered within stakeholder processes and the theoretical framework of the study. This is valuable for developing methodologies of futures research (See Chapter 7.3 for the results and discussion).

1.3 SCOPE OF THE RESEARCH

Bell (1997, 182) argues that "… In a world of specialists and specialized knowledge, there is an important – and at present neglected - role to be played by the person who sees the big picture, who sees how different things interrelate, and who sees the whole and not only some parts." Also Scharmer (2009) suggests the whole-system approach as a tool to deal with increasing dynamic complexity in the knowledge society. The stated objective to examine future prospects of the Finnish engineering education as a whole, and not only some parts or aspects within it, had a heavy impact on the research scope and design.

The study deals with the Finnish engineering education from the systemic perspective, including engineering education provided by 7 universities and 21 polytechnics. The Finnish engineering education system is defined through its key stakeholders. The applied definition of stakeholders is presented in Chapter 3.1. The challenges specific to engineering field - as an example, specific challenges of mechanical engineering or chemical engineering - are outside the scope of this study.

The whole-system approach of the study implied that the scope of the literature review in the Finnish engineering education was limited to an analysis of the nature of the engineering discipline in the changing society (Chapter 4) and nature of the Finnish engineering education system including analysis of key statistics describing the long-term development and present (Chapters 5.1 – 5.4). It would not be possible to carry out an extensive literature review from all the aspects of engineering education, for example teaching, learning, governance and funding. Furthermore, the emphasis on the stakeholder approach and applied epistemology emphasizing not only explicit, but also tacit and self-transcending knowledge, led to the stressing of the empirical research evidence.

In this study, the term "engineering education in Finland", refers to engineering education provided by higher education institutions aiming at the following degrees: B.Sc.(Tech.), B.Eng., M.Sc.(Tech.), M.Eng, Lic.Sc.(Tech.) and D.Sc.(Tech.).

In the field of technology, Aalto University, Tampere University of Technology and University of Oulu provide also degree programs of architecture. Aalto also offers a degree program of Landscape architecture (Statutes on university degrees 1136/2009). The corresponding degrees are Bachelor of Science in Architecture / Landscape Architecture and Master of Science in Architecture / Landscape Architecture.

Education in the degree programs of architecture is outside the scope of this study[7].

In the field of technology, Oulu, Jyväskylä, Metropolia, Novia and Pirkanmaa Universities of Applied Sciences provide also the degree of Bachelor of Laboratory Services. Metropolia, Oulu, Tampere, Turku, Saimaa, Savonia, Novia and Hämeenlinna University of Applied Sciences provide degree programs aiming at the Bachelor of Construction degree. Novia, Satakunta and Kymenlaakso University of Applied Sciences provide also degree programs in Maritime Management aiming at the degree of Master Mariner (Sea Captain). (Finnish Ministry of Education 2009a). Education aiming at these degrees is outside scope of this study[8].

In the context of deepening globalization, several of the anticipated challenges for the Finnish engineering education may be argued to represent general challenges of the engineering discipline worldwide. Therefore, although the scope of the future prospects of engineering education is limited to Finland, the results of this study may be useful also for the developers of engineering education outside Finland.

The scope of the presented framework of participant selection for a collaborative group communication process aiming at capturing future prospects and enhancing development of education is limited to the discipline of engineering[9]. The researcher argues that at least in the context of Finland, the presented framework for participant selection as well as descriptions of the three stakeholder processes may be valuable also in the development of higher education in other disciplines with a collaborative stakeholder approach. However, in this sense the study needs to be interpreted as a case study with its empirical evidence limited to the Finnish engineering education.

1.4 RESEARCH DESIGN AND METHODOLOGY

1.4.1 Applied Foresight Approach

Bell (1997, 73) suggests that the purpose of futures studies is "to discover or invent, examine and evaluate, and propose possible, probable and preferable futures." He argues that the ultimate aim of futures studies is to contribute to the well-being of present and future generations and the Earth's biosphere. The definition of Dator (1996) on the purpose of futures studies is similar, except forecasting the probable development is not mentioned: to explore alternative futures and to facilitate individuals and groups in formulating and implementing their preferred futures. Also Gordon (2009b) argues that the value of futures research is less in forecasting accuracy than in anticipating opportunities and threats that enable better decisions.

Martin & Irvine (1989) describe the difference between forecasting and foresight: forecasting aims to

7 The database on Finnish universities maintained by the Ministry of Education and Culture (KOTA) does not enable data search excluding architecture education. This implies minor distortion to the presented figures on engineering education as defined in this study. In 2009 the total number of Master's degrees in the field of technology was 2 708. Out of this 2 593 were M.Sc.(Tech.) degrees and 115 M.Sc.(Archit.) degrees. Thus, the share of completed degrees in degree programs of architecture of all completed Masters of Science degrees was 4%. (Statistics Finland 2010)

8 The database on Finnish polytechnics maintained by the Ministry of Education and Culture (AMKOTA) does not enable data search excluding the degrees of Bachelor of Laboratory Services, Bachelor of Construction and Master Mariner. This implies minor distortion to the presented figures on engineering education as defined in this study. According to Statistics Finland (2010), in 2008 the total number of Bachelor degrees in the field of technology was 5 257 from which the number of Bachelor of Laboratory Services was 103. The number of Master Mariner degrees was 72. There were no Bachelor of Construction degrees.

9 The challenges of applying the framework outside Finland are discussed in limitations of the study, Chapter 7.4.

predict the future by translating input assumptions into outputs, while foresight is concerned with creating an increased understanding of possible developments and forces likely to shape them.

Kuusi (1999) suggests that there are three types of epistemic utility of argumentation that are relevant for futures studies: predictive, option and commitment reasonability. Every future topic may be viewed from all these perspectives, and the relevant approach is dependent on the aims of anticipation. Predictive reasonability dominates in studies where participants[10] in a discussion look at a future topic as outsiders and can not affect on the anticipation. The anticipation of the future is limited to the extrapolation of the existing trends. Accuracy of the predictions is the main criterion of success. Studies with epistemic value in predictive reasonability correspond to the definition by Martin & Irvine (1989) of forecasting studies.

Argumentation processes with primary value in option reasonability are foresight studies, as defined by Martin & Irvine (1989), that aim to create improved understanding of possible developments and the forces likely to shape them. The epistemic value lies in the coverage of a relevant variety of options (Kuusi 1999). Godet (2001) labels these futures studies with primary focus on possible and desirable changes as "prospective futures studies".

Kuusi (1999) defines the epistemic value of commitment reasonability as relevant decision options to which relevant decision makers are willing to commit themselves. Using the terminology of Dator (1996) these are futures studies that facilitate the realization of the preferred future. According to Godet (2001), a prospective futures study becomes strategic when the focus moves further from "what could happen" to "what can we do", "what are we going to do" and "how are we going to do it". These strategic futures studies as defined by Godet (2001) correspond to futures studies aiming for commitment reasonability as defined by Kuusi (1999). Futures studies that have both prospective and strategic aims for those participating may be called strategic prospective (Godet 2001).

This study can be regarded as a strategic prospective foresight study (Godet 2001), the subsequent focus being on option and commitment reasonability (Kuusi 1999). The focus is on increasing understanding of possible future development of the Finnish engineering education and the preferable future development that the key stakeholders of the Finnish engineering education are committed to realize. Therefore, there is a need to define the aspired vision[11], various scenarios[12] for the future, as well as proposals for action in creating the future that the key stakeholders find desirable.

This study follows the tradition of describing the future through a continuum of the past, the present and the future. Slaughter (1996) uses the concept of "extended present" to express that present includes both ingredients from the past as well as seeds for the future. The Finnish engineering education does not operate in a vacuum but is impacted by the driving forces[13], trends[14] and weak signals[15] in society.

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10 Kuusi (1999) calls participants as panelists, because his model of epistemic utility of argumentation is developed with empirical focus in Argument Delphi studies.

11 Vision is a description of the most desirable future state that one is aiming to achieve.

12 Scenarios are successive images of the future development that proceed logically and can be supported with argumentation. Scenario is a story presented with future images that can be understood as a manuscript towards the defined image of the future. (Rubin 2003, 899)

13 Driving forces are important societal or wider phenomena that prevail for a certain period of time and have an impact on observed options and decision-making (Rubin 2003, 889-890).

14 Trend is a general tendency or direction of a phenomenon observed during a relatively long period of time (Rubin 2003, 902).

15 A weak signal is the first indication of change. It can be a separate phenomenon or event or a cluster of intertwined phenomena or events that become significant through connecting with other signals. When occurring, the phenomenon does not necessarily seem to be important or broad, but it may play a decisive role in the emergence of the future. Detecting weak signals is one of the most challenging areas of futures research. (Kamppinen et al. 2003, 162, 892)

In this study this is called the business environment of the Finnish engineering education. The applied foresight model is illustrated in Figure 1.6.

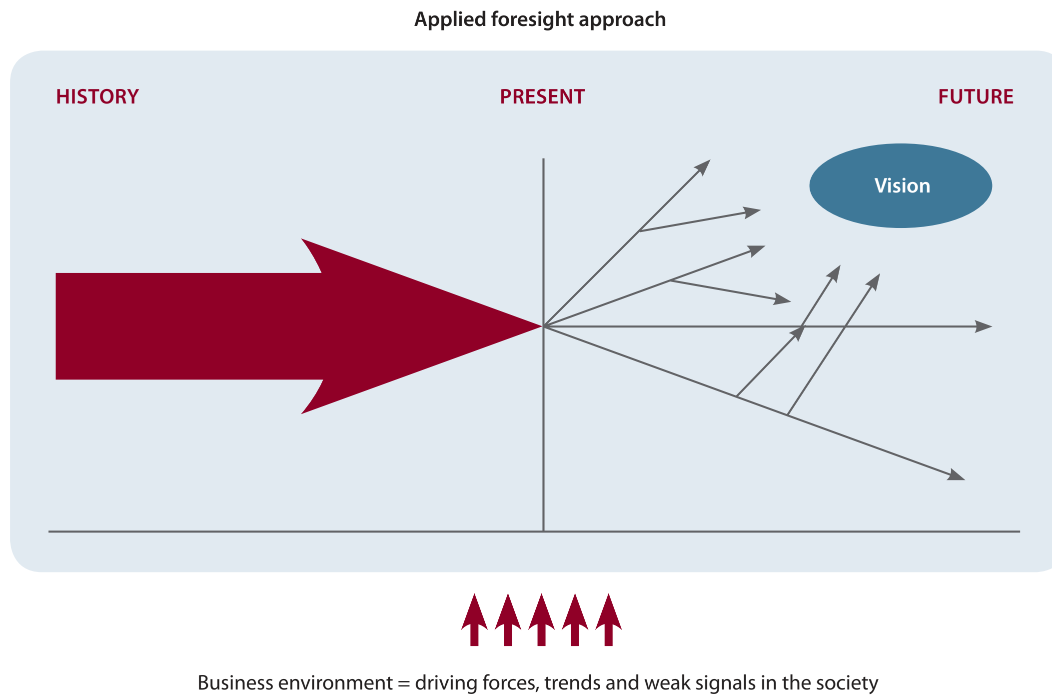

Figure 1.6 Applied foresight approach in this study.

1.4.2 Epistemology of the Study

Futures research is by its very nature multidisciplinary since everything might have a future (Heinonen & Hämäläinen 1992, Bell 1997, Kamppinen et al. 2003, Glenn 2009). Also the epistemology of futures studies differs from other disciplines. Because the future does not yet exist, we can not study it directly. Futures research can not limit the concept of knowledge to only existing knowledge of the past and present that can be verified through scientific means. This non-objective part of knowledge cannot be verified to be true or false, because future does not yet exist. (Bell 1997, Malaska 2003).

Knowledge of the future is contingent. The future exists in possible future paths not yet realized (Malaska 2003). Bell (1997) states that it is possible to study future indirectly by studying factual things that have a bearing on the future. He defines "a posit" in futures studies as a statement of the future that we treat as true. Knowledge surrogates are those posits that we accept as conjectural knowledge, because we have subjected the grounds for believing them to critical analysis and they remain unrefuted. Knowledge surrogates can be subjected to test by making the grounds for them explicit, intelligible and logically coherent, which make formulations open to critical assessment. Attempts are made to refute knowledge surrogates by examining their consistency with relevant past and present facts and with other presumptively true predictions and by seeing if they conform to the rules of logic.

Based on general contingency theory, Kuusi (1999) argues that there are four different types of expert knowledge about the future. These are knowledge on: invariant behavior or invariant criteria of sameness of learning or not-learning beings, capacity limits of learning beings, interests of learning beings, and capability limits of learning beings. Based on this typology, Kuusi (1999) suggests that there are three kinds of experts on future: scientists, decision makers and synthesizers. Scientists are experts of invariances[16]: criteria of sameness of not-learning beings (primarily natural scientists) and habits, interests and learning possibilities of learning beings (primarily behavioral scientists). Decision makers have a large supply of relevant resources and interests. They are more keen on widening the capacity limits to achieve different objectives promoting their interests than on finding invariances. The key competence of synthesizers is the ability to estimate relevance. Synthesizers understand which invariances, capacities and decisions are most important. And furthermore, they are able to anticipate the interplay of factors that shape the future. An important capability of synthesizers is systemic understanding (Kuusi 2009).

Bell (1997) limits the concept of knowledge to studying factual things. Kuusi (1999) does not define whether the knowledge of scientists, decision makers or synthezisers has an explicit and tacit component. The theories of Nonaka & Takeuchi (1995), Nonaka et al. (2000) and Scharmer (2009) on knowledge creation suggest that the importance of personal tacit knowledge and collaborative tacit knowledge that Nonaka et al. (2000) call symphatized knowledge, cannot be neglected. Also Boisot (1998) in his theory of I-space recognizes tacit knowledge in knowledge creation.

As illustrated in Figure 1.7., the applied epistemology of the study emphasizes not only explicit, but also tacit and emerging self-transcending knowledge (Nonaka et al. 2000, Scharmer 2009). Figure 1.7 also illustrates the type of knowledge that different methodologies of the study are able to grasp. The ontological level of the study is an inter-organizational system: the Finnish engineering education.

Tacit knowledge may be grasped only through face-to-face dialogue (Nonaka & Takeuchi 1995, Nonaka et al. 2000, Scharmer 2009) and self-transcending knowledge through presencing[17] (Scharmer 2009). Therefore, the primary sources of knowledge were group communication processes of stakeholders where the researcher had the role of action researcher. Action research, as defined by Stringer (2007, 34) "seeks to engage people directly in formulating solutions to problems they confront in their community and organizational lives." Community in this case is not a spatial concept, but a community of interest.

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16 Godet (1994; In: Kuusi 1999, 9) defines "invariant" as a phenomenon assumed to be permanent up to the horizon studied. In Collins English Dictionary (2000)"invariant" is defined as an entity or quantity that is unaltered by a particular transformation of co-ordinates: a point in space rather that its co-ordinates is an invariant.

17 See for the description of presencing as defined by Scharmer (2009) in Theory U in Chapter 2.2.1.

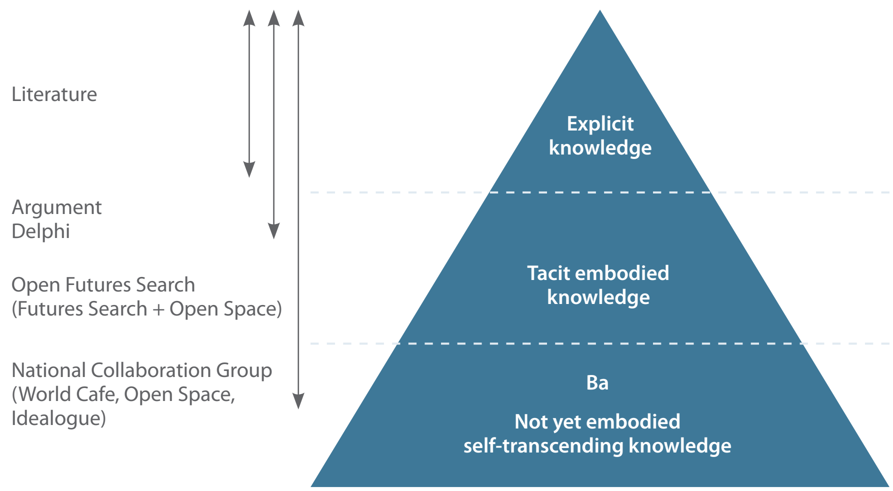

Figure 1.7 The applied epistemology of the study (combined from Nonaka et al. 2000 & Scharmer 2009) and type of knowledge that different methodologies of the study are able to grasp.

1.4.3 A Collaborative Stakeholder Approach

In this study the Finnish engineering education system is defined through its key stakeholders. The applied definition of stakeholders in the three stakeholder processes of the study is presented in Chapter 3.1.

Collins Dictionary (2000) defines the verb "collaborate" as "to work with another or others on a joint project". In this study, the stakeholders of Finnish engineering education work jointly in three stakeholder processes. In the anonymous Argument Delphi panel the aim is to frame together future prospects of Finnish engineering education that may be used for developing the education. In two face-to-face stakeholder processes, the Open Futures Search event and the National Collaboration Group for the Finnish engineering education, the aim is not only to examine future prospects, but also to create a national strategy for the Finnish engineering education.

Savage et al. (1991, 61) define the stakeholder approach as follows: "The stakeholder approach *systematically integrates executives' concerns about organizational strategy with the organization's interests* in marketing, human resource management, public relations, organizational politics, and social responsibility. This integrative perspective assumes that an *effective organization strategy requires consensus from a plurality of key stakeholders* about what it should be doing and how these things should be done."[18]

Freeman (1984, In: Friedman & Miles 2006, 27) claims that "adopting stakeholder approach requires organizations to develop expertise in the understanding of how stakeholder groups arise, *the key issues they perceive*, and their willingness to expend resources either helping or harming corporations on these issues". [19]

In this study, "the collaborative stakeholder approach" refers to the key stakeholders of the Finnish engineering education system working jointly to develop the Finnish engineering education and to create a national strategy for the Finnish engineering education.

18 Italics added by the researcher in order to emphasize relevant aspects concerning this study.
19 Italics added by the researcher in order to emphasize relevant aspects concerning this study.

1.4.4 Description of the Three Stakeholder Processes of the Study

The empirical part of this study consists of three stakeholder processes: an anonymous group communication process carried out with the Argument Delphi method, and two stakeholder processes applying face-to-face group communication methodologies: the Open Futures Search event and the work process of the National Collaboration Group for the Finnish Engineering Education. Although the stakeholder processes were separate, the two face-to-face processes may be also regarded to constitute a collaborative learning process[20].

17 out of 28 members of the core Collaboration Group participated also in the Open Futures Search event. In addition to them, there were four other persons at the Open Futures Search that were not part of the core Collaboration Group, but they attended the workshops on teaching and learning as part of the work of the Collaboration Group. Table 1.1 summarizes the key facts of the three stakeholder processes.

Table 1.1 Key facts of the three stakeholder processes of the study.

	Argument Delphi	Open Futures Search	Collaboration Group
When	9/2001 - 9/2002	29.-30.11.2006	8/2007 - 9/2009
Objective	study future prospects of the Finnish EE	national strategy for the Finnish EE	national strategy for the Finnish EE
Aimed reasonability	options	primarily options, but also commitment	options and commitment
Applied definition of stakeholders	those with direct economic and/or legal decision-making power on the Finnish EE (applied from Donalson & Preston 1995 as interpreted by Savage 2004)	those with power to affect the performance of the Finnish EE or a stake in the performance of the Finnish EE (applied from Jones 1995)	those with power to affect the performance of the Finnish EE or a stake in the performance of the Finnish EE (applied from Jones 1995)
Number of participants	21	53	28 in core group; about 50 other participants in workshops on teaching & learning in Finnish EE; 20 other in the workshop on structural development
Methodology	Argument Delphi, a variation of Policy Delphi (Kuusi 1999)	Combination of Future Search (Weisbord & Janoff 2000) & Open Space (Owen 2008)	World Cafe (Brown & Isaacs 2005), Open Space (Owen 2008), Dynamic facilitation (Nummi 2007), Idealogue (Nummi 2007), Structured Round (Rees 2005)
Work process	First round interviews, second round questionnaire	One face-to-face workshop lasting two full days	14 workshops, 4 meetings, 8 preparatory assignments
Role of the researcher	Facilitator	Facilitator	Two-fold role: initiator, planner and manager of the whole process and participant in the group representing TEK (stakeholder group: alumni)

20 Four members of the Collaboration Group, including the researcher, were involved also in the Argument Delphi panel: Markku Lahtinen and Pertti Törmälä as participants and Jukka Mäkelä as superior of the researcher.

During 2001 – 2002 the researcher carried out an **Argument Delphi** panel, for 21 decision makers[21] of the Finnish engineering education (Korhonen-Yrjänheikki 2004). The objective of the Argument Delphi panel was to find out how decision makers of the Finnish engineering education view future prospects of the Finnish engineering education. The applied definition of stakeholders was the interpretation of Savage (2004) of Donaldson & Preston (1995): primary stakeholders are those that have direct economic and / or legal stake in the issue.

The Argument Delphi, applied in the study, is a variation of Policy Delphi (Kuusi 1999, 2003). The first round consisted of thematic interviews, and the second one a questionnaire consisting of two parts: Future prospects of the business environment (see Appendix 1) and Finnish engineering education (see Appendix 2) up to the year 2015. Just like in Policy Delphi, rather than aiming at artificial consensus, the reasoning behind arguments is brought up and conflicting interests discussed. Participants of a classic Delhi panel do not meet face-to-face, and therefore the generated knowledge is purely explicit. However, in Argument Delphi, the researcher and panelists often meet face-to-face during the first round, which was the case here too. Therefore, the researcher argues that the methodology may be seen to generate also tacit knowledge, although only between researcher and individual panelists. Appendix 3 contains an overview of the Delphi method. See Chapter 3.2 for further description of the Argument Delphi panel of the study.

One of the key findings of the panel was that Finnish engineering education lacks national vision shared by the key stakeholders (Korhonen-Yrjänheikki 2004). Therefore, the aim of the second stakeholder process was to generate building blocks for framing a national strategy for the Finnish engineering education.

The second stakeholder process was an **Open Futures Search event** that the researcher designed and facilitated 29.-30.11.2006 for 53 representatives of the key stakeholders of the Finnish engineering education (Korhonen-Yrjänheikki 2007a). Participants of the workshop are listed in Appendix 4. A project team of 8 people[22] from TEK that was led by the researcher participated in organizing the event. The applied definition of stakeholders was that of Jones (1995): stakeholders are those with the power to affect performance and / or stake in performance.

The methodology of the workshop was Futures Search (Weisbord & Janoff 2000) combined with Open Space (Owen 2008) in the action planning phase. Therefore, the researcher calls the event "Open Futures Search". Future Search is a strategic planning tool that is especially suited for complex systems issues, including dilemmas within an educational system, organization, community or environment. It could be also characterized as a collective learning experience, where the whole system is in one room working together to create and act upon a shared future vision for their organization or community (Bunker & Alban 1997; Weisbord & Janoff 1999, 2000). Open Space is a methodology for dealing with complex and potentially conflicting real-life issues in an innovative and productive way. Like in this case, Open Space is sometimes used for action planning combined with another participative group work methodology (Owen 2008). The group worked face-to-face, and therefore, the generated knowledge may be seen to be explicit, tacit and potentially also self-transcending[23]. An overview of Future Search and Search Conference methodologies can be found in Appendix 5. See Chapter 3.3 for further discussion on the selection of participants and work process of the Open Futures Search event. A detailed

21 Participants of the Argument Delphi panel are listed in Chapter 3.2.1.
22 See Chapter 3.3.2 for the make-up of the project team.
23 Grasping of self-transcending knowledge requires shifting of the field structure of attention to I-in-now and conversational field structure to presencing in order to be able to grasp self-transcending knowledge. See Chapter 2.2.1 for U-theory on knowledge creation (Scharmer 2009).

description of the work process of the event is provided in Appendix 6.

The third stakeholder process of the study is the **National Collaboration Group for the Finnish Engineering Education** organized during 2007 – 2009. In March 2007 a new Parliament was elected for Finland. In the governmental program for the years 2007 – 11 the renewal of the Finnish engineering education and its strategy was brought up (Prime Mininster's Office 2007, 30). Preliminary guidelines for the national strategy of Finnish engineering education had just been published as a result of the Open Futures Search in February 2007 (Korhonen-Yrjänheikki 2007a). Furthermore, during the event and later in the seminar where the results were published[24], a strong intent was manifested by several participants of the benefits to intensify co-operation between stakeholders of the Finnish engineering education.

In late April 2007 the researcher - in the role of Director of Educational Affairs at TEK - contacted the management of Helsinki University of Technology TKK (Matti Pursula), Tampere University of Technology TUT (Jarl-Thure Eriksson) and EVTEK University of Applied Sciences (Pertti Törmälä) as well as Director of Educational Affairs at the Union of Professional Engineers in Finland UIL (Hannu Saarikangas), offering to prepare a joint proposal for the Finnish Ministry of Education to set up a National Collaboration Group for the Finnish Engineering Education.[25]

The Finnish Ministry of Education accepted the proposal and assigned funding[26] for the work, primarily for organizing the workshops and salaries of the Secretariat. In addition to the Finnish Ministry of Education, the work of the Collaboration Group was funded by TEK[27]. The educational and employment policy unit at TEK, led by the researcher, hosted the Secretariat of the Collaboration Group. The members and responsibilities of the Secretariat are described in Appendix 7.

The work process of the National Collaboration Group can be regarded as a collaborative learning process. The objectives of the Collaboration Group accepted in the first meeting of the Group on 30.8.2007 (Korhonen-Yrjänheikki 2007b) were:

1) to create a national strategy for the Finnish engineering education
2) to promote structural development of engineering education
3) to clarify division of work between universities and polytechnics in general and between different higher education institutions
4) to prepare an action plan to execute the strategy
5) to make additional development proposals if needed
6) to follow up execution of the strategy
7) to promote collaboration of stakeholders of engineering education aiming to make the Collaboration Group a unique example of benefits of close co-operation of stakeholders

The Collaboration Group consisted of 28 participants[28] including the researcher. The applied definition of stakeholders in the selection of participants was similar to the Open Futures Search event (Jones

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24 The results of the Open Futures Search event were published on 12.2.2007 at Hotel Holiday Inn Convention Center of Helsinki in a seminar open to all interested parties. Approximately 150 people representing various stakeholders of the Finnish engineering education participated in the event.

25 Parliamentarian Jukka Mäkelä that later became Chairman of the National Collaboration Group played also an important role in commenting the proposal for setting up the Group and was present also, when meeting the Minister of Education Sari Sarkomaa in May 2007. Mäkelä has extensive experience in developing engineering education. During 1/1997 – 4/2007 he worked as Director of educational affairs at TEK.

26 150 000 €

27 The funding of TEK for the Collaboration Group was approximately 130 000 €.

28 Participants of the Collaboration Group are listed in Chapter 3.4.1.

1995). In addition to the amount of time spent on pre-assignments for the workshops, the Collaboration Group spent together 15 full working days in-between August 2007 and March 2009. The applied participatory work methods included World Café (Brown & Isaacs 2005), Open Space (Owen 2008), Idealogue (Nummi 2007), Dynamic Facilitation (Nummi 2007) and Structured Round (Rees 2005). The group worked face-to-face, and therefore, the generated knowledge may be seen to be explicit, tacit and potentially also self-transcending. Description of the applied participative group communication methodologies as well as case examples are provided in Appendix 8. All events of the Collaboration Group are listed in chronological order in Appendix 9.

The first part of the process, between August 2007 and February 2008, was focused on preparing the principles of the national strategy for the Finnish engineering education (Allt & Korhonen-Yrjänheikki 2008). The process contained 4 preparatory assignments, 5 workshops and 2 meetings. The second part of the work process, carried out between March 2008 and September 2009, consisted of three separate themes that also contained supporting activities providing input to the work of the Collaboration Group.

In addition to the preparatory assignments and workshops of the Collaboration Group, the theme "Structural development and specialization of higher education institutions" contained gathering of statistics on higher education institutions providing engineering as well as compiling a publication describing profiles of all 7 universities and 21 polytechnics providing engineering education in Finland (Allt, Korhonen-Yrjänheikki & Savolainen 2009). One of the workshops dealing with structural development and specialization, organized on 22.9.2008, was open by invitation for group-external participants. A list of the participants of the workshop is available in Appendix 10.

The second theme "Development of engineering education to face challenges of sustainable development" was supported by a research consisting of an extensive literature review and 66 interviews (Takala 2009). The research was supported by a separate Steering Group. See Appendix 11 for the list of participants of the Steering Group as well as list of the meetings and workshops of the Group. The Collaboration Group used the results for framing the action plan on how engineering education could better face challenges related to sustainable development.

The third theme "Development of teaching and learning in engineering education" was supported by two two-day workshops focused on teaching and learning in engineering education (Mielityinen 2009a). 45 out of 51 participants of the first workshop (16.-17.10.2008), and 45 out of 50 of the second (15.-16.1.2009), were external to the Collaboration Group. Participants of the workshops are listed in Appendix 12.

The role of the researcher in the Collaboration Group was two-fold. She was the initiator of the Group, wrote the work plan and was the superior of the Members of the Secretariat. However, she also participated in the work process of the Collaboration Group as a representative of TEK. She was present at all workshops, meetings and dissemination seminars of the Collaboration Group, either as a participant or Chairman if Jukka Mäkelä was unable to participate.

The researcher was a co-editor of the interim report of the Collaboration Group "National Strategy for the Finnish Engineering Education" (Allt & Korhonen-Yrjänheikki 2008). Moreover, the researcher was a co-editor of the "Profile Map of the Finnish Engineering Education", with responsibility for formulating the proposals for action, finalizing the criteria for a Good Campus, editing the descriptions of the higher education institutions as well as the final revision (Allt, Korhonen-Yrjänheikki & Savolainen 2009). As a superior providing feedback and proposals for development, especially concerning the formulation of proposals for action, the researcher participated also in publications on developing teaching and learning in engineering education (Mielityinen 2009a) and sustainable development and engineering education (Takala 2009). The researcher was also Chairman of the Steering Group of research on sustainable development in engineering education (Takala 2009).

1.5 STRUCTURE OF THE DISSERTATION

The first chapter provides an introduction to the study. The theoretical framework of the study is discussed in Chapter 2. Description of the three stakeholder processes of the study is provided in Chapter 3.

Chapter 4 discusses the nature of the engineering discipline. Chapter 5 deals with the long-term development and present of the Finnish engineering education. Stakeholder views on the future prospects of the Finnish engineering education are summarized and analyzed in Chapter 6. And finally, conclusions of the study and discussion on the results are presented in Chapter 7. The structure of the dissertation is presented in Figure 1.8.

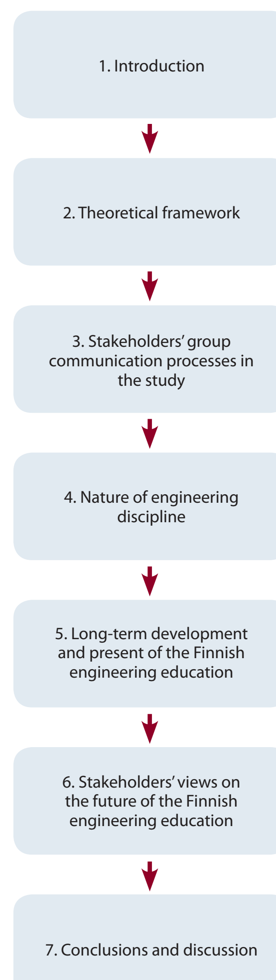

Figure 1.8 The structure of the dissertation.

2 THEORETICAL FRAMEWORK

The aim of this chapter is to provide the needed theoretical background for developing a framework for participant selection for a group communication process aiming at capturing future prospects and developing engineering education nationally (Research Question 1). The theoretical framework consists of three parts: concept of stakeholders and their identification (2.1), theories of knowledge creation (2.2), and member and group characteristics (2.3).

2.1 STAKEHOLDER CONCEPT AND IDENTIFICATION

This chapter discusses the stakeholder concept and identification. In Chapter 2.1.1 the focus is on identification of stakeholders in the organizational context. In chapter 2.1.2 the context is an inter-organizational system, and in 2.1.3 higher education. The stakeholder concept and identification in the context of this study are summarized and discussed in Chapter 2.1.4. Applied definition of stakeholders in stakeholder processes of the study is presented in Chapter 3.1.

The definition of stakeholders articulated in an internal memo at Stanford Research Institute in 1963 "Those groups without whose support the organization would cease to exist" is credited to be the earliest definition of stakeholders (Friedman & Miles 2006, 5). The most regarded definition, the classical definition of stakeholders, is that of Freeman (1984):"any group or individual who can affect or is affected by the achievement of the organization's objectives."

Most of the theoretical work on the stakeholder concept has been accomplished in relation to privately owned corporations (Donaldson & Preston 1995, Friedman & Miles 2006). Systems theory was applied to organizational systems in 1970s for example by Ackoff (1974), which impacted also the development of stakeholder theory. In the systems approach, both the identification of stakeholders and interconnections between them is critical (Freeman & McVea 2001). The focus is on collective strategies for optimizing the network rather than on individual optimization strategies. In the field of information management systems, stakeholder theories have been combined with the systems approach (see for example Pouloudi & Whitley 1997 or Boonstra & de Vries 2008).

The application of the stakeholder concept in studies of higher education is relatively new (Neave 2002a, Kantanen 2007, Bjørquist 2008), although the dimension as such is not new (Neave 2002a, Bjørquist 2008). Bjørkquist (2008) argues that much of the literature applying the stakeholder concept in higher education is closely linked to strategic management "for example giving higher education institutions recipes for stakeholder identification and stakeholders' importance".

Freeman (1984), like most of the economic theorists, argues that the origins of stakeholder theory lie in Adam Smith's theory of Moral Sentiments, published in 1759. The origins of the stakeholder concept are, however, not completely uncontested. Researcher of higher education Neave (2002a) is of the opinion that the origins lie in the theory of possessive individualism, and therefore political theorist John Locke (1632 – 1704) is the forefather. The definition of community in possessive individualism rests on individual's share – or stake – in the common wealth or possession. It is in the interest of the individual to uphold the existing order, because it had served him so well.

Donaldson & Preston (1995) classify stakeholder theories to normative, descriptive and instrumental. Friedman & Miles (2006) call descriptive and instrumental theories the analytic approach to stakeholder theories. Savage (2004) simplifies the classification in the following way: business ethics studies are normative, organization studies descriptive, and strategic management studies instrumental.

Normative theories are those that describe the purpose and function of an organization or how management or stakeholders should act based on some ethical principle (Donaldson & Preston 1995). Friedman & Miles (2006, 40 – 82) classify normative stakeholder theories to three sub-groups based on their degree of idealism. Theories of the first class are most idealized and describe the ideal, just society. Immediately realizable theories constitute the third class. They specify to whom and for what managers are responsible given the contemporary legal and institutional context. The theories in the second class are not completely ideal, but they are less readily realizable than theories of the third class.

Descriptive stakeholder theories describe and explain corporate characteristics and the behavior of managers and stakeholders and how they view their actions and roles. Reflection of the behavior can be past, present or future oriented. (Donaldson & Preston 1995, Friedman & Miles 2006)

Instrumental theories are used to identify the connections between stakeholder management and achievement or organizational objectives. They describe how management should act to promote organizational interests. (Donaldson & Preston 1995, Friedman & Miles 2006). Instrumental stakeholder theory establishes connections between certain practices and end states (Jones 1995).

Jones (1995) presents an instrumental stakeholder theory for stakeholder management based on mutual trust and co-operation. He argues that ultimately agency, transaction costs and team production problems are commitment problems (opportunism) and efficient contracting - in other words relationships with stakeholders - is profoundly affected by the costs of solving these commitment problems. And furthermore, because ethical solutions to commitment problems are more efficient than mechanisms designed to curb opportunism, firms contracting with their stakeholders on the basis of mutual trust and co-operation will gain competitive advantage.

Later Jones presented together with Wicks (Jones & Wicks 1999) a proposal for convergent stakeholder theory that is a synthesis of normative and instrumental approaches. Similarly to Donaldson & Preson (1995), they argue that the ultimate underpinning of stakeholder theorizing is the normative approach. Trust and co-operation lie at the core of the convergent stakeholder theory. Trust is defined with the help of Hosmer (1995, 399): "Trust is the expectation by one person, group, or firm of ethically justifiable behavior – that is, morally correct decisions and actions based on ethical principles of analysis – on the part of the other person, group, or firm in a joint endeavor or economic exchange." The normative core of the theory is that "relationships characterized by mutual trust and co-operation are morally desirable". And finally, the supporting instrumental theory claims that "Firms whose managers establish and maintain mutually trusting and co-operative relationships with their stakeholders will achieve competitive advantage over those whose managers do not."

Mitchell et al. (1997) point out that although legitimacy, and subsequently the normative approach is important, we can not forget power and urgency as key attributes of stakeholder theory as well. Thus, their theory of stakeholder identification does not support the normative underpinning of stakeholder theory.

Freeman (1999) criticizes Jones & Wicks (1999), arguing that the Donaldson & Preston (1995) three-class typology of stakeholder theories that convergent stakeholder theory takes for granted is, at best, dubious and takes researchers applying stakeholder concept to wrong direction.

Freeman (1999) calls for divergence in stakeholder theorizing, because that enables different useful ways of understanding organizations in stakeholder terms: "If we drop the tripartite typology of Donaldson & Preston, then plainly there is no need for anything like convergent stakeholder theory. There is nothing to converge – no separate contributions for philosophers and management theorists. There are just narratives about stakeholders and narratives about these narratives- that is, theory… By choosing to call groups stakeholders rather than interest groups, constituencies or publics, we have already mixed up fact and value. Stakeholder is an obvious literary device meant to call into question the emphasis on stockholders."(Freeman 1999, 234)

Freeman (1999) points out that his classical definition of stakeholders (1984) is fundamentally instrumental in nature. "…If organizations want to be effective, they will pay attention to all and only those stakeholders that can affect or be affected by the achievement of organization's purposes. That is, stakeholder management is fundamentally a pragmatic concept. Regardless of the content of the purpose of a firm, the effective firm will manage the relationships that are important." (Ibidem, 234). Therefore, he argues that the instrumental stakeholder theory, as presented by Jones (1995), synthesis of ethics and economics, is the most important way forward in stakeholder theorizing.

Trevino & Weaver (1999) and Gioia (1999) also criticize the Jones & Wicks (1999) proposition of convergent stakeholder theory. They claim that stakeholder theory itself should be seen as a research tradition. Normative stakeholder theory argues that for moral reasons, attention needs to be paid to multiple stakeholders, while empirical stakeholder studies illustrate when and why corporates do not always pay attention to such a wide array of stakeholders as the normative approach would suggest, or whether organizational performance actually benefits from paying attention to multiple interests of stakeholders (Trevino & Weaver 1999). Gioia (1999) agrees with Freeman (1999) on the need to focus more on empirical research, thus emphasizing instrumental and descriptive aspects of stakeholder theorizing.

2.1.1 Identification of Stakeholders in Corporate Context

The definition of stakeholders varies between extremely broad and narrow. As illustrated in Figure 2.1, in addition to the dimension of broad and narrow definitions, Friedman & Miles (2006, 10 – 13) divide stakeholder definitions to strategic and normative. An example of a narrow strategic approach to stakeholders is Clarkson's (1995, 106) definition of primary stakeholders: "one without whose continuing participation the corporation cannot survive as a going concern." While a narrow normative definition would be for example "those who owed significant responsibility" (Friedman & Miles 2006, 5). Extremely broad definitions of stakeholders attribute to stakeholders not only some subset of living human beings, but also the natural environment, human transferred objects (for example cars or computers), humans who have already died and those not yet born, and furthermore mental images like love and community (Starik 1994).

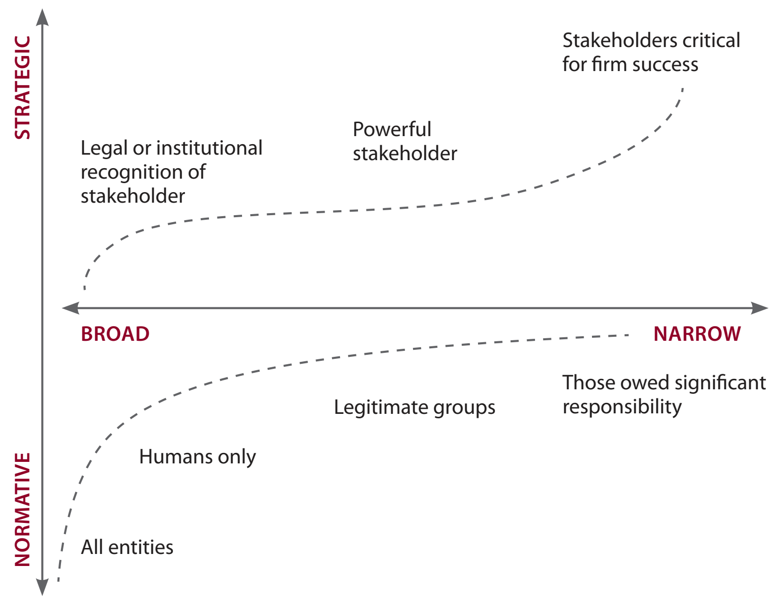

Figure 2.1 Classification of stakeholder definitions (Friedman & Miles 2006, 11).

Savage et al. (1991, 61) emphasize criteria of interest combined with power of influence in defining stakeholders: "those individuals, groups, and other organizations who have an interest in the actions of an organization and who have the ability to influence it." Antonacopoulou & Meric (2005) suggest also interest as an important attribute when defining stakeholders, but not combined with one-sided power to influence. They criticize narrow power-interest definitions of stakeholders for ignoring the importance of weak social links (Granovetter 1973) in comprehensive analysis and knowledge creation.

According to Antonacopoulou & Meric (2005), stakeholders interact because they share common interests and depend on each other to accomplish these. Therefore, knowledge and learning are two key processes that influence the way stakeholder relations are formed. Stakeholders are "individuals or groups of individuals that interact – or can interact – with the organization". (Antonacopoulou & Meric 2005, 131)

Mitchell et al. (1997) claim that power and legitimacy are treated mostly as competing attributes in stakeholder definitions as well as in organization theories. Scholars with a narrow definition of stakeholders tend to emphasize legitimate claims based upon contract, exchange, at-risk status, moral interest or right or legal title or right in the harms and benefits generated by corporate actions. And on the contrary, researchers advocating a broad definition often emphasize stakeholders' power to influence irrespective of whether there are legitimate claims.

Moreover, Mitchell et al. (1997, 863 - 864) state that no individual organizational theory offers systematic answers to questions about stakeholder identification and salience from the viewpoint of power, legitimacy and urgency. Agency, resource dependence and transaction cost theories are useful in explaining why power is an important attribute in stakeholder relationships[29], but they neglect legitimacy as an attribute. On the contrary, organization theories with open-system orientation, such as institutional and population ecology theories, are helpful in explaining the effects of environment upon organizations – organizational legitimacy is closely linked with survival[30] - but they do not pay attention to power in relationships between managers and stakeholders. And furthermore, urgency – the degree to which stakeholder claims call for immediate attention – is not the primary feature of any organizational theory[31].

The stakeholder map of an organization is dynamic, and therefore, stakeholder diagnosis needs to be an on-going activity (Savage et al. 1991, Mitchell et al. 1997, Cummings & Doh 2000, Antonacopoulou & Meric 2005). Stakeholders may move from one category to another (Savage et al. 1991, Mitchell et al. 1997), and may even be in two categories at the same time, depending on the context of stakeholder analysis (Cummings & Doh 2000).

Savage et al. (1991) & Mitchell et al (1997) highlight that the classification of stakeholders of an organization is issue-dependent. Cummings & Doh (2000) emphasize that corporate stakeholder analysis depends on whether the approach is the market, political/social or technological value creation process. One can not assume that a supportive stakeholder in one issue is supportive also in another issue or value creation process.

Also Starik (1994, 94) suggests that the question of what a stakeholder is can only be determined by the concept user. There is no right set of criteria. What is more, the concept of mutuality and relationships may offer an approach that results in obviating the need to define the term. "The term could imply only those which make their stakeholder status known or visible, or those who have any "affect"-ingness characteristic. It could refer to either both actual or potential entities, and those which meet various criteria, such as power, legitimacy, probability, or impact. It could include the non-human natural environment, past or future generations, non-living objects, or non physical mental-emotional constructs, or none of these."

The pivotal contribution of Mitchell et al. (1997) for the identification of stakeholders in the corporate context based on stakeholder salience is presented in more detail in Appendix 13. The Appendix contains also a more detailed description of the Cummings & Doh (2000) value creation approach and the Antonacopoulou & Meric (2005) learning approach to stakeholder identification.

2.1.2 Identification of Stakeholders in Inter-organizational Systems

By bringing together ideas from network analysis and stakeholder analysis, Pouloudi & Whitley (1997) suggest four principles for identifying inter-organizational stakeholders[32]. The principles and suggested

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29 Agency theory deals with how principals are able to control the behavior of their agents in order to achieve their, rather than their agents' interests. Managers are expected to pay attention to those stakeholders that have the power to reward and / or punish them. (Jensen & Meckling 1976). Resource-dependency theory proposes that those stakeholders that control resources needed by the organization have power and management should pay attention on them. (Pfeffer 1981). Transaction cost theory suggests that stakeholders outside the corporate boundary may increase transaction costs to the level that justify their absorption into the firm, where costs of hierarchy are lower that the transaction costs of a market failure. (Jones & Hill 1988).

30 Under institutional theory, illegitimacy results in isomorphic pressures on organizations that do not obey accepted norms (DiMaggio & Powell 1983). Under population ecology theory, the consequence of the lack of legitimacy is organizational mortality (Carroll & Hannan 1989).

31 Agency and transaction cost theory treat urgency in terms of contribution to the cost and behavioral theory deals with it as a consequence of unmet aspirations. Institutional, resource dependence and population ecology theories treat urgency in terms of outside pressures to the firm. (Mitchell et al 1997, 864).

32 In addition to theoretical considerations of network and stakeholder analysis, Pouloudi & Whitley (1997) base the presented principles on empirical evidence from the studies on information systems in the area of drug use management.

implications are:

1) *Stakeholders depend on the specific context and time frame.* Therefore, it is only meaningful to draw a stakeholder map taking into account the particularities of the context and domain studied and map needs to be reviewed regularly.
2) *Stakeholders cannot be viewed in isolation.* It is necessary to analyze direct and indirect links between different stakeholder groups. This refers, for example, to how information is exchanged and how each stakeholder influences or is influenced. Stakeholders' stakeholders should not be ignored.
3) *The position of each stakeholder may change over time.* Changes in the environment – for example in legislation or competitive environment - may have significant effects on the stakeholder relationships. In the case of trying to analyze stakeholder favorability to the system, historical analysis may reveal important information.
4) *Feasible options may differ from the stakeholders' wishes.* Because stakeholders often have different interests, they follow different agendas and try to achieve different objectives. Power relations and politics of the domain under investigation need to be considered.

Pouloudi & Whitley (1997) argue that understanding the roles, interrelations and viewpoints of the different stakeholders is helpful for anticipating the future development of the domain under study, in their case drug use management.

By building on case studies[33], the Mitchell et al. (1997) framework on stakeholder identification, principles of stakeholder identification in inter-organizational systems presented by Pouloudi & Whitley (1997), and network approach of Walsham (1993) to stakeholder identification, Boonstra & de Vries (2008) present a framework for stakeholder identification in inter-organizational systems. The underpinning definition of stakeholders is the classical definition of Freeman (1984).

As examples of questions for stakeholder identification Boonstra & de Vries (2008) list:

- Who are the initiators of the inter-organizational system?
- Who are the sponsors of the inter-organizational system?
- Who have to adopt the inter-organizational system and make it work?
- Who are the intended users?
- Who will receive the output of the inter-organizational system?
- Who are the intended developers and operators of the inter-organizational system?
- Who will be impacted and affected by the inter-organizational system?
- Who will win or lose by using the inter-organizational system?

For the analysis of stakeholders, Boonstra & de Vries (2008) propose using the attributes of power and interest with the alternatives low or high as presented in Figure 2.2. With the dimension power they mean capacity to exert one's will over others in order to realize certain intended benefits as applied from Buchanan & Badham (2000). By applying Fincham (1992), the nature of power is described as processual (nature of interaction between interest groups) or institutional (structures of inequality that form the external components on which power is mandated within organizations).

33 Case studies in retail sector in the Netherlands during 1997 – 2005.

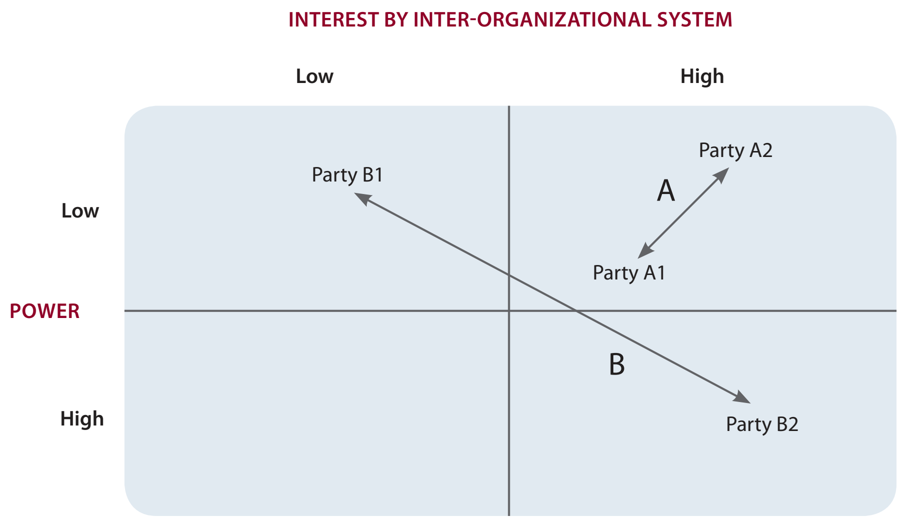

Figure 2.2 The Boonstra & de Vries (2008) framework for stakeholder identification in inter-organizational systems that combines attributes of power and interest. An example of balanced (A) and unbalanced (B) inter-organizational relationship.

2.1.3 Stakeholder Concept and Identification in Higher Education

The Humboldtian model of a university has had a far-reaching impact on the structure and functioning of universities in Europe (van Vught 2004). It is based on the idea that universities need to be protected from external forces, such as politics or the economy (van Vught 2004, Magālhaes & Amaral 2000) and beyond academic work professors do not have further social obligations (Lepenies 1992; In: van Vught 2004). In the Humboldtian model the role of the state is to control universities and to act as a protector preventing third parties from intervening (Magālhaes & Amaral 2000). Thus, if applying the Humboldtian model of university, the approach of involving external stakeholders to have an impact on the development of university does not seem appropriate.

But does the Humboldtian model of university as an isolated entity fit into the present knowledge society and economy? The researcher agrees with Clark (1998), Chesbrough (2003 a,b), van Vught (2004) and Weber & Duderstadt (2004) in that it does not. Clark (1998) considers the paradigm shift towards a more entrepreneurial university a part of a broad societal phenomenon and result of a growing imbalance in the environment-university relationship in the knowledge economy. Also Weber & Duderstadt (2004) link the increasing need of involving stakeholders to the societal change to knowledge economy implied by the fact that society is increasingly dependent on the advances of scientific and technological knowledge. They suggest that, in general, increasing complexity and the interdisciplinary nature of problems leads to a need to interact more closely with stakeholders. Chesbrough (2003b) and Van Vught (2004) argue that among the core reasons for intensified interaction with external stakeholders is the need to integrate the different knowledge functions -creation, transfer and application – into an integrated and interdisciplinary network.

Also Nonaka et al. (2000) and Scharmer (2009) suggest that, in general, when the complexity of the environment increases, as is happening with the present knowledge economy, there is a need to increase the diversity of examined approaches as well, thus employing the multi-stakeholder approach. The researcher suggests that the growing interdependence of actors in creating, applying and distributing knowledge as described by Chesbrough (2003 a, b) and van Vught (2004) underlies the need for more interaction with external stakeholders. This may be interpreted also as part of increasing dynamic complexity of society, calling for the whole system approach, and a wide variety of stakeholders as defined by Scharmer (2009).

Neave (2002a) argues that the 12th century University of Bologna is the ancestor of the "stakeholder university". He argues that massification of higher education[34] is closely tied with the rediscovery of stakeholders in European higher education. He argues that with the massification of education "the watchword continuity was replaced by the imperative of change, with emphasis on higher education's duty to meet social demand on the one hand and the demands of labor market on the other hand. " In accordance with Neave (2002a), Magālhaes & Amaral (2000) argue that practical considerations related to financial stringency and massification of education have led to the paradigm shift of increasing involvement of external stakeholders.

Maassen (2000), Magālhaes & Amaral (2000) and Neave (2002a) suggest that the stakeholder-approach in higher education is linked with the concept of changing the governance structure from collegial to market-driven. Furthermore, the state is no more a controller but rather a supervisor of universities (Magālhaes & Amaral 2000). The stakeholder approach enables to take into account actors and networks other than the government and higher education institution. Although Neave (2002a,b) is fairly critical with the term stakeholder in higher education, he points out that the stakeholder approach might be a useful tool in bringing together certain elements in higher education studies that have been studied separately, but would benefit from an integrated approach. Examples are government-higher education relationships and changes in governance and internal management systems (2002 b).

Kantanen (2007) claims that as a result of increasing pressure from different stakeholders, universities are at risk of forgetting the kernel of their work and the order of priority of stakeholders[35]. Therefore, Kantanen (2007) argues that identification and prioritizing of stakeholders[36] would need to be considered as the first step in enhancing stakeholder relations of universities. Amaral & Magalhaes (2002) also suggest that increased institutional autonomy including the changing role of the state from controller to supervisor together with increasing interaction with external stakeholders limit the academic freedom that they see as the ideal model of a research university.

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34 Massification of higher education means the fast expansion of higher education in enrollment that is intertwined with the change of the society to knowledge economy including expansion of service industry (Altbach et al. 2009). The US was the first country that achieved 40% of the age group attending post-secondary education, which took place already in 1960. Massification of higher education has been a global trend since 1980s in Western Europe, Japan and Australia - later also China and India. Between 2000 – 07 the share of the age cohort globally enrolled in higher education grew from 19% to 26% (Ibidem). For the statistics on expansion of Finnish engineering education see Chapter 5.4.1.

35 Based on Kankaala et al. 2004, 35; Lemola 2004, 120 and Rinne & Koivula 2005, 113.

36 Kantanen (2007) is a positive example of a study applying the stakeholder concept in the field of higher education since the term stakeholder is explicitly defined (Mitchell et al. 1997 with the adaptation of Luoma-aho 2005). However, the researcher disagrees with the interpretation of Kantanen (2007) concerning the core of stakeholder thinking: Kantanen (2007) argues that the core of stakeholder thinking is that there are other values in business besides its value to shareholders (Ibidem, 59) and that satisfied stakeholders legitimate existence of an organization (Ibidem, 63). For example Friedman & Miles (2006) point out that the original roots of stakeholder thinking and many of the contributions are made in debate how to maximize the stockholder value. Also Mitchell et al (1997, 857) point out that narrow definitions of stakeholders often limit stakeholders to those with direct relevance to corporate economic interests. For the debate on whether stakeholder theorizing has a normative core or not, see also Chapter 2.1.

Luoma-aho (2005) criticizes the stakeholder typology of Mitchell et al. (1997) when applying it to higher education, because it does not recognize different levels of stakeholder attributes – power, legitimacy and urgency. Luoma-aho (2005) proposes adding frequency of stakeholder contacts as a fourth element to the Mitchell et al. (1997) stakeholder typology because she claims it is a key element in creating trust and commitment.

Kantanen (2007, 63) classifies the stakeholders of a university using the Mitchell et al. (1997) typology with the addition of frequency of stakeholder contacts (Luoma-aho 2005): Dormant stakeholders are other ministries. Discretionary stakeholders consist of family and friends. Activist groups and parties in crisis situations are demanding stakeholders. Dominant stakeholders comprise of schools, alumni and enterprises. Any group can be a dangerous stakeholder. Community partners, journalists and employers are classified as dependent stakeholders. And finally, definitive stakeholders are ministry of education, staff, students, academic community, local leaders and financiers.

By applying Freeman's (1984) classification of stakeholder foundations for influence and different stakeholder regimes[37], Bjørkquist (2008) frames different kinds of interpretations of stakeholder groupings of a university in a descriptive case study aiming to explain stakeholder influence over time with constructing stakeholder regimes as a means of studying the norms and structures. The regimes are based on different kind of interpretations on norms and structures of the university.

Bjørkquist (2008) does not explicitly present her definition of stakeholders of a university but points out that she is in favor of a broad definition like for example that of Amaral & Magalhães (2002, 2) "a person or entity with legitimate interests in higher education, and which, as such, acquires the right to intervene" applied from Freeman's classical definition (1984), and that definition shows a stakeholder relationship can be formal or informal. Amaral & Magalhães (2002) define legitimacy by adopting the Suchman (1995, 574) formulation: "a generalized perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs and definitions."

Amaral & Magalhães (2002) claim that it is important to separate between internal and external stakeholders of the university. They define internal stakeholders of a university to consist of academic staff, non-academic staff and students. They argue that students are not customers but part of the academic community[38]. "External stakeholders are groups or individuals that have an interest in higher education even though they are not members of the higher education community (Ibidem, 11)." Listed external stakeholders are state, employers, taxpayers, parents and international organizations like European Commission or organizations of employers like ERT and IRDAC.

Neave (2002a) criticizes Freeman's classical definition of stakeholders for being too broad for the higher education context: "when everybody is somebody then nobody is anybody". Mitchell et al.'s (1997) stakeholder identification with the attributes of power, legitimacy and urgency he finds "a little more helpful". Neave (2002a) does not explicitly present his definition of stakeholders at the university context. He points out that the major alternations are in the place, relative weight and legitimacy of the stakeholders. Thus, it seems that power, legitimacy, and whether stakeholder is internal or external to the university, are important attributes according to Neave (2002a).

The term "publics" is also used, for example by Henderson (2001), when discussing university stake-

37 According to Freeman (1984), stakeholders' different foundations for influence can be divided into economic, political and voting. Stakeholders that are able to provide or retain economic resources have economic influence. Political influence may be formal consulting of involved parties or informal lobbying. Stakeholders with voting influence have formal decision authority. The relationship is based on contracts and regulations.

38 They refer to the Göteborg Student Declaration and Prague Minister Conference of the Bologna process.

holders from the view point of public relations. Henderson (2001) defines students, faculty, staff and administration as internal publics. External publics are sponsors and sponsoring organizations, accrediting agencies, business groups, professional groups, high school counselors, potential students, donors, foundations, unions, state boards, community, campus neighbors, media, parents, law enforcement, federal/state/city government, alumni and religious institutions.

2.1.4 Summary and Discussion

The definition of relevant stakeholders is issue-dependent (Savage et al. 1991, 63; Starik 1994, 94; Mitchell et al. 1997, 879; Cummings & Doh 2000) and dynamic, thereby the relevant stakeholders may change over time (Savage et al. 1991, Mitchell et al. 1997, Cummings & Doh 2000, Antonacopoulou & Meric 2005).

With reference to the CHEPS research program "Higher Education & Stakeholder Society", Kantanen (2007) suggests that in the higher education context, the government is comparable to a shareholder in the enterprise context. The researcher argues that since the approval of the new university legislation in Finland in 2009 (Act 558/2009) that enabled foundation-owned universities, the state can not be regarded as the sole shareholder. In addition to the Finnish state, the founders of the Aalto University Foundation and Tampere University of Technology Foundation are industry and alumni[39].

When the task of the group is to contribute to the development of a discipline of higher education in a knowledge-based society characterized by increased dynamic, emerging and social complexity (Scharmer 2009) - in this case the Finnish engineering education system - the task can be considered a complex task with a wide variety of needed knowledge, skills, networks and decision-making power. Furthermore, the task is characterized by high interdependency of participants, because none of them alone is able to have an impact on the development of the system as a whole.

The needed diversity of knowledge, skills, networks and decision-making power suggests a fairly broad definition of relevant stakeholders. Also the ontological level, an inter-organizational system (Pouloudi & Whitley 1997, Boonstra & Vries 2008) and the higher education context (Clark 1998, Amaral & Magâlhaes 2002 , Bjørquist 2008) suggest a fairly broad definition of stakeholders. Concerning stakeholders external to the university, legitimate interests form a relevant criterion (Amaral & Magâlhaes 2002).

The researcher views the selection of participants for a group communication process aiming to develop higher education as a matter of instrumental stakeholder theorizing as defined by Jones (1995) and Donaldson & Preston (1995): in order to achieve certain ends, certain means are used. The instrumental stakeholder management theory of Jones (1995), suggesting that mutual trust and co-operation in stakeholder relationships can be a significant source of competitive advantage, is supported from knowledge creation point of view by Nonaka et al. (2000), Nahapiet & Ghoshal (1998) and Scharmer (2009).

The researcher agrees with the approach of Antonacopoulou and Meric (2005) that there is a need to extend stakeholder theory from contractual power relationships to examining stakeholder relations as knowledge relations. Stakeholders interact because they share common interests and depend on each other to accomplish these. The researcher argues that this approach of defining stakeholders fits well into the context of higher education, especially when aiming to define stakeholders for a collaborative

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39 Especially in the case of this study, when the focus is engineering education system in Finland since Aalto University and Tampere University of Technology educate roughly 70 % of all M.Sc.(Eng) graduates in Finland (Finnish Ministry of Education KOTA database).

knowledge creation process such as this study. Therefore, the next chapter (2.2) contains a discussion on four theories on knowledge creation.

The applied definition of stakeholders in empirical stakeholder processes of the study is presented in Chapter 3.1. The suggested definition of stakeholders when selecting participants for a group communication process aiming at capturing future prospects and developing engineering education nationally (Research Question 1) is presented in the conclusions of the study, in Chapter 7.2.

2.2 THE PROCESS OF KNOWLEDGE CREATION

This chapter provides a summary of four theories on knowledge creation: knowledge spiral (Nonaka & Takeuchi 1995, Nonaka et al. 2000), I-Space (Boisot 1998), creation of intellectual capital (Nahapiet & Ghoshal 1998) and U-theory (Scharmer 2009). The summary is by no means an exhaustive description of theories on knowledge creation. The researcher selected the above listed contributions that she finds especially relevant, bearing in mind the objectives of this study. Discussion on different approaches to knowledge and knowledge creation in the presented four theories is provided in Chapter 2.2.2.

2.2.1 Different Approaches to Knowledge Creation

Knowledge Spiral (Nonaka & Takeuchi 1995; Nonaka et al. 2000)

Nonaka & Takeuchi (1995) define knowledge as a "dynamic human process of justifying personal belief toward the truth". What differentiates knowledge from information is that knowledge is always contextual and also about belief, commitment and action (Nonaka & Takeuchi 1995, Nonaka et al. 2000). Knowledge is always a function of a particular perspective and intention and "knowledge to some end".

Nonaka & Takeuchi (1995) argue that there are two types of knowledge: explicit and tacit. Explicit knowledge can be expressed in formal and systematic language – for example manuals, books and formulae. Tacit knowledge, on the contrary, is personal and hard to formalize and rooted in action, processes and commitment. Both types of knowledge are essential for knowledge creation. Without tacit knowledge explicit knowledge loses its meaning. Therefore, the shared context is always needed in knowledge creation. Nonaka et al. (2000) call the shared context "Ba". "Ba" is the place for self-transendence and multicontext-platform for knowledge creation: "In knowledge creation, generation and regeneration, Ba is the key, as Ba provides the energy, quality and place to perform the individual conversions and to move along the knowledge spiral." "Ba" is illustrated in Figure 2.3.

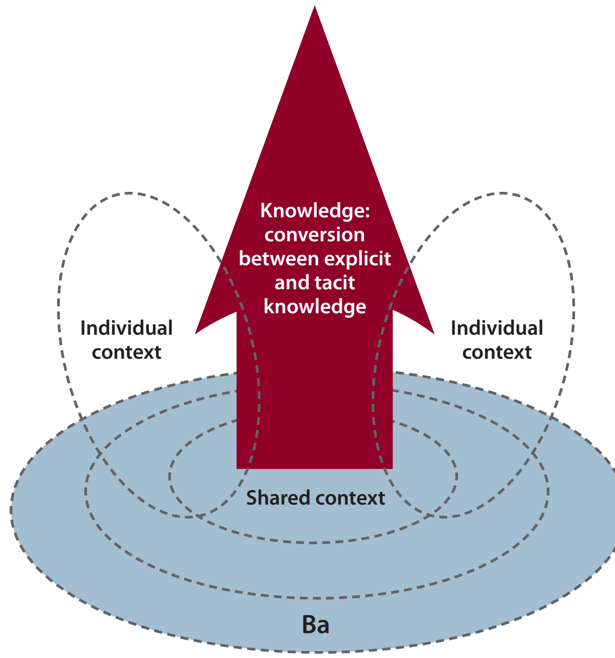

Figure 2.3 "Ba" as a shared context in motion (Nonaka et. al 2000).

Nonaka & Takeuchi (1995) introduced four modes of knowledge conversion: socialization, externalization, combination and internalization:

Socialization: from tacit knowledge to tacit knowledge. Tacit knowledge is acquired through shared experience. That is because without a shared experience it is difficult to understand another individual's thinking process. The socialization process usually starts with building a field of interaction that facilitates the sharing of experiences and mental models. Mutual trust promotes the socialization process. Observation, imitation and practice are ways of socializing tacit knowledge. The result of the socialization process can be called sympathized knowledge, such as shared mental models or technical skills.

Externalization: from tacit knowledge to explicit knowledge. Concept creation through dialogue or collective reflection is a typical form of externalization. Metaphors and analogies are often useful in knowledge conversion from tacit to explicit knowledge. Association of two issues by using metaphor is driven mostly by intuition and holistic imagery. The result of the externalization process is conceptual knowledge.

Combination: from explicit knowledge to explicit knowledge. The combination mode of knowledge creation is about combining different bodies of existing knowledge. In an organization, the combination mode is triggered by combining newly created knowledge and existing knowledge from different sections of the organization and synthesizing it into a new product, service or organizational innovation. For example documents, telephone conversations and traditional meetings are ways of exchanging and combing explicit knowledge. New knowledge is obtained through sorting, adding, combining and categorizing existing knowledge. The result of the combination process is systemic knowledge.

Internalization: from explicit knowledge to tacit knowledge. Internalization is a process of converting explicit knowledge into tacit knowledge. The process is closely related to learning by doing. Knowledge becomes a valuable asset, when experiences acquired through socialization, externalization and combination are internalized into tacit knowledge. From the viewpoint of organizational learning it is then essential that the tacit knowledge obtained by an individual is converted into tacit knowledge of other members of organization through the socialization process. Verbalization of explicit knowledge to documents, manuals or orally conveyed stories promotes the internationalization process. Rapid prototyping may accelerate the accumulation of developmental experiences leading to internalization. The knowledge obtained through the internalization process is operational knowledge.

The knowledge spiral from socialization to internationalization through externalization and combination is presented in Figure 2.4.

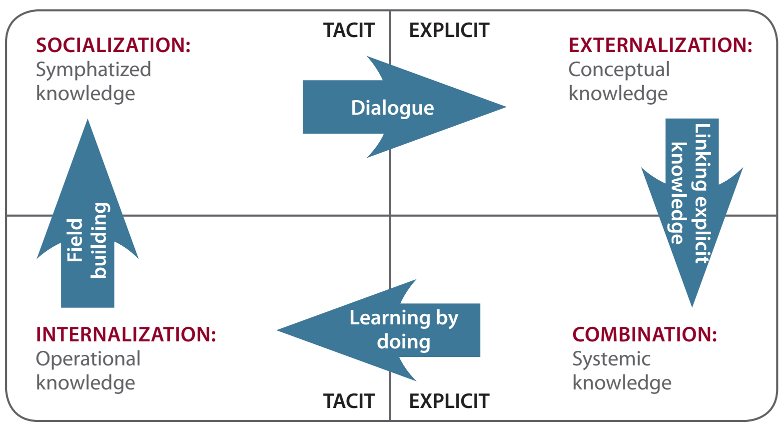

Figure 2.4 Knowledge conversion between tacit and explicit knowledge. Summarized from Nonaka & Takeuchi (1995).

Nonaka & Takeuchi (1995) define the ontological dimension of knowledge creation as consisting of four levels: individual, group, organization and inter-organization. They argue that the organizational knowledge creation process moves horizontally between the epistemological dimensions of knowledge, explicit and tacit, and vertically between different ontological levels. Intention, autonomy, creative chaos, redundancy and requisite variety are five enabling conditions that promote the knowledge creation process[40]. The organizational knowledge creation process consists of five phases: sharing tacit knowledge, creating concepts, justifying concepts, building an archetype, and cross-leveling knowledge.

The organizational learning process starts from the critical phase of sharing tacit knowledge among multiple individuals with different backgrounds and motivations. In order to build mutual trust, individuals' emotions and mental models need to be shared. For sharing, a social field is needed. Typically in an organization it is a self-organizing team. An autonomous team facilitates organizational knowledge creation through the requisite variety of team members who experience redundancy of information and share their views on organizational intention. The management drives creative chaos through challenging goals and by giving the team a high degree of autonomy.

The second phase corresponds to externalization in the knowledge spiral. The shared tacit mental model is verbalized and crystallized into explicit concepts through dialogue. Externalization is facilitated by the use of multiple reasoning methods. Abduction, which employs metaphors and analogies, is particularly useful. Autonomy helps individuals to think out of the box, while intention at the same time serves as a tool converging their thinking in one direction. Requisite variety enhances thinking from multiple perspectives. Redundancy helps to understand the metaphors and crystallize concepts. And finally, chaos promotes fundamental change of thinking.

The third phase is similar to a screening process. Namely, the newly-created concepts need to be tested if they are worth while or not. Individuals screen information automatically. However, in an organizational learning process there is a need to explicitly assess the concepts. It is primarily the role of top management to set the justification criteria. Justification criteria can be both quantitative – such as cost, profit, margin, and the degree to which a product can contribute to a firm's growth-, and qualitative – such as aesthetics, adventure or romanticism. Justification criteria should be consistent with the needs of society at large that ideally are in line with the organizational intention. Redundancy of information facilitates the justification process.

In the fourth phase, the justified concept is converted into something concrete. In the case of new product development, it is a prototype. If it is a service or organizational innovation, it is a model of an operating mechanism. This phase corresponds to combining explicit knowledge. Requisite variety and redundancy of information facilitate co-operation between various departments of organization that is usually needed in this phase. Organizational intention serves also as a useful tool.

The organizational knowledge creation is a never-ending process that upgrades itself continuously. In the fifth phase, a new archetype may trigger a new cycle of knowledge creation intra-organizationally.

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40 **Intention** – Commitment underlies the human knowledge-creating activity (Polanyi 1958). Therefore, an organization should foster the commitment of employees by formulating an organizational intention, usually through the strategy, and proposing it to them.

Autonomy – Individuals and teams should be allowed to act autonomously as far as the circumstances permit. This is likely to increase unexpected opportunities and motivation of individuals.

Fluctuation and creative chaos – When individuals face a breakdown, there is an opportunity for fundamental re-thinking. Instead of not only solving the problem but first to redefine the problem. Ambiguous visions of top management is an example of intentionally creating chaos. Its benefits can be reached only if individuals have the opportunity for dialogue with others. Creative chaos may help to externalize the tacit knowledge and increase the commitment of individuals.

Redundancy – Sharing of redundant information promotes sharing of tacit knowledge. Rotation of personnel and overlapping or even competing teams are examples of building redundancy in the organization. Formal and informal meetings and networks increase sharing of both explicit and tacit knowledge, thus increasing organizational knowledge creation. However, one needs to keep in mind the risk of information overload and balance between the advantages and costs of redundancy.

Requisite variety – In order to deal with the challenges posed by the environment, the internal diversity of the organization must match the variety and complexity of the environment (Ashby 1956). To maximize the requisite variety, everyone in the organization should have access to the broadest variety of information, going through the fewest steps. Flat organization structure, frequent change of organizational structure and frequent rotation of personnel are different means of increasing requisite variety.

Furthermore, through dynamic interaction, it may mobilize inter-organizational knowledge creation, for example, with customers, suppliers or competitors. For the cross-leveling of knowledge to function properly, it is essential that knowledge is freely applicable in all units regardless of who invented it. Redundancy of information, requisite variety, and fluctuation are likely to promote cross-leveling of knowledge. Organizational intention may act as a guide indicating whether knowledge should be cross-fertilized within the organization or not.

Summary of the organizational knowledge creation theory of Nonaka & Takeuchi (1995) is presented in Figure 2.5.

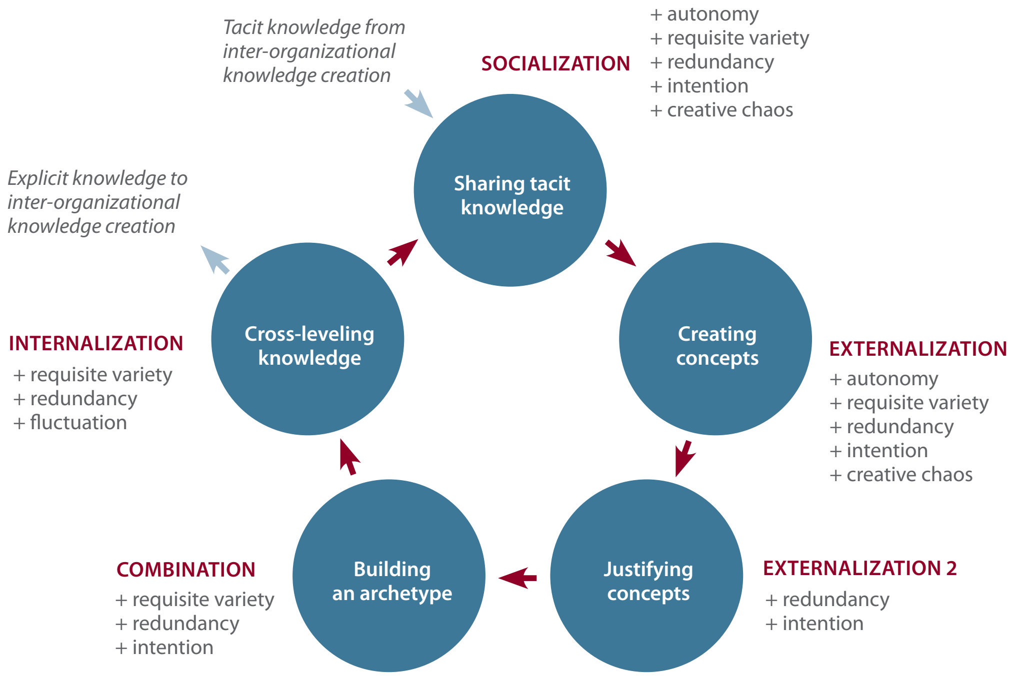

Figure 2.5 Summary of the organizational knowledge creation theory of Nonaka & Takeuchi (1995).

I-Space (Boisot 1998)

For Boisot (1998), knowledge is a capacity that is built on information extracted from data. Knowledge economizes on the use of physical resources in three ways: through modification of data structures and their information bearing capacity, by embedding information in documents and symbolic support systems, and by enhancing the understanding of intelligent agents that interact with physical resources. Those accumulations that bring a stream of useful services economizing consumption of physical resources are knowledge assets.

Boisot (1998) argues that knowledge assets can be classified along two dimensions: codification and abstraction. Codification gives form to knowledge assets, whereas abstraction gives structure.

Codification can be perceptual or conceptual. When codification is carried out by humans it is always a mixture of both since prior conceptual knowledge impacts how we perceive a situation. Abstraction is a form of reductionism. It consists of two phases. For the first, there is a need to capture correlations between different attributes. Thereafter, one must discard the attributes that seem irrelevant for grading. Effective complexity describes the level of abstraction. Effective complexity is measured by the number of bits of information required to specify whatever regularities characterize the task.

Codification and abstraction together lower the cost of potentially usable knowledge into knowledge assets: “If codification allows us to save on data-processing resources by allowing us to group the data of experience into categories, abstraction allows us to realize further savings in data processing by minimizing the number of categories that we need to draw on a given task.” (Ibidem, 48 – 49). However, the knowledge paradox is that the more useful knowledge assets become through codification and abstraction, the more difficult they are to hold on to. Well codified and abstract knowledge is fluid and can easily be shared, whereas viscous knowledge is qualitative and data rich and flows slowly if at all. The extent to which knowledge is structured and shared defines a culture.

Diffusion describes the availability of data and information for those who want to use it. However, this does not directly imply adoption since technical, semantic and pragmatic challenges impede adoption. Technical challenges constitute, for example, channel capacity and noise levels and are primarily of interest to communication engineers. Semantic challenges are related to meaning and arise, for example, if the sender and receiver do not share the same codes or if they use them for different contexts or purposes. Even if the message was meaningful for the receiver, there may still be a pragmatic challenge: does the message motivate the receiver for action. In order for the message to be effective in triggering action, the sender and receiver must share compatible orientations - values, attitudes and motivations.

Boisot (1998) suggests that structuring data for the purpose of sharing it creates a fundamental asymmetry between senders and receivers, because senders always know more than they are able to transmit with the codified and abstracted message. Whether this matters or not is dependent on how effectively the sender succeeds in choosing data-structuring strategies that capture the relevant dimensions of the knowledge to be transmitted.

Boisot (1998) describes a four-stage knowledge evolution process in I-space that he calls the social learning cycle. In the first stage, relatively uncodified, unconcrete and undiffused personal knowledge turns into codified, abstract and undiffused proprietary knowledge through codification and abstraction. In the second, proprietary knowledge converts into codified, abstract and diffused textbook knowledge through diffusion. In the third, the textbook knowledge turns into relatively uncodified, concrete and diffused common sense through absorption – learning-by-doing or learning-by-using – and impacting, in other words, embedding of abstract knowledge into concrete practices. And in the fourth, common sense converts into personal knowledge through scanning. The social learning cycle as described by Boisot (1998) is illustrated in Figure 2.6.

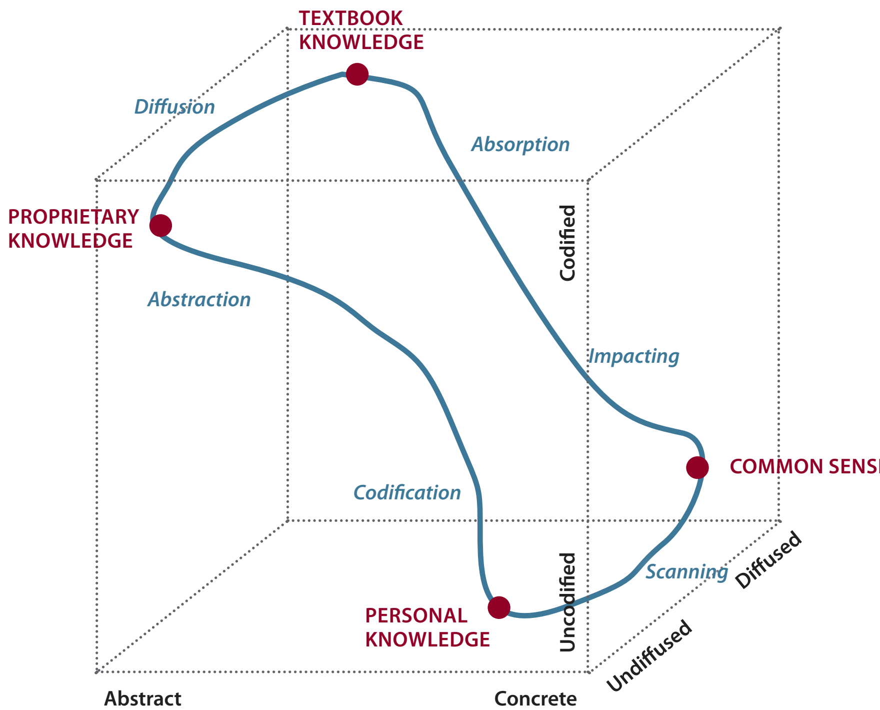

Figure 2.6 Summary of the social learning cycle in I-space as described by Boisot (1998).

Creation of Intellectual Capital (Nahapiet & Ghoshal 1998)

Nahapiet & Ghoshal (1998) argue that no clear distinction can be made between explicit and tacit knowledge, because all knowledge processes have a tacit dimension and the same generic process underlies all forms of knowledge conversion.

Following Schumpeter (1934), Moran & Ghoshal (1996) argue that all new resources are created through either combination or exchange. Taking this as a standpoint, Nahapiet & Ghoshal (1998) present a theory on how social capital turns into new intellectual capital through combination and exchange processes[41]. This is accomplished by analyzing different dimensions of social capital – structural, cognitive and relational[42] - and conditions for the combination and exchange processes to occur. The theory is summarized in Figure 2.7.

Nahapiet & Ghoshal (1998) argue that social relationships are important both in the development of

41 Nahapiet & Ghoshal (1998) define human, social and intellectual capital: Human capital = The acquired knowledge, skills, and capabilities that enable persons to act in new ways; Social capital = The sum of the actual and potential resources embedded within, accessible through, and derived from the network of relationships possessed by an individual or social unit.; Intellectual capital = Knowledge and knowing capability of a social collectivity.

42 The *structural social capital* is the overall pattern of connections between actors. Its most important aspects are presence or absence of network ties between actors, configuration and morphology of the network and existence of networks created for one purpose that may be used for another (appropriable organization). *Cognitive social capital* consists of the resources providing shared representations, interpretations, and system of meaning among actors. Shared language, codes and narratives are key aspects of cognitive social capital. *Relational social capital* describes the personal relationships that people have developed with each other during course of history, thus it consists of assets created and leveraged through relationships. Key facets of relational social capital are trust, norms, obligations and identification. Nahapiet & Ghoshal (1998)

human capital and intellectual capital. Combination is defined as "making new combinations – incrementally or radically – either by combining elements previously unconnected or by developing novel ways of combining elements previously associated." By exchange of knowledge Nahapiet & Ghoshal (1998) mean exchange of explicit individual and collective knowledge as well as exchange of individual and collective tacit knowledge. If resources are possessed by different parties, exchange is a prerequisite for resource combination.

The key difference compared to Nonaka & Takeuchi (1995) theory on knowledge creation is that Nahapiet & Ghoshal (1998) do not differentiate explict and tacit knowledge. They are of the opinion that all knowledge processes have a tacit dimension, and the same generic process underlies all forms of knowledge conversion.

Nahapiet & Ghoshal (1998) argue that there are four conditions that affect the deployment of intellectual capital:

- *Access* - Opportunity exists to make the combination or exchange of knowledge
- *Anticipation of value* - Parties must expect interaction to create value even if they are uncertain of what will be produced and how.
- *Motivation* - Parties involved in combination or exchange must expect that they are able to realize some of the new value created in the engagement.
- *Combination capability* – An individual's combination capability depends upon the existence of related prior knowledge, while organization's combination depends on the links across a mosaic of individual capabilities.

Nahapiet & Ghoshal (1998) suggest that the structural dimension of social capital – network ties, configuration and appropriable organization - influences primarily the deployment of intellectual capital by affecting the access to knowledge: who you know has an impact on what you know. However, network ties are also likely to increase the anticipation of the value of interaction since knowledge may become available sooner through personal contacts.

Meaningful communication requires at least some sharing of the context between interactors. Therefore, the cognitive dimension of social capital influences the access and anticipation value of intellectual capital. Both shared language and narratives contribute to combination capability.

Trust as part of the relational dimension of the social capital is likely to increase the opportunities for, and thereby access, to the exchange of knowledge. And what is more, when the relationship is high in trust, people are more willing to participate in social exchange in general and especially in co-operative interaction. This means that trust increases anticipation of value and motivation to participate.

Norms are part of the relational social capital and represent a degree of consensus in the system. Norms related to co-operation may create a strong foundation for creating intellectual capital by increasing opportunities and motivation for knowledge exchange. And consequently, obligations and expectations that are kind of norms created in personal relationships, are also likely to increase access and motivation to create intellectual capital.

And finally, as part of relational social capital, identification within a group enhances concern for collective processes and outcomes. Shared identity increases motivation for co-operation and is likely to increase anticipation of the value of knowledge.

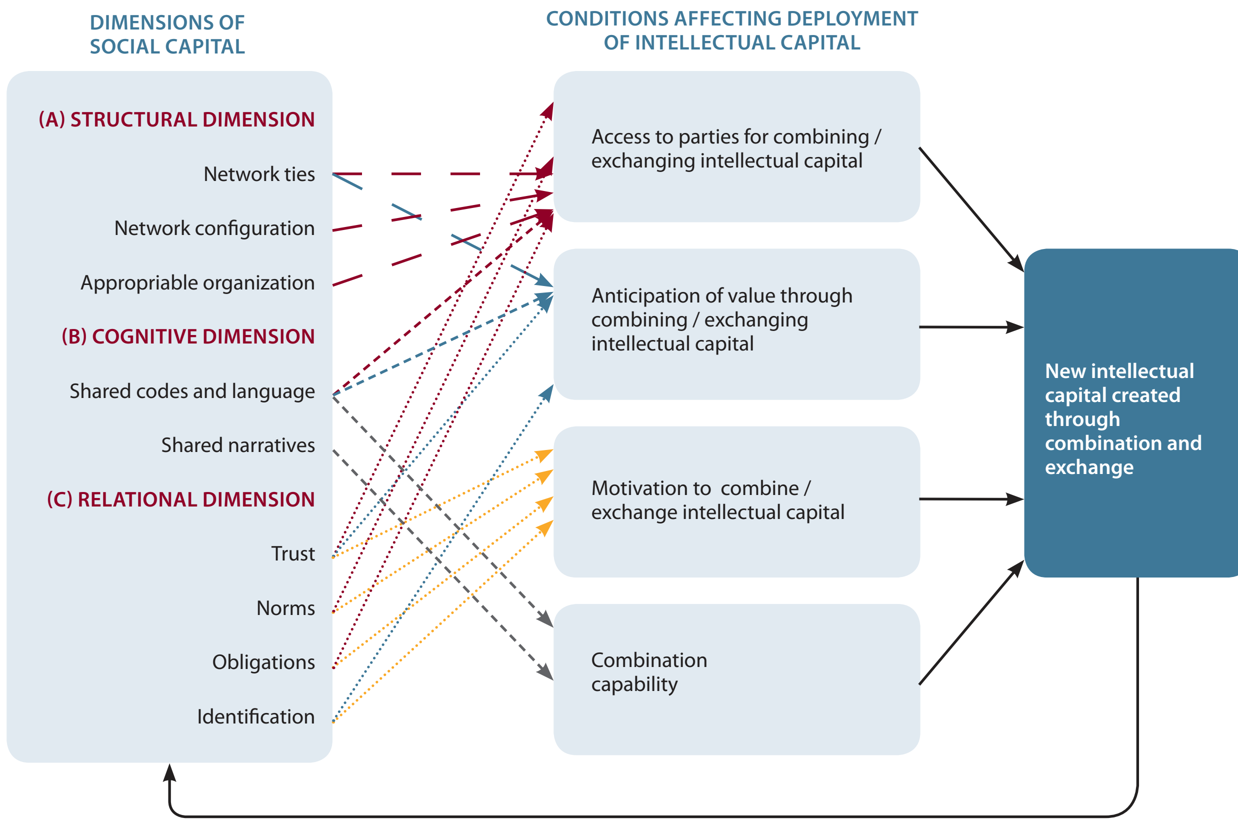

Figure 2.7 Social capital in the creation of intellectual capital (Nahapiet & Ghoshal 1998, 251)

Nahapiet & Ghoshal (1998) describe the specific features of social capital that, unlike other forms of capital, are owned jointly by the parties and cannot easily be traded. Social capital can make possible something that is possible to reach only collectively or that can be achieved only with an extra cost. Social capital allows to enhance allocative efficiency - efficiency of action and diminish opportunism - and adaptive efficiency, in other words, it increases creativity and learning.

Nahapiet & Ghoshal (1998) argue that the co-evolution of social and intellectual capital underpins organizational advantage and this may also occur in some forms of inter-organizational networks. Social capital is typically a by-product of other activities. Its development requires a focus – an entity around which joint activities are organized and that forms a basis for the network closure. Therefore, they maintain that those organizations that develop particular configurations of social capital are likely to be more successful.

Forms of social capital are also dependent on the stability and continuity of social structure. It takes time to build trust. Commitment to continuity facilitates also other processes that are influential in the development of social capital, namely interdependence, interaction and closure. Interaction is a precondition for the development and maintenance of social capital. High levels of social capital are usually developed in contexts characterized with a high level of mutual interdependence. Network closure facilitates the development of norms, identity and trust. In a nutshell, the cognitive and relational dimensions of social capital accumulate in network structures where linkages are strong, multidimensional and reciprocal. (Ibidem)

The creation and maintenance of social capital, particularly its relational and cognitive dimensions, is costly. Costs are likely to be influenced by the size and complexity of the social structure in which social capital is embedded. Technology may offer possibilities to extend the network, but the significance of interdependence, interaction, and closure suggest that there still remain important upper limits. Adding people may even reduce certain forms of social capital, such as personal obligations or high status. (Ibidem)

Theory U (Scharmer 2009)

Scharmer (2009) argues that the three different types of intelligence – mind, heart and will – and the inflection points associated with them constitute a social grammar. And furthermore, the inflection points when moving from one field structure of attention to another are identical on all ontological levels. Opening and suspension through open mind facilitate change of field structure from I-in-me to I-in-it. Thereafter, deep dive and redirection forms through open heart forms a path way from I-in-it to I-in-you. And finally, letting go and letting come through open will paves the way for I-in-now. The different field structures of attention and their manifestations in different ontological levels are summarized in Figure 2.8.

FIELD STRUCTURE OF ATTENTION	MICRO: INDIVIDUAL ATTENTION	MESO: CONVERSATION & LANGUAGING	MACRO: INSTITUTIONAL STRUCTURE	MUNDO: GOVERNANCE MECHANISM
1. I-IN-ME	Downloading	Downloading	Centralized	Hierarchy
2. IN-IN-IT	*OPEN MIND: OPENING AND SUSPENSION, COPING WITH DYNAMIC COMPLEXITY*			
	Seeing	Debate	Decentralized	Market
3. I-IN-YOU	*OPEN HEART: DEEP DIVE AND REDIRECTION, COPING WITH BEHAVIORAL COMPLEXITY*			
	Sensing	Dialogue	Networked	Dialogue
4. I-IN-NOW	*OPEN WILL: LETTING GO AND LETTING COME, COPING WITH EMERGING COMPLEXITY*			
	Presencing	Presencing	Innovation ecosystem	Collective presence

Figure 2.8 Field structures of attention, their manifestations in different ontological levels and inflection points connected with different types of complexity. Summarized from Scharmer (2009, 241-242).

By combining the three different types of knowledge – explict, tacit and emerging knowledge - with different types of systems with their relation to emergence, Scharmer (2009) presents a framework for epistemological and ontological grounding for the 21[st] systems theory (presented in Figure 2.9). He argues that while the old main stream dealt with explicit knowledge and linear systems, the new mainstream is focused on tacit embodied knowledge in non-linear systems (emergence and being situated in a context). Furthermore, one of the greatest challenges of the 21[st] century science is to extend scientific investigation to self-transcending primary knowing and systems, where we approach edges of human consciousness.

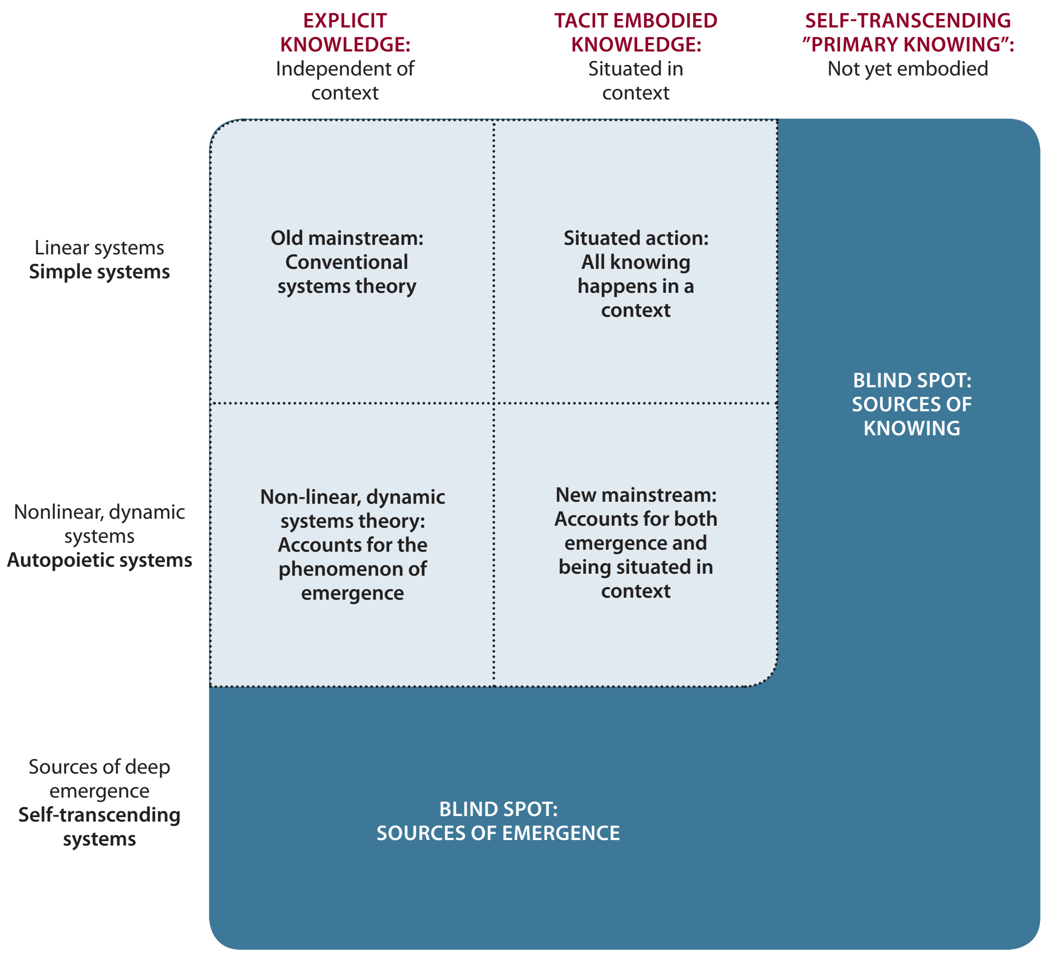

Figure 2.9 A framework for epistemological and ontological grounding for the 21st systems theory (Scharmer 2009, 107).

Scharmer (2009) presents Theory U as a social technology for collaborative knowledge creation. Theory U can be applied to practical situations as a process, as a set of field principles, or by operating from the source[43]. The connection to the source is articulated in three root principles: intentional grounding, relational grounding and authentic grounding. The intentional grounding suggests that the way we attend the situation determines how the situation unfolds. Relational grounding sets forth that the social field not only connects us to one another but also to ourselves. It is a tacit medium of connection. Authentic grounding suggests that the U process is a social breathing process inhaling total immersion in the current field, exhaling through bringing the field of the future into reality as it desires, and in-between exists a small crack of nothingness, the authentic Self.

The foundation of the theory U lies in the assumption that every human being is not one but two. "One is the person we have become through our journey of the past. The other is the dormant being of the future we could become through our forward journey. Who we become will depend on the choices we make and actions we take now. That being of the future is our highest or best future possibility… The essence of presencing is to get these two selves, these two beings, to talk and listen to each other, both individually and collectively."(Ibidem, 401).

Therefore, Scharmer (2009) suggests that learning is not limited to learning from the history, but that it is possible to learn from the future as it emerges. This requires shifting the inner place from which a system operates. Theory U describes the social technology for performing that shift consciously as an individual, group, organization, or a system.

Scharmer (2009) suggests that the evolution of conversational field structures related to knowledge creation may be classified in four stages as illustrated in Figure 2.10. They differ in terms of type of listening and how quickly the conversational impulse manifests into speech. Listening 1 is characterized by downloading habitual patterns from the past. In listening 2 people form factual connection and state differences in debate. Dialogue is typical of listening 3. Connection is personal, characterized by sharing and listening to each other and thinking together through dialogue. Conversational field of listening 4 evolves from source connection through authentic sharing and listening to each other to dialogue attending to the deeper space, and finally collective presence and flow.

43 By operating from the source Scharmer (2009) means operating from the most desirable future. By applying Nonaka & et al. (2000) it could be expressed a operating from the shared context "Ba".

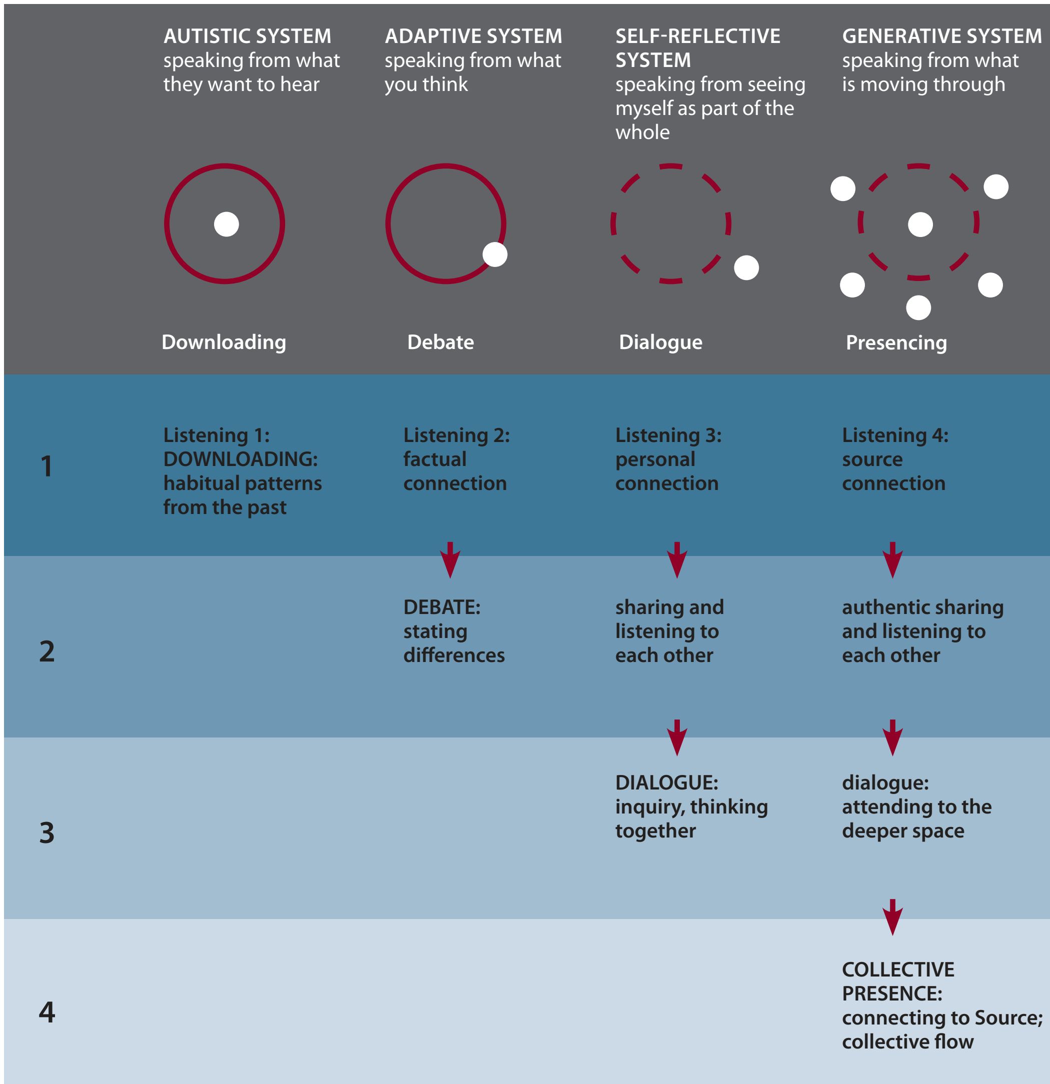

Figure 2.10 Fields of conversation, their corresponding system and evolution of conversational field structures. Summarized from Scharmer (2009).

Theory U as a social technology[44] consists of five phases: co-initiating common intent, co-sensing field of change, co-presencing inspiration and common will, co-creating strategic microcosms and co-evolving through innovation ecosystems. The phases are illustrated in Figure 2.11 and described in more detail in Appendix 14.

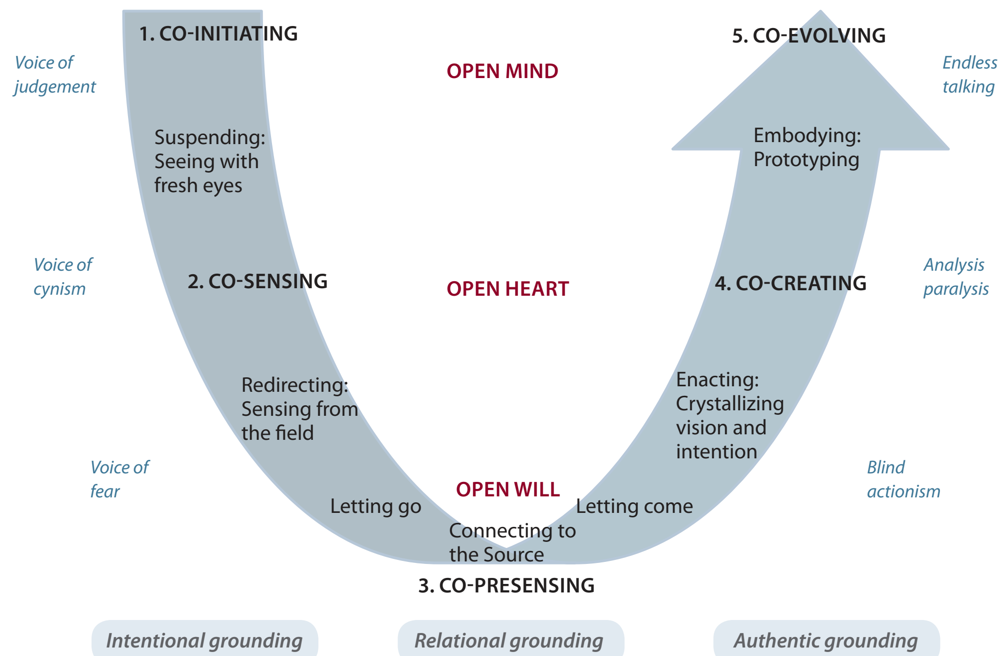

Figure 2.11 Theory U as a social technology process for change. Summarized from Scharmer (2009).

2.2.2 Summary and Discussion

Despite the attempts for synthesis of the Western dualism of epistemology, Nonaka & Takeuchi (1995) argue that the main stream characterizing the Western science, for example organization theory and business strategy, neglects the importance of bodily experience, the tacit knowledge as defined by Polanyi (1966). The Western approach to knowledge is in stark contrast with the Japanese intellectual tradition that emphasizes oneness of humanity and nature, body and mind, as well as self and other. The researcher points out that an example of knowledge creation theories neglecting tacit knowledge is that by Nahapiet & Ghoshal (1998).

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44 U-process may be applied as a set of field principles – U-theory – or as a practical social technology for collaborative knowledge creation, for example planning the future of a system (Scharmer 2009). It seems that the U-methodology is still more of a theory on collaborative knowledge creation than a practical methodology, because the actual work process is not described in detail (see Scharmer 2009). An example on this is a cursory statement "larger groups may need to set up subgroups in order to work efficiently." (Scharmer 2009, 419). Several questions emerge: How in practice? Are the groups self-selected? Is the work organized as World Café (Brown & Isaacs 2005) or Open Space (Owen 2008)? What is a small group and a large group? However, U-theory and the developing U-methodology is in the epistemological sense unique compared to other group communication methodologies: the aim is not only to involve explicit and tacit knowledge but also self-transcending emerging knowledge. Thus, the researcher finds the methodology a very interesting and promising attempt for developing next-generation collaborative knowledge creation methodologies.

Boisot (1998) agrees with Nonaka & Takeuchi (1995) and Scharmer (2009) that a distinction between tacit and explicit knowledge can be made, but for him distinction is not categorical like for Nonaka & Takeuchi (1995). It seems that for Boisot (1998) tacit knowledge is a function of codification and abstraction that incurs a cost.

Boisot (1998) divides tacit knowledge into three categories: knowledge that everybody understands and therefore does not articulate it, personal knowledge that nobody fully understands and therefore does not articulate it, and things that are not said because while some people can understand them, they cannot costlessly articulate it. He argues that Nonaka & Takeuchi (1995), in their definition of tacit knowledge, are primarily concerned with the knowledge that cannot be costlessly articulated.

Scharmer (2009) agrees with Nonaka & Takeuchi (1995) that explicit and tacit knowledge are different types of knowledge, and conversion between them is important in knowledge creation. However, Scharmer (2009) suggests that, in fact, the shared context for knowledge creation "Ba" as presented by Nonaka et al. (2000) is a third type of knowledge: self-transcending primary knowing that is emerging knowledge not yet embodied. Nonaka et al. (2000) suggest that all knowledge is context-sensitive. Scharmer (2009) argues that tacit knowledge is dependent on the context, but explicit is non-reflective and independent of the context.

How to face the increasing complexity of the knowledge society through developing knowledge creation lies at the core of the knowledge creation theories of Boisot (1998) and Scharmer (2009), while Nonaka et al. (2000) do not emphasize the increasing complexity as the key driver. The knowledge creation theories of Nonaka et al. (2000) and Scharmer (2009) are similar in that sense that they are primarily concerned with collective knowledge creation, while I-space of Boisot (1998) approaches knowledge creation from the individual's point of view.

The researcher suggests that, in fact, there are two social learning cycles that operate on different ontological levels. It seems that the knowledge spiral of Nonaka & Takeuchi (1995) represents the collective-driven social learning cycle, while the learning cycle of Boisot (1998) is the individual-driven learning cycle. The researcher argues that these are the two sides of the coin, and the social learning cycle consists of both individual-driven and collective-driven learning cycles. In Figure 2.12 this is illustrated by applying Boisot's (1998) I-space with the dimensions of abstraction, codification and diffusion. Figure 2.13 illustrates individual- and collective-driven learning cycles by applying the knowledge spiral of Nonaka & Takeuchi (1995).

The individual-driven social learning cycle starts, when diffused, uncodified, and concrete common sense turns through scanning[45] - identifying opportunities and threats in the environment - into concrete, uncodified and undiffused personal knowledge (transition 1' in Figure 2.12). Personal knowledge as defined by Boisot (1998) corresponds to the concept of operational knowledge as defined by Nonaka & Takeuchi (1995) that is tacit individual knowledge. Personal knowledge (operational knowledge) turns through codification and abstraction into proprietary knowledge as described by Boisot (1998) (transition 2' in Figure 2.12). An example of proprietary knowledge is a patent.

Because the learning cycle of Nonaka & Takeuchi (1995) describes a collective-driven social learning cycle, there is no concept for proprietary knowledge in this theory of knowledge creation. Proprietary knowledge turns through diffusion into abstract, codified and diffused textbook knowledge (transition 3' in Figure 2.12). The textbook knowledge corresponds to systemic knowledge as defined by Nonaka

45 If data is well codified and abstract, scanning may be rapid. However, if data is uncodified and context-specific, scanning may be slow and random. An example made by Boisot (1998) is how long it took for the scientists to accept as a plausible hypothesis that industrial emissions may be raising the mean temperatures of the biosphere.

& Takeuchi (1995) that is explicit collective knowledge. Through absorption (learning by doing) and impacting (embedding abstract knowledge into concrete practices), textbook knowledge turns into concrete, uncodified and diffused common sense (transition 4' in Figure 2.12). Referring to Nonaka & Takeuch (1995), this is the tacit and collective symphatized knowledge.

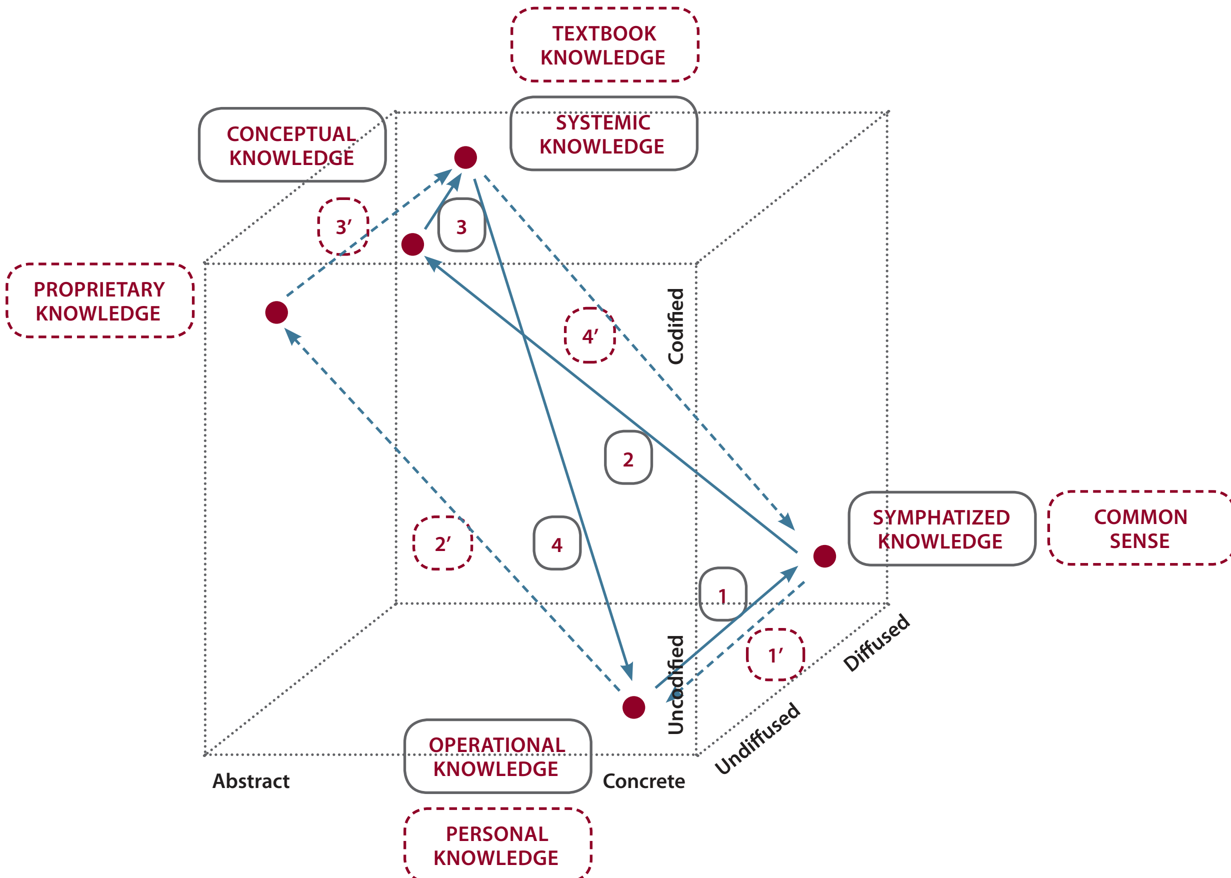

Figure 2.12 Individual- and collective-driven social learning cycle in I-space. Nonaka & Takeuchi (1995) knowledge spiral in I-space by Boisot (1998).

The collective-driven social learning cycle (Nonaka & Takeuchi 1995) starts through the process of socialization (field building), when individual tacit operational knowledge turns into tacit collective sympathized knowledge (transition 1 in Figure 2.13). This is the common sense as described by Boisot (1998). Through the process of externalization (dialogue), the tacit collective sympathized knowledge turns into explicit knowledge called conceptual knowledge (transition 2 in Figure 2.13). Through the process of combination (linking explicit knowledge), the conceptual knowledge turns into systemic knowledge (transition 3 in Figure 2.13).

The knowledge creation theory of Boisot (1998) does not make a distinction between conceptual and systemic knowledge but these seem to correspond to text book knowledge (codified, abstract, diffused). Moreover, through internalization (learning-by-doing), the collective and explicit systemic knowledge turns into individual and tacit operational knowledge (transition 4 in Figure 2.13). Boisot (1998) calls it personal knowledge.

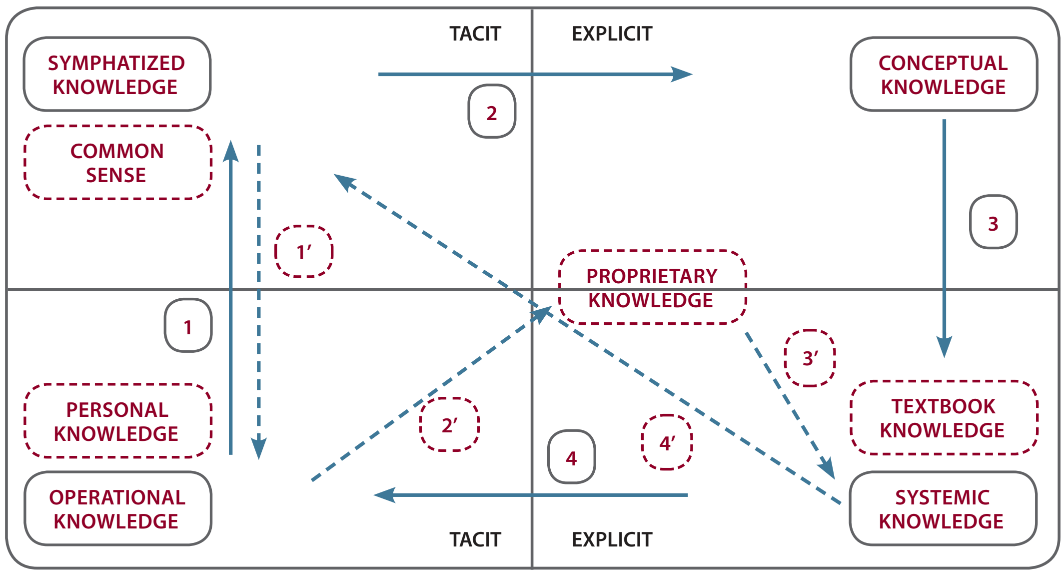

Figure 2.13 Individual and collective-driven social learning cycle as knowledge spirals. Boisot (1998) I-space in the knowledge spiral framework of Nonaka & Takeuchi (1995).

Boisot (1998) claims that no clear distinction can be made between explicit and tacit knowledge, while Nonaka & Takeuchi (1995) argue quite the contrary. By examining Figures 2.12 and 2.13 it seems that, in fact, both of them are partly right. In collective-driven social learning cycle knowledge conversion is clearly between tacit and explicit. In the individual-driven social learning cycle knowledge conversion from personal to proprietary knowledge and proprietary to textbook knowledge cannot be properly described with the tacit – explicit dimension. This is because proprietary knowledge lies in-between tacit and explicit knowledge. It is highly codified and abstract like explicit knowledge, but at the same time there always remains a tacit dimension since it is possessed by an individual.

When examining the U-theory of Scharmer (2009) on knowledge creation, the researcher suggests that through the process of seeing (I-in-it), sensing (I-in-you) and presencing (I-in-now) it is possible to combine individual and collective-driven social learning cycles. And moreover, it is possible through presencing to enable the third type of knowledge: not yet embodied self-transcending knowing. There is a risk that the field of attention shifts to I-in-me leading to conversational mode of downloading resulting in apparent knowledge. Based on the observations of Nahapiet & Ghoshal (1998), it seems that the lower the trust among the group, the higher the risk to shift to the conversational mode of downloading, which results in apparent knowledge ignoring, for example, weak signals.

Nahapiet & Ghoshal (1998) remind us of the risks of collective blindness. Nonaka et al. (2000) phrase the risks by stating that knowledge assets not only foster but may hinder knowledge creation. These knowledge assets hindering knowledge creation may comprise inadequate requisite variety (Nonaka et al. 2000) and a lack of weak ties in the network (Granovetter 1973), which slow down the creation of new knowledge. On the other hand, too much requisite variety, not enough redundancy of information

(Nonaka et al. 2000) and philos relationships[46] in the network (Krackhardt 1992) may lead to a lack of the shared context hindering knowledge creation (Nonaka et al. 2000) and creating change (Krackhardt 1992).

Figure 2.14 summarizes different field structures of attention with the corresponding mode of conversation and nature of knowledge.

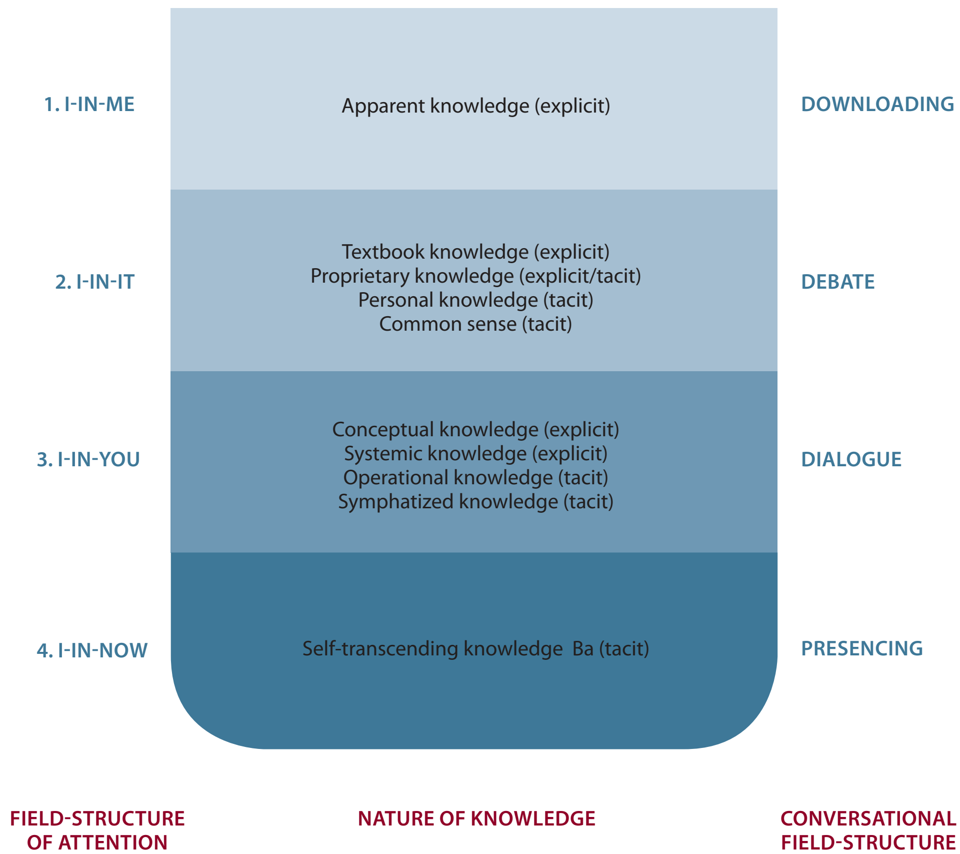

Figure 2.14 Summary of different field structures of attention with the corresponding mode of conversation and nature of knowledge (Scharmer 2009, Nonaka & Takeuchi 1995 and Boisot 1998).

2.3 MEMBER AND GROUP CHARACTERISTICS

Stangor (2004) argues, as presented in Figure 2.15, that member and group characteristics and group process have a reciprocal relationship between satisfaction and group outcomes. The previous chapter discussed group characteristics and processes from the viewpoint of knowledge creation. This chapter focuses on member and group characteristics.

46 Krackhardt (1992) defines philos relationships as strong, affective and time-honored relationships.

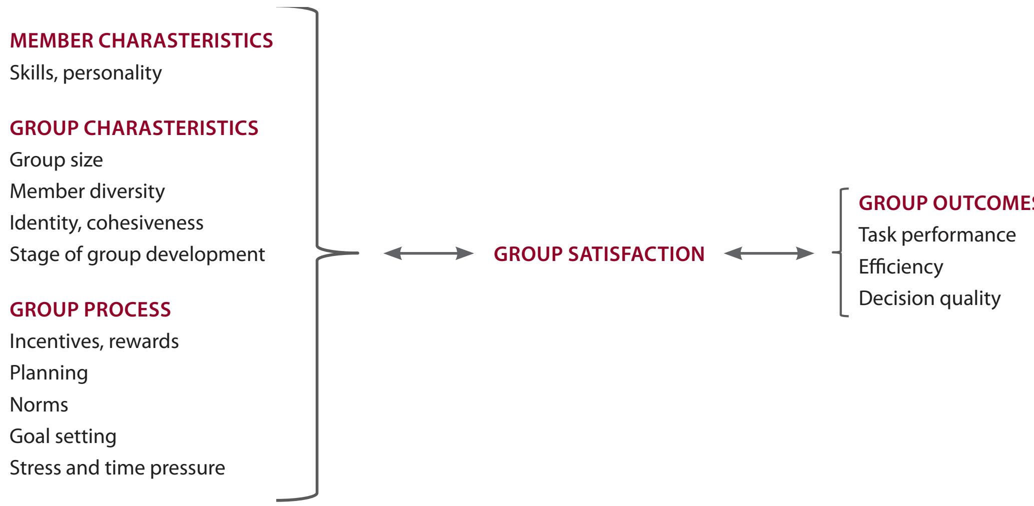

Figure 2.15 A model of group productivity (Stangor 2004, 240).

Chapter 2.3.1 discusses group size. Member skills and personality are examined in Chapter 2.3.2. The focus of Chapter 2.3.3 is on diversity of group members. Chapter 2.3.4 deals with group cohesion and social identity. Anonymity is discussed in Chapter 2.3.5. Summary and discussion are presented in Chapter 2.3.6.

Appendix 15 contains a definition of social group, discussion on features of group process in general, as well as potential problems in group communication. These are also relevant aspects that the researcher considered when developing the framework for participant selection (see Chapter 7.2) and addressing the methodological development of future studies (see Chapter 7.3). However, in order to keep the actual publication as compact as possible, it was decided to move this discussion to the Appendix.

2.3.1 Group Size

The suggested number of invited participants varies considerably between different group working methodologies. Owen (2008) argues that there is no need to worry about too large a number of people, when applying Open Space; it can be applied to a group of 5 people as well as to 1 000 people. Weisbord & Janoff (2000) suggest that the ideal number of participants in a Future Search varies between 60 – 70. Brown & Isaacs (2005) suggest that preferably the group in World Café should not be smaller than 12, but there is no maximum. They have applied it also to a group of 1 200 people.

Emery & Purser (1996) suggest inviting 15 – 35 participants when applying Search Conference. Kuusi (1999) and Turoff (1975) argue that the sufficient number of participant in an anonymous Delphi process is 15 – 50, because it is the quality of participants that counts, not the number. However, as Bunker & Alban (1997) point out, also in most of the methodologies intended for large groups, such as Open Space or World Café, the actual work takes place in small group conversations. Another way to motivate large groups of people to commit to the process individually is dot voting (Bunker & Alban 1997, 203): each participant has stickers to place on the flip-charts for prioritizing or otherwise classifying items.

The benefits of a large group are the increased amount of energy (Stangor 2004) and the wide range of skills that the larger amount of people bring to the process (Baron & Kerr 2003, Stangor 2004). However, large groups are more likely to suffer from communication, co-ordination and motivation problems than small groups.

As the group size increases, people feel more anonymous. This may lead to less social responsibility resulting in less task involvement and lower motivation including social loafing and free riding. (Baron & Kerr 2003, Stangor 2004). "The idea is that as numbers increase, the personal sense of responsibility for the outcomes of the group decreases and this affects behavior. People in large groups are less likely to act when they see an occasion that calls for action." Bunker & Alban (1997, 203 – 204)

Diffusion of responsibility can also be seen as part of the problem of group polarization as found by Kogan & Wallach (1967: In: Stangor 2004, 204 – 205). According to the explanation, individuals in a group may be willing to take a more extreme stand than when alone, because if the risky decision does not work out, he or she may always blame the group. Additionally, diffusion of responsibility can also be interpreted as part of the problem of free riding (Baron & Kerr 2003): if responsibility is shared, there is a risk that someone hides in the crowd and others need to take care of the actual work.

When the group size is increased, some people experience heightened fear for participation and also, there is less air time available. As a result, smaller share of individuals contribute to the discussion (Baron & Kerr 2003). Conflicts are more frequent in large groups and participants often find co-operation more difficult (Stangor 2004).

Bunker & Alban (1997) define large groups as groups that are larger than dozen people. This is because in groups up to dozen people everybody has a reasonable chance to speak, be listened and responded to. Because of the challenges in large groups, the most effective working groups are mostly groups of 4 – 5 people (Stangor 2004). However, the optimal group size is also dependent on the group and the task. Groups characterized by high ability, commitment or social identity may suffer less from loss of motivation and benefit from a larger group size. (Stangor 2004)

2.3.2 Member Skills and Personality

The selection of participants with effective personalities and appropriate skills is a key factor to consider when planning a working group (Stangor 2004) or any group communication process (Linstone & Turoff 1975, Bunker & Alban 1997).

Concerning face-to-face group communication methodologies, for example Weisbord & Janoff (2000) in the case of Future Search, Owen (2008) concerning Open Space, Emery & Purser (1996) in the case of Search Conference and Brown & Isaacs (2005) concerning World Café, judge selection of participants as one of the key success factors. And similarly, when carrying out an anonymous Delphi communication process, selection of the right participants is included among critical success factors (Linstone & Turoff 1975; Kuusi 1999, 2003; Gordon 2009a).

Stangor (2004, 241) argues based on Bowers et al. (1997), Cannon-Bowers et al. (1995) and Widmeyer (1990) that "The relationship between member characteristics and group performance is interactionist, in the sense that the skills and personalities must be appropriate for the particular group under consideration and for the particular task it is performing".

The extent to which member skills influence group performance depends on the complexity of the group task and the amount of co-ordination required (Stangor 2004). In relatively simple tasks, such as in automobile assembly line, the number of individuals working on the task influences primarily the group outcome. Whereas in more complicated tasks, like in a surgical team or large corporation, there is a need to include individuals with a wide variety of skills. Because communication and co-ordination among group members is essential in complicated tasks, the nature of group communication process is also important.

People differ in their ability and willingness to work in groups. People with high need for affiliation are more willing to work in groups. In contrast, people that suffer from social anxiety feel tense in social settings, have difficulties to blend in with the group and remain in the background. Moreover, interaction of people differs in groups, because everybody has their own personal and social goals that they want to meet through participation in the group (Stangor 2004).

2.3.3 Diversity of Group Members

Homogeneity of group members increases cohesiveness. Therefore, groups reach faster consensus on the best way to perform the task and make decisions more quickly and effectively. There is also less conflict. Based on Bond & Shiu (1997), Stangor (2004) argues that similar groups may also show better task performance.

However, diversity of members in personalities, experiences and abilities also entails several potential advantages. Men and women, as well as different ethnic groups, bring different orientations that may improve group performance (Stangor 2004). A wider range of resources may improve creative thinking (Janis 1972, Moreland 1996; In: Stangor 2004). Vegt & Janssen (2003) argue that diversity of group members increases innovativeness if the members of the team perceive a high level of goal interdependence.

Appreciating diversity and criticism may also reduce tendencies towards conformity, thus reducing the risk of groupthink[47] (Nahapiet & Ghoshal 1998, Baron & Kerr 2003, Stangor 2004, Forsyth 2010). However, extreme levels of diversity may be problematic for the group process. Diversity increases the risk of conflict. In diverse groups it is also more difficult to get past the formation stage (Stangor 2004).

Developers of several participative group working methods emphasize the importance of participant diversity as one of the key preconditions for the successful application of the methodology: Weisbord & Janoff (2000) in the case of Future Search, Owen (2008), when applying Open Space, Brown & Isaacs (2005) in the application of World Café, and Scharmer (2009) in the case of U-methodology. Table 2.1 summarizes selection criteria for participants, when applying the Delphi method, Future Search, Search Conference, World Café, Open Space or U-process.

Owen (2008, 132) uses the same phrasing in selecting the participants for an Open Space than Weisbord & Janoff (2000) in participant selection for a Future Search: the whole system needs to be presented at the event. This is because with diverse perspectives everyone can get more understanding of the whole, and furthermore, this enhances forming of new relationships (Weisbord & Janoff 2000).

Owen (2008) stretches the concept of relevant stakeholders even wider than Brown & Isaacs (2005) by suggesting voluntary self-selection and stating that ”who ever cares should come” (Owen 2008, 25) and “the richer the stew, the better the results” (Owen 2008, 132). Thus, Owen (2008) seems to suggest the commitment of participants is the single most important criterion.

Also Kuusi (1999) suggests that diversity of participants is important when selecting participants for an anonymous group communication method, Argument Delphi. Kuusi (1999) specifies diversity to mean participants with diverse types of knowledge that he classifies as scientists, decision makers and

47 For the discussion on problems of group communication processes, including groupthink, see Appendix 15.

synthesizers. What is more, he finds it important to involve customers as well as known critics, in order to cover all relevant aspects of the topic (Kuusi 1999). Also Turoff (1975) reminds us of the importance to include critics when applying the Delphi method, and Brown &Isaacs (2005) make the same claim with regard to World Café.

Brown & Isaacs (2005) and Scharmer (2009) argue that often people at the bottom of the current system with little or no voice are neglected although it would be important to include them since they can potentially bring different views and help to reframe the issue.

Scharmer (2009, 387; 419) presents two lists of actors who to invite to a group communication process with U-methodology that the researcher combined:

- Key decision makers: Practioners that are problem-owners accountable for results and executive sponsors
- Key knowledge suppliers: Practioners on the front-line who know the real problem first hand
- Activist(s): One or few activists with strong personal passion, thus wholly committed to make the project work
- People at the bottom of the current system: People with little or no voice in the current system[48].
- Creative outsiders: People outside the system who can offer a view or competence critical to the success of the project

Also, the approach of network analysis suggests that both similarity and diversity of group members have their advantages. Granovetter (1973) argues that weak ties are important for diffusion of information and more likely to generate innovation than strong[49] ties. This is because strong ties tend to bond similar people and information obtained through such a network is more likely to be redundant. Krackhardt (1992) suggests that although weak ties might be more useful in generating new information, this does not equal to generating change. Trust among participants is required to bring about change. "Change is the product of strong, affective, and time-honored relationships." (Krackhardt 1992, 238). These strong ties Krackhardt (1992) calls philos relationships. He claims that not all strong ties are philos relationships. A network of advice interactions stemming from routine work problems may be characterized by frequent interaction and shared history, but if affection is missing, it is not a philos relationship.

Bowers et al. (2000) researched 567 teams with 2 256 participants to find out if the groups that are homogenous with respect to ability, gender and personality perform better than heterogenous teams. The results indicated only small and not significant favor of heterogenous groups. They concluded that the strength of heterogenous groups is related to the type and difficulty of the task. Stangor (2004, 245) suggests that "the congruency of members and tasks seems more important than the characteristics of the members of the group process alone." Also Bunker & Alban (1997, 220 - 221) argue that, in general, participants to a group communication process need to be selected based on the purpose statement of the event, in other words, who do we need to achieve the goals.

A summary of the suggested criteria for participant selection, when applying the Delphi method, Future Search, Search Conference, World Café, Open Space or U-methodology is presented in Table 2.1.

48 Brown & Isaacs (2005) and Scharmer (2009) suggest that in the case of education, this is students. However, the researcher argues that in the Finnish higher education the students rather may be seen to belong to the group of key knowledge suppliers. As an example, Act on Polytechnics (351/2003) regulates that students need to be represented in the Board. This is the case also in publicly owned universities (Universities Act 558/2009). Based on her empirical experiences the researcher argues that Student Unions and the National Union of Finnish Students SYL are remarkable actors in developing education at Finnish universities.

49 Granovetter (1973) describes a tie as strong if persons are in contact often (at least twice a week) and weak if they interact occasionally (less than twice a week but more than once a year) or rarely (less than once a year).

Table 2.1 Suggested criteria for participant selection when applying the Delphi Method, Future Search, Search Conference, World Café, Open Space or U-methodology.

Method	Purpose & special characteristics	Number of participants	Used term of participants	Key selection criteria
Delphi Method	tool in complex situations for mapping different aspects and options and to convert expert opinion where not only one right answer exists; anonymous or using pen-names in computarized Delphi (panelists may be aware of the make-up)	mostly 15 - 50, in traditional versions up to 1000	experts (except policy Delphi: informed advocates and referees)	selected with interest and willingness to co-operate combined with relevant knowledge / expertise and enough diversity bearing in mind the purpose; involvement of customers and critics beneficial
Future Search	tool for collaborative future planning	60 - 70; actual work in groups of 5 - 8 people	stakeholders	all with a stake (interdependency) and desire; information, authority, resources, affected; maximum diversity; judgement of stakeholders as essential, desirable or optional
Search Conference	tool for collaborative future planning	15 - 35	interest groups / reference groups	people known as concerned with the purpose; diverse enough; participation of decision makers important; Do NOT use traditional tokens of expertise as selection criteria
World Cafe	tool to foster constructive dialogue to explore key challenges and opportunities around real-life issues and for building community and commitment	widely applicable: 12 - 1200; actual work in groups of 4 - 5 people	stakeholders	people that care about the questions they are working on; diversity of thought & experience most important criterion; remember to consider also people with unique and different perspectives as well as those affected
Open Space	tool to deal with complex and potentially conflicting real-life issues in innovative and productive ways; combined with another methodology applied often for action planning	widely applicable: 5 - 2000; actual work in small groups	stakeholders	all interested = voluntary self selection; maximum diversity; ideally whole system represented; topic must be of passionate concern to those involved
U-process	tool to lead from the future as it emerges through accessing collective intelligence and learning (still more a theory than methodology, methodological development uncompleted)	applicable, as small as possible bearing in mind needed diversity in knowledge and experience	stakeholders	those with intention to create change and that have knowledge and/or networks and/or power ; diverse enough; emergent stakeholders important; involve under-represented groups with less voice; NOT mostly experts

2.3.4 Group Cohesion and Social Identity

Group cohesion and social identity are variables that describe the relationship between people and the groups they belong to. Social identity describes how much an individual feels as part of the group and how important group membership is to him or her. Feeling that one is part of a group has an important influence on group behavior, and therefore it is an important variable for understanding group behavior (Stangor 2004). Social identity, self-categorization and optimal distinctiveness theories are related to social identity. (Baron & Kerr 2003, Stangor 2004)

Group cohesion refers to the extent of liking the other members of the group. It describes the positive emotional attachment, significance and importance that group members have with other members of the group. Similar beliefs and values shared by group members increase group cohesiveness. In addition, strong group interdependence in performing group tasks, strong group norms and desire to maintain these norms increase group cohesion.

Group cohesion is related to trust, group satisfaction, less anxiety and more positive group communication (Baron & Kerr 2003, Stangor 2004). If a group is cohesive, individuals are more interested in group outcomes. However, increase in group cohesiveness does not automatically increase task performance within a group. There is a risk that if a group is too cohesive, it becomes too confident about its ability to perform well. As a result, the group does not fully discuss the issues of importance or seek knowledge external to the group. Also, a group might spend too much time socializing, because members of cohesive groups tend to like each other. Stangor (2004, 26) argues that one explanation for conflicting results on consequences is that group cohesion itself does not increase or decrease group performance but cohesion increases conformity to group norms. "If the norm is to work hard and to be productive, cohesion will increase performance. However, if the norm is to goof off, that, too, will happen."

The make-up of the group is also related to the motivation of its members (Baron & Kerr 2003, 63): "How hard one is willing to push oneself in a group depends a good deal on who is in the group and what kind of relationships they have with one another."

2.3.5 Anonymity

The interactionist approach to behavior of people developed by Kurt Lewin suggests that the behavior of people, thus also openness of communication, is dependent on personal characteristics and influence of other people in the social environment[50] (Stangor 2004, 11 – 12). Therefore, comments made by a person in a group are affected not only by his or her own beliefs, but also what he or she thinks the others believe and how they will react to his or her opinions.

However, Kuusi (1999, 187 – 189) argues that the openness of communication of participants in an anonymous Argument Delphi study that needs to be taken into consideration when selecting participants for the group communication process is dependent on personal characteristics, norms of the organizations they work for, and the organizer of a foresight study. Kuusi (1999) does not specify in detail what kind of impact he means by the organizer of the foresight study. Is it for example, trust on the organizer of the foresight study, or difference in perceived norms between the organization they work for and the organizer of the foresight study?

While promoting research methods with anonymity, such as Policy Delphi, Turoff (1975, 82) summarizes the risks of face-to-face group communication:

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50 Behavior = f (Person, Environment)

- A dominant person in the group takes over the working process
- Individuals are not willing to take a position on an issue before all the facts are known or before they are aware of the opinion of the majority.
- Fear of authority: People find it difficult to contradict with individuals in higher positions.
- Once a person has taken a position publicly, they are often unwilling to change it.
- People are afraid of losing face by presenting an uncertain idea that may turn out not to be working.

Hiltz & Turoff (1993, 96) argue that situations where participants do not need to be afraid of how peers view their opinions, are likely to promote interaction, problem solving and objectivity. The presented views are evaluated based on intrinsic merits without regard to personal origin or aspects of origin. Kuusi (2003, 212) suggests that one of the benefits accompanied with anonymity is that it promotes identification of weak signals. When participants are not afraid of bringing up preliminary ideas, weak signals are more likely to be identified.

Although Jones (1995) argues based on Frank (1988) that honest trustworthy behavior even in the absence of face-to-face communication is difficult to fake, anonymity has potential drawbacks as well. One severe problem of anonymity seems to be the lack of accountability (Sackman 1975, Kuusi 1999, 2003). "Each panelist is faceless in any of the results and can always blame nameless others for any findings he dislikes." (Sackman 1975, 52). The researcher suggests that the problem of accountability is most severe in on-line Delphi, because participants are not accountable even to the Delphi manager on their opinions.

Kuusi (2003, 219 – 220) summarizes the problems of anonymity as follows:

- Participants of the group process are not aware of the real motives of others. It is possible to support opposite ideas in public discussion compared to an anonymous group process.
- It is possible to disseminate misleading and / or false information on purpose, because there is no risk of getting caught (public judgment).
- Unjustified misgivings about pretended opinions may be directed to a person, leading to unnecessary suffering.
- It is possible to disseminate confidential information without punishment because of protection provided by anonymity.

The researcher suggests that there is an additional serious drawback to anonymity: the only tacit knowledge accumulated is personal individual tacit knowledge. In anonymous group communication it is not possible to gain symphatized knowledge since it is created only through shared experiences face-to-face (Nonaka & Takeuchi 1995). And furthermore, the self-transcending knowledge as described by Scharmer (2009), is not attainable without face-to-face dialogue and shifting of the conversational field structure to presencing.

Anonymity increases the risk for free riding (Baron & Kerr 2003, 58). And furthermore, Sackman (1975) and Spears et al. (1990) argue that anonymity increases the risk of group polarization. Thus, it seems that the proposition to deal with the problem of groupthink by switching the mode of communication from face-to-face to anonymous, as suggested by Turoff (1975), Kuusi (1999, 2003) and Hiltz & Turoff (1993), is somewhat problematic.

2.3.6 Summary and Discussion

The participants involved are most often called experts, when applying an anonymous group communication process, the Delphi method (Linstone & Turoff 1975, Kuusi 1999, 2003; Gordon 2009a), except in policy Delphi, where the applied terms are advocates and referees. Kuusi (1999) uses also the concept of "developer community" when applying Argument Delphi to technology foresight. In face-to-face group communication processes the most common term of invited participants is stakeholders. The term "stakeholder" is used by Bunker & Alban (1997), Weisbord & Janoff (2000), Brown & Isaacs (2005), Scharmer (2009) and Owen (2008). An exception is Emery & Purser (1996) that favor the terms "interest group" and "reference group". **The researcher suggests using the term stakeholder** when selecting participants to an anonymous or face-to-face group communication process aiming at capturing future prospects and enhancing the development of engineering education nationally.

The statement of Nonaka et al. (2000, 24) that **commitment underlies human knowledge creating activity** is supported by Granovetter's (1973) attributes of a tie, Krackhard's (1992) definition of philos relationship, Nahapiet & Ghoshal's (1998) framework of conditions promoting creation of intellectual capital, perceived task attractiveness as a factor decreasing the risk of social loafing (Zaccaro 1984; In: Baron & Kerr 2003, Stangor 2004), findings of Scharmer (2009) in his U theory, Owen's (2008) findings regarding the application of Open Space, and Brown & Isaacs's (2005) observations during application of World Cafe. The commitment of participants affects also the optimal group size since groups characterized by high commitment and strong social identity may benefit from a larger group size (Stangor 2004). Therefore, it seems that, in general, when selecting participants for a group communication process, initial commitment would need to be considered as a key attribute.

According to chaos theory, in systems in which evolution is highly sensitive to initial conditions, microscopic causes can sometimes generate macroscopic effects (Boisot 1998). The capacity to identify weak signals, "capacity to see the crack" (Scharmer 2009), is among key capabilities in the present society (Boisot 1998, Scharmer 2009). Assuming that the present society is an edge-of-chaos economy characterized by increased complexity (Boisot 1998, Scharmer 2009), it seems relevant to analyze the **capability of a group to grasp weak signals** when selecting participants for a group communication process revolving around the future of higher education.

Kuusi (1999) suggests that the **openness of information policy** of potential contributors needs to be considered when assessing the reliability and validity of a foresight study. And therefore, it could be considered also when selecting participants for an anonymous Delphi study or in general for a working group. Kuusi (1999) argues that the information policy of participants in a Delphi study is dependent on personal characteristics, norms of the organization they work for, and organizer of the foresight study.

The Lewinian interactionist approach to behavior suggests that the behavior of people, thereby also openness of communication, is dependent on both personal charasteristics and other people in the social environment (Stangor 2004). Nahapiet & Ghoshal (1998) suggest that the variables of the relational dimension affecting motivation for knowledge creation in face-to-face contexts are trust, norms, obligations and identification. Nonaka et al. (2000, 28) emphasize the key importance of trust, commitment, love and care as factors moderating the shared context for knowledge creation in face-to-face dialogue.

Could it be that in anonymous group communication, when the shared social context among participants is missing, the norms and obligations of the social environment the participants work for is an important factor affecting openness of communication, whereas in face-to-face dialogue it is more a matter of the group process, and therefore, not so relevant to consider in participant selection?

The suggested **number of invited participants** varies considerably between different group communication methodologies. However, also in most of the methodologies intended for large groups like Open Space or World Café, the actual work takes place in small group conversations. This is because the most effective working groups are mostly groups of 4 – 5 people (Weisbord & Janoff 2000, Stangor 2004,). The optimal number of participants is intertwined with the question what is the degree of diversity in skills and experience needed to carry out the task of the group (Stangor 2004, Scharmer 2009). And, what is the optimal number and diversity of participants, bearing in mind that achievement of a shared context is necessary for purposeful knowledge creation (Nonaka & Takeuchi 1995, Boisot 1998, Nahapiet & Ghoshal 1998, Nonaka et al. 2000) and that "the probability of achieving a shared context is inversely proportional to the size of the target population" (Boisot 1998, 61). Groups characterized by high commitment and social identity may benefit from a larger group size (Stangor 2004).

Both **similarity and diversity of group members** have their advantages. Group cohesion is related to increased trust, group satisfaction, less anxiety, more positive group communication and faster decision making. Strong time-honored relationships that Krackhardt (1992) calls philos relationships are characterized by trust, which is a key ingredient for change. However, as a result of group cohesiveness, a group may also become too confident of performing well and does not fully discuss issues or seek group-external knowledge. Group cohesiveness may increase the risk of groupthink especially if there are other enhancing factors, such as insulation of the group, authoritarian leadership and high level of stress (Janis 1972); however empirical evidence is not unambiguous (Baron & Kerr 2003, Stangor 2004, Forsyth 2010).

Diversity of group members in personalities, experiences, abilities, gender and ethnical background entail several potential advantages that may help group performance (Stangor 2004). Coverage of weak ties in the network is important for the diffusion of information, and therefore important for innovation (Granovetter 1973). Wider range of resources may improve innovative thinking (Janis 1972, Moreland 1996) if members perceive a high level of goal interdependence (Vegt & Janssen 2003). Diversity of group members may also reduce the risk of groupthink (Baron & Kerr 2003, Stangor 2004, Forsyth 2010).

In order to benefit from the diverse skills and experiences in collective knowledge creation and not run into potential problems that are more common in larger groups – e.g. social loafing, free riding and group polarization - the initial commitment of participants is of special importance (Baron & Kerr 2003, Stangor 2004). If participants perceive high goal interdependence, which is the case when aiming at enhancing development of engineering education nationally, a highly committed group may benefit from diversity as a factor increasing innovativeness (Vegt & Janssen 2003).

A shared context is a necessity for purposeful knowledge creation (Nonaka & Takeuchi 1995, Boisot 1998, Nahapiet & Ghoshal 1998, Nonaka et al. 2000). An important factor is that trust moderates the functioning of the shared context (Nonaka & Takeuchi 1995) . The researcher would summarize the balancing between diversity and similarity as the existence of **enough requisite variety and weak ties, in other words, diversity of participants, is of key importance in knowledge creation, but they cannot be utilized unless the shared context for knowledge creation "Ba" exists moderated by trust and commitment, because a shared context is a prerequisite for knowledge creation** (Nonaka et al. 2000, Scharmer 2009). Thus, the importance of the shared context in purposeful knowledge creation limits also how broad the definition of relevant stakeholders is when planning a group process aiming to develop a discipline of higher education.

The selection of participants for the group communication processes of this study[51] is described in the next chapter. Based on findings related to the theoretical framework and stakeholder processes, a framework for selecting participants for a group communication process in the context of this study is presented in Chapter 7.2.

51 For the description of participant selection in Argument Delphi, see Chapter 3.2.1, Chapter 3.3.1 for Open Futures Search, and Chapter 3.4.1 for the Collaboration Group.

3 STAKEHOLDERS' GROUP COMMUNICATION PROCESSES IN THE STUDY

This chapter provides a description of the three stakeholder processes in this study. The applied definition of stakeholders in the empirical stakeholder processes of the study is presented in Chapter 3.1. Chapter 3.2 describes the Argument Delphi panel. The Open Futures Search event is discussed in Chapter 3.3. Chapter 3.4 focuses on discussing the National Collaboration Group for the Finnish Engineering Education.

3.1 APPLIED DEFINITION OF STAKEHOLDERS IN THIS STUDY

Two different definitions of the key stakeholders of the Finnish engineering education were applied during the three different stakeholder processes of the study, as illustrated in Figures 3.1 and 3.2.

In the **Argument Delphi** of the study, the objective was to find out how the decision makers of the Finnish engineering education anticipate Finnish engineering education to develop up to the year 2015. Thus, the researcher found that power to have an impact economically or legally would need to be considered as a key attribute. Therefore, by applying Donaldson & Preston (1995), as interpreted by Savage (2004), the researcher defined the stake as either direct or indirect economic and / or legal power. Primary stakeholders are those that have direct economic and / or legal power on the Finnish engineering education, and secondary stakeholders those that have indirect economic and / or legal power. Using the definition described above, the researcher defined the primary and secondary stakeholders of the Finnish engineering education as follows:

The primary stakeholders of the Finnish engineering education**:**

- Top management of universities and polytechnics (rectors and boards)
- Political decision makers (Government of Finland, Finnish Parliament, Finnish Ministry of Education[52], Municipalities)
- The Finnish industry (represented through companies and the Confederation of Finnish Industries)
- National research funding and technology research organizations (National Technology Agency of Finland TEKES[53], VTT Technical Research Centre of Finland, and the Academy of Finland)

The secondary stakeholders of the Finnish engineering education:

- The engineering students at universities and polytechnics (represented through student unions, and university students through the National Union of Finnish Students SYL, and polytechnics students through the Union of Finnish Polytechnic Students SAMOK)
- The staff at universities and polytechnics (teachers, researchers, non-academic staff)
- The Finnish engineers (represented through the Finnish Association of Graduate Engineers TEK[54] and the Association of Finnish Engineers UIL[55] and the Confederation of Unions for Professional and Managerial Staff in Finland AKAVA)
- Non-technical fellow universities and polytechnics in Finland
- Fellow universities and polytechnics outside Finland

52 From spring 2010 onwards called the Ministry of Education and Culture.
53 Later changed name into the Finnish Funding Agency for Technology and Innovation TEKES.
54 From January 2011 onwards called Academic Engineers and Architects in Finland – TEK.
55 Later changed name into Union of Professional Engineers in Finland (UIL).

- Upper secondary schools in Finland (staff, management, students, The Union of Finnish Upper Secondary School Students)
- The European Union (the Parliament and the Commission)
- The media

Directors of municipalities could be interpreted to belong to the decision makers and primary stakeholders of the Finnish engineering education, because municipal funding comprises over 40% of the funding of polytechnics[56] (Finnish Ministry of Education 2002). However, representatives of municipalities were not invited to the Delphi panel, because the focus of the study is on the national-level engineering education system, and regional factors are therefore out of the scope.

In educational systems other than that of Finland, students might be regarded as primary stakeholders also, when limiting stakeholders to those that have direct economic or legal power. However, in Finland degree-oriented tertiary education is by law (Universities Act 645/1997[57]) free of charge. Thus, students do not have direct economic power.

Universities Act (645/1997) states that a university consists of teachers, researchers, other personnel and students. The polytechnic community consists of full-time teachers, other full-time staff, and students of degree-oriented programs (Act on Polytechnics 351/2003). If the focus of the study had been related to the future of engineering education from the viewpoint of a single institution, students and personnel had clearly been part of primary stakeholders, according to the definition stated above. However, since the ontological level of the study is the national system of education, the researcher interpreted that students and university staff have derived legal power, and thus belong to secondary stakeholders.

Health-, welfare- and biotechnology are anticipated to become significant areas of technology for Finland (Hernesniemi et al. 1995, Himanen et al. 2004). Therefore, STAKES was defined as part of primary stakeholders, although it is not among traditional partners of universities providing engineering, like VTT and TEKES. University of Helsinki is a renowned research organization nationally. The Chancellor of the university has a privilege compared to other universities: the right to be present and speak at the Government sessions on matters on University of Helsinki (Universities Act 645/1997 20§). The researcher found the Chancellor of Helsinki University as an important influencer regarding the national policy on tertiary-level education, and therefore, defined him as part of primary stakeholders.

56 This figure illustrates the situation in 2002. Referring to the state budget of 2010, the municipal funding in polytechnics is 503.5 m€, which is roughly 57 % of the total funding.
57 The present Universities Act 558/2009 and Act on Polytechnics 351/2003.

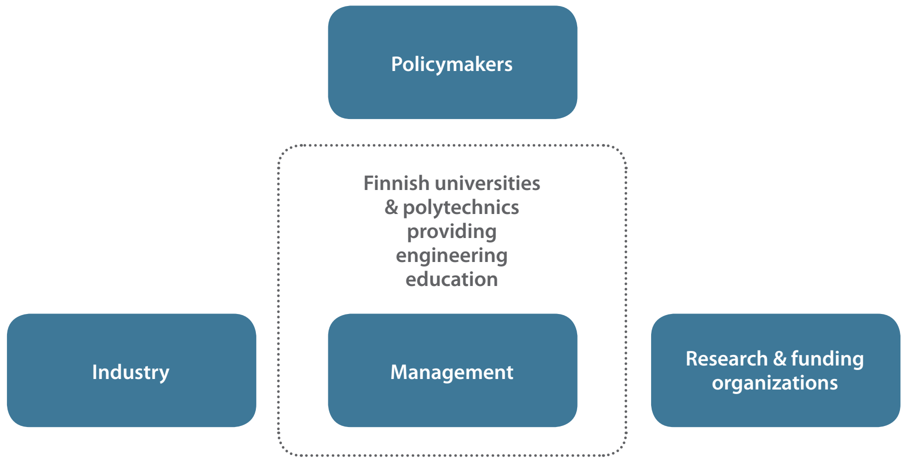

Figure 3.1 The primary stakeholders of the Finnish engineering education as defined in the Argument Delphi panel. The primary stakeholders were limited to decision makers. Definition of stakeholders applied from Donaldson & Preston (1995) as interpreted by Savage (2004).

The aim of the **Open Futures Search event** to frame a national strategy for the Finnish engineering education can be regarded as a complex task with a wide variety of needed knowledge, skills and networks. This was the case also for the **National Collaboration Group for the Finnish Engineering Education** that continued to frame the strategy and needed action plans. The researcher found that the definition of primary stakeholders cannot be limited to only those with direct economic or legal power, thus excluding students and staff.

For example, if applying the stakeholder definition of Jones (1995, 407), students and staff belong among them: stakeholders are those "with the power to affect the firm's performance and/or a stake in the firm's performance". Even if applying a somewhat narrower definition of primary stakeholders presented by Clarkson (1995, 106), staff and students are included: "Primary stakeholder group is one without whose continuing participation the corporation cannot survive as a going concern… If any primary stakeholder group, such as customers or suppliers, becomes dissatisfied and withdraws from the corporate system, in whole or in part, the corporation will be seriously damaged or unable to continue as a going concern."

Consequently, in addition to the decision makers of the Finnish engineering education that were invited to the Argument Delphi, engineering students and staff were defined to be part of the core stakeholders in the Open Futures Search, as well as Collaboration Group.

For the Open Futures Search event and the Collaboration Group, the researcher defined the key stakeholders as those with the power to affect the performance of the Finnish engineering education or with a stake in the performance of the Finnish engineering education (applied from Jones 1995). The defined key stakeholders were:

- The management of universities and polytechnics providing engineering
- The staff of universities and polytechnics providing engineering
- Developers of teaching and learning at universities and polytechnics providing engineering
- The engineering students
- The policymakers

- The industry
- The alumni
- The research and funding organizations

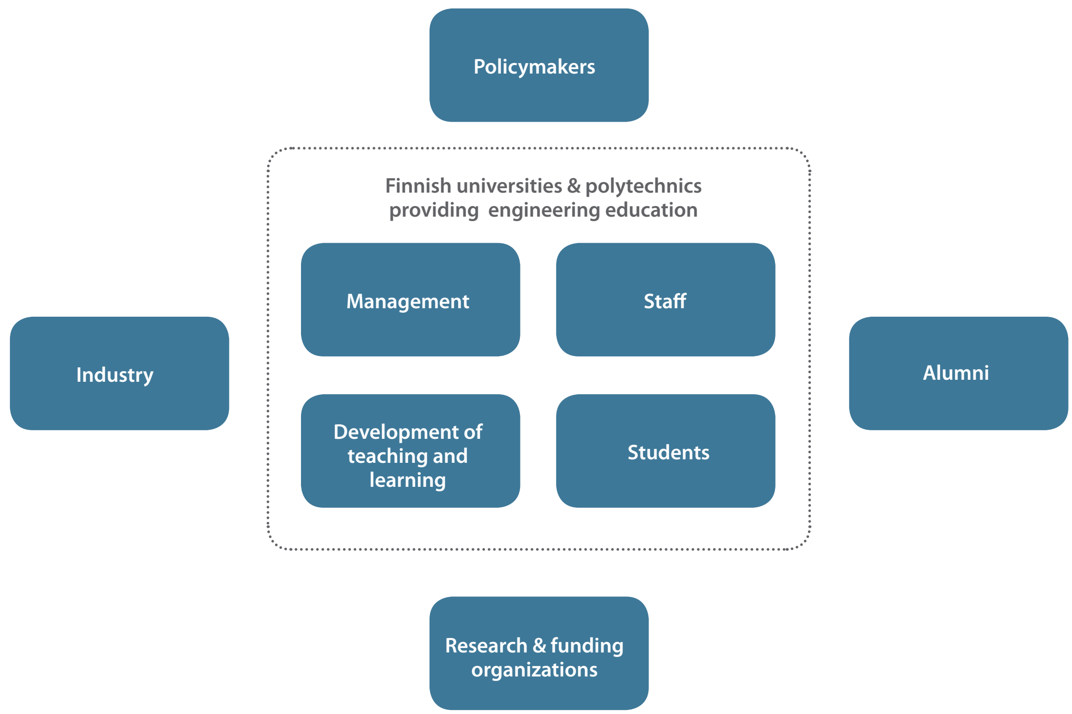

Figure 3.2 The key stakeholders of the Finnish engineering education as defined in Open Futures Search event and the National Collaboration Group for the Finnish engineering education. Definition of stakeholders applied from Jones (1995).

3.2 DESCRIPTION OF THE ARGUMENT DELPHI

This chapter provides a description of the Argument Delphi process of the study. The selection of participants is presented in Chapter 3.2.1. Chapter 3.2.2 provides a description of the research process with Argument Delphi. The reliability and validity of the Argument Delphi is discussed in Chapter 3.2.3. The Delphi method is described in general in Appendix 3.

3.2.1 Selection of Participants to the Argument Delphi Panel

The Delphi panel consisted of 21 representatives of the primary stakeholders of the Finnish engineering education as defined in Chapter 3.1. The make-up of the Delphi panel is presented in Figure 3.3.

Rectors from universities in the Delphi panel were Paavo Uronen from Helsinki University of Technology TKK[58], Jarl-Thure Eriksson from Tampere University of Technology TUT and Markku Lukka

58 From January 2010 onwards part of Aalto University.

from Lappeenranta University of Technology LUT. Rector Pertti Törmälä from EVTEK University of Applied Sciences[59], Rector Markku Lahtinen from TAMK University of Applied Sciences and Manager of Engineering Education Mirja Alaniemi from Jyväskylä University of Applied Sciences JAMK represented polytechnics management.

The researcher paid attention to selecting managers both from multidisciplinary and engineering-focused polytechnics. A minor shortage is that the only multidisciplinary research-oriented university of the study is Lappeenranta that is not widely multidisciplinary. Available disciplines are engineering and economics. The reasons for the decision were that the number of participants in the Delphi panel is limited, and if the researcher would have increased the number of rectors of universities, there would have been a need to increase the number of polytechnics rectors as well. Lappeenranta University of Technology and Oulu University grant roughly the same number of Master's degrees in engineering[60]. However, the total number of students in Lappeenranta is much smaller, and the researcher decided it would be important to include a representative of a small university of technology to the study as well. Mirja Alaniemi from Jyväskylä University of Applied Sciences was not a Rector, but the highest-ranking manager in the field of engineering, so the researcher interpreted her to be part of the stakeholder group.

Speaker of the Parliament Riitta Uosukainen, Minister of Environment Satu Hassi, Parliamentarian Esko Aho, Permanent Secretary Markku Linna from the Finnish Ministry of Education, and Manager of the Unit of Higher Education Markku Mattila from the Finnish Ministry of Education represented policymakers. The politicians selected for the study represent different parties. The aimed key contribution of the political decision makers was to bring knowledge and hindsight as to the key trends and factors of uncertainty in the business environment of the Finnish engineering education.

The researcher paid also attention to the background of the invited persons. Esko Aho is the former Prime Minister of Finland and has got a broad comprehensive view of the Finnish society. Riitta Uosukainen is the former Minister of Education. Satu Hassi was a Parliamentarian. She has a post-graduate degree in engineering and has written physics textbooks for primary and secondary education. Markku Linna and Markku Mattila were the highest-ranking public servants in the Finnish Ministry of Education.

The most significant employers of Finnish engineers with the M.Sc.(Tech.) degree, from the viewpoint of volume of employed engineers, are Nokia, Metso, Helsinki University of Technology TKK[61], ABB, Fortum, Tampere University of Technology and UPM-Kymmene (TEK 2001). Six of the seven listed organizations were represented in the Delphi panel.

President Juhani Kuusi from Nokia Research Center, President Mikko Niinivaara from ABB Finland, Vice President Martin Granholm from UPM-Kymmene, President Matti Carpen from ElisaCom, President Pekka Sillanaukee from FitBiotech and President Eppie Eloranta from Nicefactory represented industrial executives. When selecting the industrial representatives, the researcher paid attention to selecting participants that represent different clusters of businesses and different sizes of enterprises. However, ICT and electronics were slightly emphasized because of their importance as part of the Finnish industry and export[62].

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59 From August 2008 onwards EVTEK has been part of Metropolia University of Applied Sciences (Finnish Ministry of Education 2008).

60 Year 2009 The number of granted Master's degrees in engineering at Lappeenranta University of Technology LUT was 423, while the corresponding number at Oulu University OY was 345. In LUT the total number of students was 5 706 and in OY 15 661 (Finnish Ministry of Education KOTA database 2010).

61 Since 1.1.2010 part of Aalto University.

62 Year 2002 electronics was the largest business cluster with 23% share of the value of production. The second largest contribution was made by pulp and paper industry with the share of 20%. (Statistics Finland 2002)

President Veli-Pekka Saarnivaara from the Finnish Funding Agency for Technology and Innovation TEKES, President Erkki Leppävuori from Technical Research Center of Finland VTT, Vice President Mauno Konttinen from the National Institute for Health and Welfare STAKES and Chancellor Risto Ihamuotila from University of Helsinki represented top managers of research organizations.

The researcher aimed at having at least one female in every stakeholder group. However, the female representative invited to the subgroup of top management in research organizations ignored the invitation. Two out of five representatives from political decision makers are women. In the field of technology only 6% of executives are women (TEK 2000). The share of women in the top management of state administration is 22% (Finnish Ministry of Finance 2004, 21). The share of women in the Delphi panel is regrettably small, 4 out of 21 (19%), but corresponds to the overall situation in the Finnish society.

POLICYMAKERS

Markku Linna, Permanent Secretary, Ministry of Education
Markku Mattila, Director, Ministry of Education
Ritta Uosukainen, Speaker of the Parliament
Satu Hassi, Minister of the Environment
Esko Aho, Parlamentarian

PRESIDENTS OF UNIVERSITIES & POLYTECHNICS

Paavo Uronen, President, Helsinki University of Technology
Jarl-Thure Eriksson, President, Tampere University of Technology
Markku Lukka,President, Lappeenranta University of Technology
Pertti Törmälä, President, EVTEK University of Applied Sciences
Markku Lahtinen, President, TAMK University of Applied Sciences
Mirja Alaniemi, Director, Jyväskylä University of Applied Sciences

TOP MANAGEMENT OF INDUSTRY

Juhani Kuusi, President, Nokia Research Center
Mikko Niinivaara, President, ABB Finland
Martin Granholm, Vice-President, UPM-Kymmene
Matti Carpen, President, ElisaCom
Pekka Sillanaukee, President, FitBiotech
Eppie Eloranta, President, Nicefactory

TOP MANAGEMENT OF RESEARCH ORGANIZATIONS

Veli-Pekka Saarivaara, President, TEKES
Erkki Leppävuori, President, VTT
Risto Ihamuotila, Chancellor, University of Helsinki
Mauno Konttinen, Assistant Director General, STAKES

Figure 3.3 The make-up of the Argument Delphi Panel. The titles of participants correspond to those at the time of the selection (year 2001).

3.2.2 The Research Process of Argument Delphi

The first round of Argument Delphi is usually implemented using interviews (Kuusi 1999, 2003), like also in this study. The interviews lasted 1.5 – 2.5 hours, and were divided into two parts: “Finland year 2015” and “Finnish engineering education year 2015”. The researcher made notes during the interview and documented every interview separately into a 5 – 10 pages memo within 48 hours after the interview. Higher education policy has induced tension between the stakeholder groups. The researcher decided not to tape the interviews in order to courage decision makers’ open communication in the interviews.

In addition to the interview memos, the researcher also made summaries of the interviews using mind maps[63] on the topics population, culture and values, technology, research and development, business life and education. The mind maps were particularly useful in the creation of scenarios and mini-scenarios on the future of Finland in 2015.

The second round was a questionnaire, divided into two parts following the interview. The engineering education system was discussed as a whole, including education in universities and polytechnics.

Part one of the questionnaire in the second round consisted of arguments, wild cards and scenarios on "Finland year 2015" (Appendix 1). The panel assessed forty arguments on the future of Finland and Finnish technology, four scenarios on Finland in 2015, mini-scenarios on higher education volume and funding, funding of R&D, image and appreciation of technology, as well as field-specific technology scenarios.

Part two of the questionnaire[64] in the second round (Appendix 2), consisted of 97 arguments divided into 10 parts: educational system, degree system and student selection, regional offering and profile building, the EU and international competitiveness, educational planning and development, number of students, content of studies, learning environment, continuing education and life-long learning, administration, funding and steering system and stakeholders. Moreover, panelists assessed four scenarios on the Finnish engineering education system.

The panelists assessed the probability and desirability of the arguments by assessing each argument as probable or improbable and desirable or undesirable. The probability of scenarios was assessed using the scale 1 – 4, where 1 = highly probable, 2 = probable, 3 = improbable and 4 = highly improbable. The desirability of scenarios was assessed using the scale 1 – 4, where 1 = highly desirable, 2 = desirable, 3 = undesirable and 4 = highly undesirable.

In order to be able to evaluate how well the researcher succeeded in making a logical synthesis of the panelists' interviews for the scenarios presented in the second-round questionnaires, panelists were asked not only to assess the probability and desirability of the scenario but also:

- Would you like to add an item to the list of core items for Scenario NN given in the beginning of the Scenario? If yes, which item or word would you like to add?
- Does the core item list of Scenario NN include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?
- Which paragraph do you feel is the most central to Scenario NN?
- Do you think Scenario NN contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario NN?

The panelists' evaluations of the contents and core items of the Finnish engineering education 2015 scenarios is discussed in Chapter 6.3.1. Panelists' evaluations of the core items and contents of the scenarios on Finnish engineering education and Finland 2015 are also briefly discussed in the next chapter, which is focused on assessing the reliability and validity of the Argument Delphi panel.

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63 These mind maps are reported in Finnish in Appendices of Korhonen-Yrjänheikki (2004).

64 Questionnaires attached in the Appendices are English translations. The translation of the questionnaires (Appendices 1 and 2) was made by Vuokko Kellomäki (Valtasana Oy) in 2003.

3.2.3 Reliability and Validity of the Argument Delphi Panel

There is no one right way to carry out a Delphi panel and it is not easy to implement one (Gordon 2002). Another weakness of the Delphi method is also the extensive effort and time that the several rounds of Delphi require. One of the most well-known critics of the Delphi method is Sackman (1975).

Sackman (1975) evaluates Delphi as a poorly conducted opinion poll. He suggests using rigorous statistical methods like evaluations of statistical significance when applying the Delphi method. The researcher agrees with Kuusi (1999) and Mannermaa (1991) that basically the same criticism could be pointed to all slipshod research work using opinion polls.

There is a fundamental difference in the way that Sackman (1975) and Kuusi (1999) interpret the method. For Sackman (1975) the main purpose of Delphi is to deploy it for forecasting future development, or, following the definition of Kuusi (1999), predictive reasonability: the accuracy of predictions. For Kuusi (1999) the main focus is on reasoning arguments. In other words, the main focus is either on the option reasonability - the epistemic value of a study is dependent on how well different relevant alternative future developments are discovered - or on commitment reasonability - the epistemic value of a study is dependent on the level of commitment of participating decision makers on the relevant options for future development revealed in the study.

Furthermore, the objective of Argument Delphi is not to aim for consensus (Kuusi 1999, 2003), like Sackman (1975) describes the Delphi method. Sackman (1975) argues that drop-out rates in Delphi are high and selection of experts not grounded. Additionally, researchers do not combine the anonymous Delphi method for comparison with face-to-face group communication methodologies.

The strengths of the Delphi method lie in its ability to frame different options for the future before decision making (Linstone & Turoff 1975, Bell 1997, Kuusi 2003). The main focus in the Delphi panel of this study was to open up different possible, probable and desirable futures, meaning that option reasonability is the most relevant criterion when evaluating the epistemic value.

In this study, the selection of participants is argued in detail, and one of the aims is to develop a framework for participant selection. There were no drop-outs in the Delphi study. Moreover, all the 21 participants interviewed answered the questionnaire.

The researcher agrees with the criticism by Sackman on the problems of anonymity. The problems of anonymity are discussed in Chapter 2.3.5. In addition to the anonymous Delphi method, also a wide variety of face-to-face group communication methods were applied in the other two empirical studies within this research, in the Open Futures Search (see Chapter 3.3) as well as during the work process of the National Collaboration Group for the Finnish engineering education (see Chapter 3.4).

The researcher appreciates Sackman's (1975) criticism on prioritizing expert opinion more over the diversity of individual knowledge and experience. The researcher advocates the use of the term stakeholders instead of experts when applying the Delphi method. The developed framework for participant selection brings up a wide variety of criteria for consideration when selecting participants for a group communication process, especially in the context of developing higher education.

Because there is no one right way to carry out a Delphi study, there is no one right way to assess its reliability (Woudenberg 1991). The key factor affecting the relevant way of assessing reliability is whether a study applying the Delphi method is regarded as quantitative or qualitative research. The Argument Delphi applied in this study is a tool for qualitative research (Kuusi 1999).

Kuusi (2003, 216 – 217) lists six criteria that can be used for evaluating the success of a Delphi study: 1) level of success in the selection of the Delphi panel, 2) anonymous argumentation, 3) level of success in searching and defining relevant issues and topics for discussion, 4) success in leading a structured discussion where arguments and reasoning behind them are continuously and systematically evaluated, 5) the ability to collect systematically, cumulatively and in a user-friendly way the relevant future arguments from several experts representing different viewpoints and expertise and 6) the relevance of research results from the strategic decision-making point of view. These aspects are assessed briefly below.

The researcher selected participants for the Delphi panel in a systematic way and paid careful attention to all four phases of the panel selection: framing of the stakeholder map, definition of the key stakeholders bearing in mind the objective of the panel, decision on the number of panelists and selection of the most suitable panelists. All selections were thoroughly argued. The decision makers of the Finnish engineering education were aware of the make-up of the panel but argued anonymously.

The 1.5 – 2.5 hour thematic interviews in the first round of the Delphi with all the 21 panelists provided a good starting point for searching and defining relevant issues and topics within the Finnish engineering education system. In the second round of the Delphi, participants not only assessed the probability and desirability of the arguments and scenarios but also provided reasoning for their opinions. The panelists assessed also how well the researcher was able to formulate the scenarios on the Finnish engineering education system and future of the Finnish society. They were also able to comment if they wanted to change something in the scenario.

As may be observed from Table 3.1, 18 – 21 panelists out of 21 were satisfied with the core items of the Finland 2015 scenarios, and 14 – 18 did not want to change anything in the contents.

Table 3.1 Share of Delphi panelists that were satisfied with the list of the core items and contents of the Finland 2015 scenarios as such.

Finland 2015 -scenario	Satisfied with the core items list as such	Satisfied with the contents of scenario as such
1: Slowing Down the Development of Information Society	18/21	15/21
2: A Global Information Society of Materialistic Values	18/21	15/21
3: A Learning Industry and Global Welfare	21/21	14/21
4: Chaos, Terrorism, and Environmental Catastrophes	20/21	18/21

As Table 3.2 indicates, depending on the scenario, 16 – 20 panelists out of 20 were satisfied with the core items list of the Finnish engineering education, and 15 – 19 did not want to change anything in the contents. For further details on the evaluation on the core item list and scenarios on Finnish engineering education, see Chapter 6.3.1.

Table 3.2 Share of Delphi panelists that were satisfied with the list of the core items and contents of the Finnish engineering education 2015 scenarios as such.

Finnish engineering education system 2015 -scenarios	Satisfied with the core items list as such	Satisfied with the contents of scenario as such
1: New Parallel Model	16/20	15/20
2: Parallel in Theory - Overlapping in Practice	19/20	17/20
3: Return to the Old Parallel Model	17/20	16/20
4: All Higher Education Institutions Become Universities	20/20	19/20

The results of the Delphi panel were used as preliminary material for organizing the Open Futures Search event, in other words, they were utilized in the strategic planning of the Finnish engineering education. The results not only reveal where Finnish decision makers on the Finnish engineering education agree and disagree but also reasons behind disagreement are reported and analyzed. One of the key findings of the study that the Finnish engineering education lacks national vision is an important finding from the strategic development point of view.

3.3 DESCRIPTION OF THE OPEN FUTURES SEARCH EVENT

The description of the methodology of the Open Futures Search event is divided into three parts. The selection of participants for the event is described in Chapter 3.3.1. Chapter 3.3.2 contains a description of the work process in the event including a description of organizing the event. Reliability and validity are assessed in Chapter 3.3.3.

3.3.1 Selection of Participants

Based on the preliminary framework for participant selection that the researcher developed after the first empirical part of the study for Argument Delphi (Korhonen-Yrjänheikki 2005), Weisbord & Janoff (1999, 2000) views on the Future Search and selection criteria of a Search Conference (Bunker & Alban 1997, Emery & Purser 1996), the researcher developed a framework for participant selection that consists of four phases:

1. Create a stakeholder map of the system
2. Select key stakeholders by bearing in mind the purpose of the event
3. Decide on the number of participants
4. Select suitable participants

The framework is presented in Figure 3.4. Appendix 4 contains a list of the participants in the event.

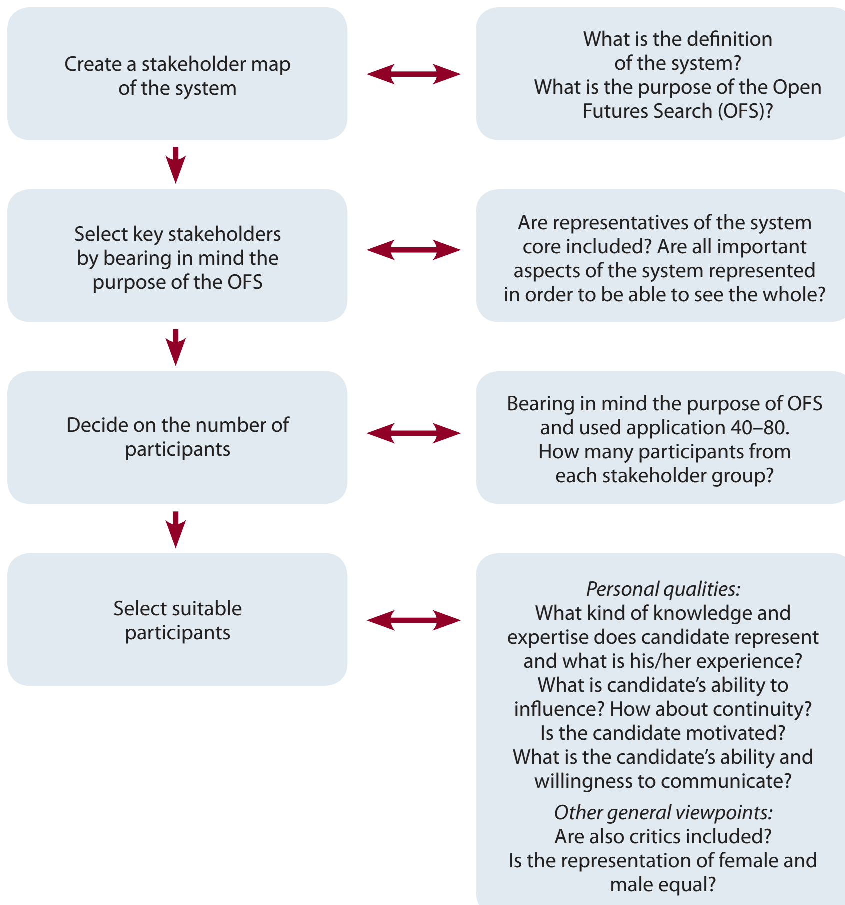

Figure 3.4 The selection process of the participants for the Open Futures Search dealing with the future of the Finnish engineering education system.

1. Create a stakeholder map of the system

The key questions when creating the stakeholder map of the system are:

- What is the definition of the system?
- What is the purpose of the Open Futures Search?

In the present study the system under examination is the Finnish engineering education defined through its key stakeholders. The applied definition of stakeholders is presented in Chapter 3.1.

The researcher defined the purpose statement of the participatory stakeholder event as follows: The objective of the event is to create collaboratively a national strategy for the Finnish engineering education up to 2015 including

- a shared vision
- identification of current and potential future strengths and resources
- cornerstones of the strategy and action plan for realizing the vision
- enhancement of key stakeholders' co-operation in improving competitiveness of the Finnish

engineering education globally. The Open Futures Search is a best practice example of intensive stakeholder co-operation in improving engineering education nationally.

2. Select key stakeholders by bearing in mind the purpose of the Open Futures Search

The key questions when selecting which stakeholders to include are:

- Are representatives of the system core included?
- Are all the important aspects of the system represented in order to be able to see the whole?

In the core of the Finnish engineering education system there are 7 universities and 21 polytechnics that provide engineering education in Finland. The researcher decided to invite representatives from 6 out of 7 universities providing engineering education. These universities are Helsinki University of Technology[65], Tampere University of Technology, Lappeenranta University of Technology, University of Oulu, University of Vaasa and Åbo Akademi.

The University of Turku was left out. It is a small and new unit in engineering education that acquired the right to grant degrees in engineering in 2004. University of Turku does not have a separate engineering faculty, but engineering can be studied in the faculty of mathematics and natural sciences. Moreover, representatives of already one university in Turku were invited, namely Åbo Akademi.

The event dealed with the Finnish engineering education as a whole, and therefore, representatives of 6 out of 21 polytechnics were also invited to the event. Representatives were invited from EVTEK[66], Tampere, Savonia, Satakunta, Oulu and Saimaa University of Applied Sciences.

Savonia and Satakunta University of Applied Sciences represent polytechnics that are located in a city where there is no university providing theoretical-oriented engineering education.[67] Among factors that affected the selection of polytechnics were volume of engineering education, employment of graduates, and regional representativeness.

The system core consists of management of universities and polytechnics, teaching and research faculty, persons responsible for pedagogical development and study counseling, as well as students. The researcher defined the key actors outside the system core that would need to be represented in order to get an understanding of the whole of the system as follows: the policymakers, industry, the alumi represented through labor-market organizations related to engineering and technology, and technology-oriented research and funding organizations. They have an impact on the funding and steering of engineering education and engineering profession.

Emery & Purser (1996) argue that one of the challenges is that although participants are invited as stakeholders, in the end they do not represent the stakeholder groups they belong to but themselves. This is an incontestable challenge that the researcher is aware of. In Future Search, participants work mostly in mixed groups but also in stakeholder groups, which may help them to act both as individuals as well as representatives of different stakeholder groups.

3. Decide on the number of participants

The researcher decided to target at the ideal number of participants, namely 64 as suggested by Weisbord & Janoff (1999) when applying the Future Search method. The estimation of the researcher before the

65 From 1.1.2010 onwards part of Aalto University.

66 From August 2008 onwards part of Metropolia University of Applied Sciences.

67 Tampere University of Technology provides a small-scale engineering program in Pori that is primarily targeted for adult learners interested in a Master's program. In 2011 B.Sc.(Tech.) education is not anymore at all available.

conference was that approximately 10% of those that sign up will either cancel their participation too late to allow the researcher to invite a new representative, or not show up. This means that by inviting 70 persons the researcher aimed to end up with approximately 64 participants.

After deciding on the total number of participants in Future Search, the next step is to decide how many representatives are invited from each stakeholder group. The core of the Finnish engineering education system invited to the event consisted of 12 higher education institutions. The researcher found it necessary to invite management, faculty, as well as student representatives from all the institutions. In order to be able to invite enough representatives of key stakeholder groups external to the system core, the researcher decided to invite only 6 representatives of development of teaching and learning (3 from universities and 3 from polytechnics). This means a total of 42 participants representing the core of the system.

From among policymakers, the researcher decided to invite civil servants representing the Finnish Ministry of Education, Finnish representative of educational affairs in the European Union, representatives of the Social democratic party, the Center party, and the Coalition party. A total of 10 representatives were invited.

The researcher invited 12 representatives of the employers of the Finnish engineers. 80% of the Finnish M.Sc. (Tech.) are employed by the private sector, 15% by the state and 5% by municipalities (TEK 2004). The researcher invited nine representatives of the private sector and one representative from the public sector[68], as well as representatives from the Confederation of Finnish Industries EK and Technology Industries of Finland. The factors considered when selecting participants from industry were representativeness of different clusters, the number of engineers the company employs in Finland, and representativeness of different sizes of companies. The main target group was those responsible for co-operation with higher education institutions, but the researcher considered also personal qualities as selection criteria, as discussed below.

Four persons were invited from the following organizations to represent technology research and funding organizations: The Finnish Funding Agency for Technology and Innovation TEKES, the Technical Research Center of Finland VTT, the Academy of Finland and the Finnish National Fund for Research and Development SITRA.

The Open Futures Search was organized on 29.-30.11.2006. At the beginning of November, 63 persons had signed up for the conference. 53 ended up persons participating in the conference. The participation by stakeholder groups is presented in Table 3.3. As one can observe from the table, the participation rate of the system core, representatives from universities and polytechnics, was 0.83. The participation of stakeholder groups external to the system core was 0.64. Policymakers stand out as a group which had the largest number of cancellations. Only one third of those that signed up for the event actually participated.

68 The share of public sector as an employer of engineers would suggest 2 – 3 representatives. However, public sector employers are also represented through other stakeholder groups participating in the Future Search, namely universities, polytechnics, VTT and TEKES. That is why the researcher decided to invite only a representative from the Finnish Army from the public sector and 9 representatives from the private sector.

Table 3.3 Invited participants and the actual participants in the Open Futures Search by stakeholder group.

Stakeholder group	Number of invited	Number of participants	Participants / Invited
System core: universities & polytechnics	42	35	0.83
Management	12	11	0.92
Staff	12	10	0.83
Development of teaching and learning	6	3	0.5
Students	12	11	0.92
External systems core (boundary riders)	28	18	0.64
Industry	12	9	0.75
Policymakers	10	3	0.33
Alumni	2	2	1
Technology research & funding organizations	4	4	1

4. Select suitable participants

The key questions affecting who to select from each stakeholder group were devised by the researcher as follows:

- What kind of expertise does the candidate represent and what is his / her experience? *In this case, what kind of knowledge and expertise does the candidate have in the Finnish engineering education?*
- What is the candidate's ability to influence? *In this case, for example participation in the governance of university and ability to influence the legislation steering higher education.*
- How about continuity? *In this case, for example, the person is not shortly retiring (in case of faculty) or finishing studies (in case of students).*
- Is the candidate motivated? *In this case, how has the candidate shown motivation to develop engineering education.*
- What is the candidate's ability and willingness to communicate?

Other aspects that the researcher found to be important to consider are:

- Are also critics included?
- Is the representation of female and male participants equal?

The researcher classified personal qualities in the selection process to five criteria: experience, ability to influence, motivation, continuity and ability and willingness to communicate openly. Furthermore, the researcher paid attention to the gender balance. The gender was a decisive factor for the selection in those cases where there were two candidates with equal skills and qualities. The researcher kept also in mind that it is desirable to include also critics among the participants in order to stimulate the discussion and open up different possibilities.

The researcher asked for recommendations for participants from several individuals and groups including justification using the above-listed five criteria. The researcher organized a workshop for the

Educational Committee of TEK on 28.4.2006 aiming to brainstorm potential candidates for the event. Members of the Educational Committee sent more proposals also through e-mail after the workshop. In addition, recommendations were asked from the Educational Board of the Union of the Finnish Engineers (UIL) through e-mail. Moreover, the researcher e-mailed the representatives of TEK and the UIL regionally in Finland to request recommendations for suitable participants. Moreover, the working group TEKSTRA consisting of representatives of the Educational Committee of TEK, and TEK staff working for educational affairs, gave recommendations and feedback on the invitation list.

The researcher contacted in June 2006 - approximately six months before the planned conference – a few key people that the researcher thought would be needed to at the event. The exact date of the conference was selected to fit their calendars. Thereafter, the researcher approached other persons on the invitation list. All 70 candidates were approached through a personal e-mail, and some of them the researcher also called. In many cases the researcher specified also why the person was chosen to be invited to the conference. In the invitation letter the researcher presented

- the exact dates and venue of the conference
- the purpose of the conference
- why it is important to participate, i.e. benefits acquired from participation at the conference
- the participative working method and phases of the working process on a general level
- why it is important to participate two full days
- the invited stakeholder groups
- examples of persons invited

3.3.2 The Work Process of the Event

The researcher carried the main responsibility for the event, led the project team[69], planned and facilitated the event, and wrote a report on the results of the event (Korhonen-Yrjänheikki 2007a). Sanna Allt acted as assistant facilitator and made a plan of practical arrangements before her maternity leave started in July 2006. At the conference site, Tiina Länkelin with the help of Linda Koivunen, was responsible for practical arrangements.

The work process at the event was documented thoroughly. Sanna Allt, Linda Koivunen, Arja Lindfors, Tiina Länkelin, Sanna-Katri Räikkönen, Sari Taukojärvi and Ville Taajamaa from TEK documented the discussions in the working groups. Sari Taukojärvi and Sanna-Katri Räikkönen documented also the plenary discussions. Moreover, Sanna Allt wrote down key words of the plenary discussion on a power point slide, which was used as a group memory during the event.[70]

The quality of the conference setting influences people's well-being, and thus, has an impact to their ability to work (Bunker & Alban 1997, Weisbord & Janoff 2000, Rees 2005). Therefore, the researcher decided to put effort not only to the planning of the contents of the seminar and selection of the participants but also on the venue and set-up of the conference. There needs to be a lot of wall space in the room since all the data and information produced at the conference is recorded on flip charts, timelines and a mind map that need to be posted on the wall. Moreover, it is preferable to have large windows and natural light. The event was organized at Congress Hotel Aulanko in Hämeenlinna. The Congress Hotel Aulanko meets well the above described criteria for an ideal setting of a Future Search. Suitability of the venue is assessed as part of the overall assessment of the event presented in Chapter 3.3.3. The set-up of

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69 The project team of the event met four times before the event on 25.9.2006, 19.10.2006, 13.11.2006 and 22.11.2006.
70 And furthermore, several other employees from TEK participated in preparing the event like for example Maisa Nissinen (communications), Mika Virtala (IT) and Juha Fagerström (practical arrangements).

the conference room is presented in Figure 3.5.

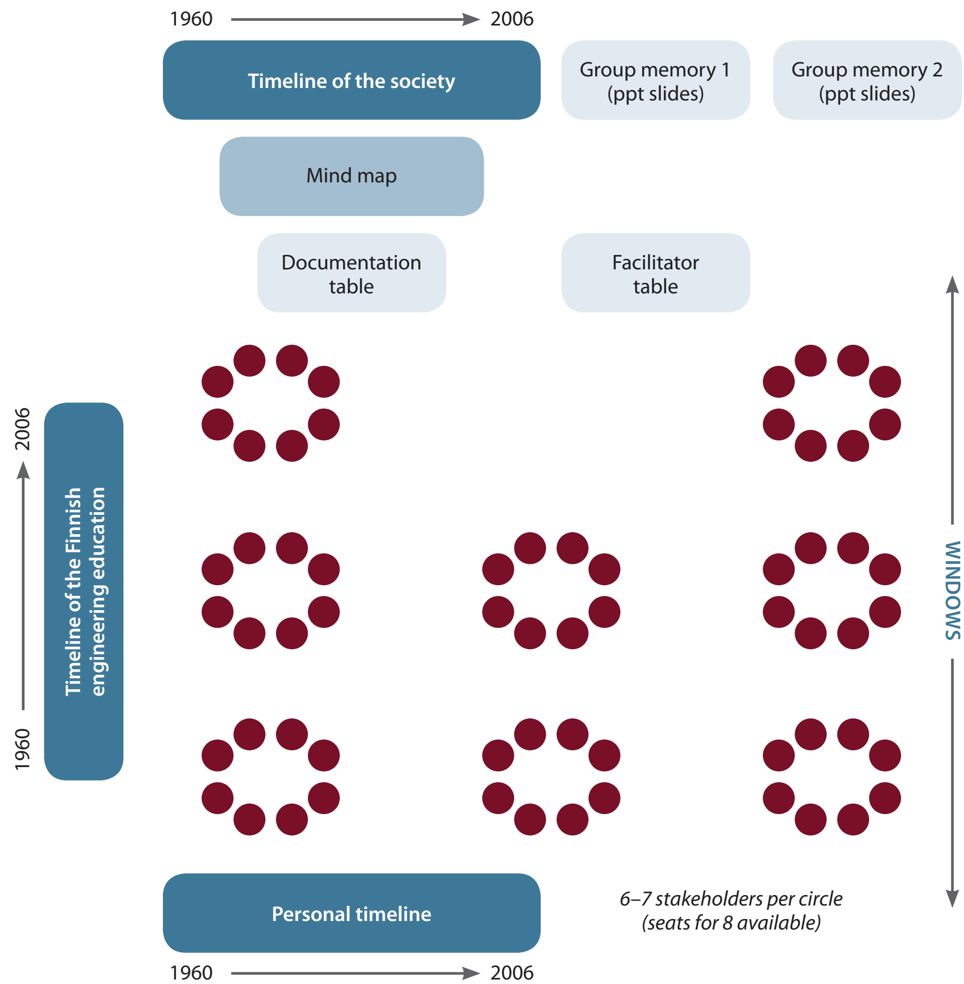

Figure 3.5 The set-up of the conference room at the Open Futures Search event.

After thorough analysis of the Search Conference and Future Search methods, the researcher decided to resort to the Future Search method. The most important reason for this was its better suitability over Search Conference to system-wide issues, for example the Finnish engineering education system. Furthermore, the stakeholder approach of Future Search fits well the objectives of this study. And moreover, as Bunker & Alban (1997) also argue, the researcher finds the working methods of a Future Search more evocative and inspiring than those applied in a Search Conference. Future Search and Search Conference methods are described in Appendix 5.

However, the researcher did not use the Future Search method literally as described by Weisbord & Janoff (2000), but applied it to fit better the objectives of the event. The researcher decided to apply the Open Space methodology for the action planning phase of the event. Overview of the Open Space method is presented in Appendix 8, describing the participative group work methodologies applied during the work of the Collaboration Group.

In case of a conflict situation, the researcher decided not to apply the approach of a traditional Future Search aiming at minimizing conflict (Weisbord & Janoff 2000) but to discuss and rationalize it, as described in Search Conference (Emery & Purser 1996). On the planning of the work process of the event, the researcher got feedback from Pepe Nummi, a professional facilitator and founder of GrapePeople Oy.[71] Table 3.4 summarizes the comparison of Search Conference and Future Search methods and applied variation of the Future Search, the researcher calls "Open Futures Search".

Table 3.4 Comparison of the Search Conference and Future Search methodologies with the Open Futures Search event of the study.

	Search Conference	Future Search	Future Search of the study "Open Futures Search"
Theoretical background	von Bertalanffy (open systems theory), Bion (group dynamics), Asch (effective dialogue)	von Bertalanffy (open systems theory), Bion (group dynamics), Asch (effective dialogue), Janssen (4-room appartment), Lippit & Schindler-Rainman (preferred future)	von Bertalanffy (open systems theory), Bion (group dynamics), Asch (effective dialogue), Janssen (4-room appartment), Lippit & Schindler-Rainman (preferred future), Owen (open space - complex adaptive systems)
Classification as a group method	planning	planning	planning
Participants	as individuals	as stakeholders and individuals	as stakeholders and individuals
Number of participants	20 - 35	60 - 80	53
Working mode	small groups and plenary sessions (more plenary sessions than in Future Search)	individual, small groups and plenary sessions	individual, small groups and plenary sessions
Working methods	traditional	traditional and new	innovative
Phases	environmental appreciation, system analysis (past, present, future), action planning	past, present (environment and system), future, action planning	past, present (environment and system), future, action planning
Common ground	search for common ground	search for common ground	search for common ground
Conflict situations	rationalizes conflicts	minimizes differences	rationalizes conflicts
Action planning	traditional group work	individually and traditional group work	open space
Duration	18 hours over 3 days	2 full working-days separated in 3 days	2 full working days
Work book	no	yes	yes

71 Face-to-face meetings 29.9.2006, 2.10. 2006 and 10.11.2006, e-mail consultation and 4 days of facilitator training in September and October 2006 in a group of approximately 15 people lead by Pepe Nummi.

The participants of the conference were e-mailed the conference program and information concerning practical arrangements about six weeks before the event. Two weeks before the conference the researcher sent the workbook of the event to all participants. In order not to inhibit creative work and push participants to a tight schedule beforehand, the participants received a schedule of the conference only on a general level. It is the duty of the facilitator to make sure that the work progresses and that there is enough time for all the phases of the event[72].

Chapter 1 of the workbook contained the definition of the purpose of the conference and participating stakeholders that were presented also in the invitation letter. The framework of the event, key rules for working, and guidelines for the group work were presented in Chapter 2. Chapters 3 – 9 presented the description of all the workshops of the conference, their objectives, and working methods. An exemplary workbook (Weisbord & Janoff 2000) was utilized in preparing the event workbook. The next chapter of this study provides an overview of the work process at the event described in Chapters 3 – 9 of the conference workbook[73].

The work process of the event is summarized below and in Figure 3.6. A detailed description of the work process is in Appendix 6.

Day 1

1. Introduction (40 min)
   - musical performance (5 min)
   - welcome speech by the sponsor (5 min)
   - introduction to the event by the facilitator (15 min)
   - opening activity, participative group process "Cocktail-party"(Nummi 2007) (15 min)

2. Historical analysis: society, Finnish engineering education, individual (120 min)
   - individual assignment (20 min)
   - small group work, mixed stakeholder groups (30 min)
   - small group presentations (30 min)
   - plenary dialogue (40 min)

3. Focus on the present, part 1: Analysis of the business environment (85 min)
   - individual assignment (10 min)
   - small group work, mixed stakeholder groups (20 min)
   - plenary dialogue, visual tool mind-map (30 min)
   - individual assignment, prioritization (10 min)
   - plenary dialogue (15 min)

4. Focus on the present, part 2: Analysis of the present in the Finnish engineering education: current prouds and sorries (125 min)
   - small group work, divided by stakeholder group: 1) key issues for concern, what is currently done and what should be done 2) strengths and weaknesses analysis (30 min)
   - small group presentations (40 min)
   - discussions in small groups on similarities and differences in group presentations, new ideas (15

72 Discussions with certified facilitator Pepe Nummi in the autumn 2006 and facilitator training organized by GrapePeople Oy.
73 The workbook is in Finnish, and therefore, not enclosed as an Appendix.

min)
- plenary dialogue (40 min)

5. Focus on the future: ideal future scenario of the Finnish engineering education (80 min)
   - individual assignment: it would be great if…(10 min)
   - small group work, mixed stakeholder groups: ideal future scenario (70 min)

Day 2

1. Introduction (15 min)
   - welcome and program of the day, facilitator (5 min)
   - opening activity, participative group process: “Line” (Nummi 2007) (10 min)

2. Focus on the future: ideal future scenario of the Finnish engineering education, continued from day 1 (100 min)
   - small group work, mixed stakeholder groups (20 min)
   - small group presentations (50 min)
   - plenary discussion (30 min)

3. Common ground and action planning with Open Space (Owen 2008 modified) (260 min)
   - small group work, mixed groups: rephrase the vision statements, list items, issues, viewpoints that need to be further processed for the strategy (30 min)
   - synthesis group: proposal for discussion items and conveners, others on a coffee break (30 min)
   - presentation of the synthesis group, plenary discussion and decision on the Open Space meetings rounds 1 – 2 (30 min)
   - Open Space meeting round 1, 7 meetings on-going (45 min + 15 min)
   - Open Space meeting round 2, 7 meetings on-going (45 min + 15 min)
   - small group discussions (ad-hoc groups) need for new themes (5 min)
   - plenary discussion and decision on the Open Space meetings round 3
   - Open Space meeting round 3, 6 meetings on-going (35 min + 10 min)

4. Summary, feedback, next steps (80 min)
   - individual assignment: prioritization and commitment (15 min)
   - plenary dialogue: summary, report and next steps (50 min)
   - closing activity, participative group process “Talking stick” (Nummi 2007, also called Structured Round, see for example Rees 2005) (15 min)

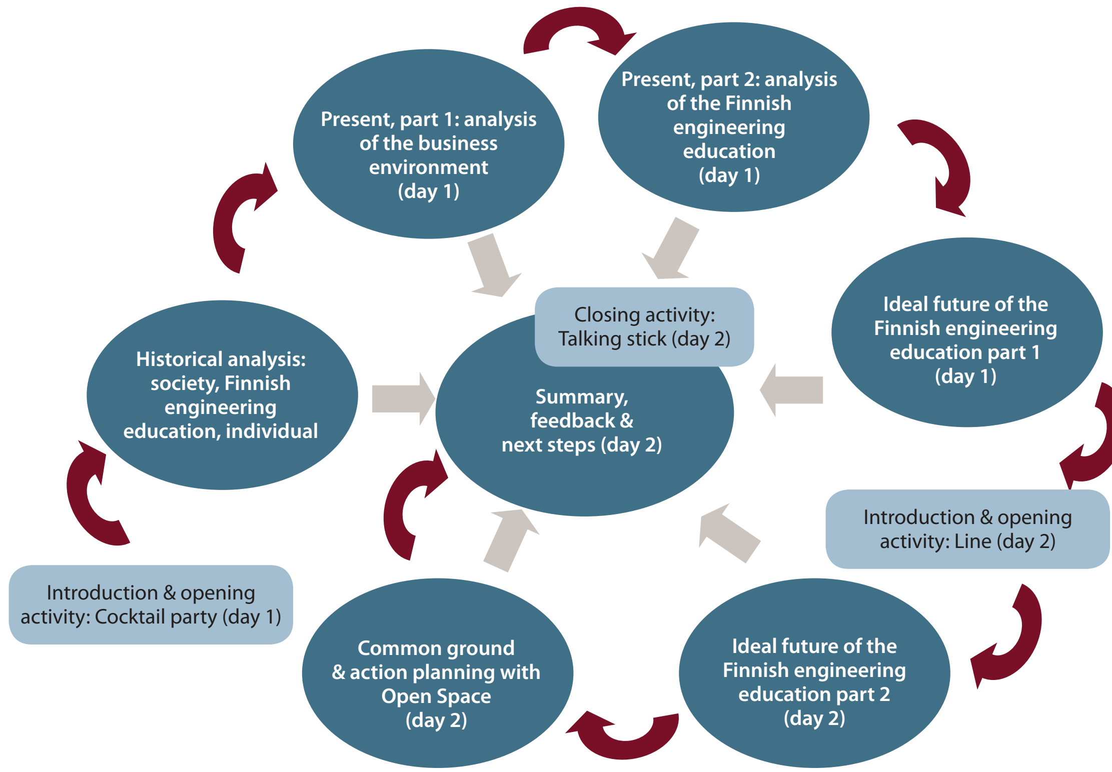

Figure 3.6 The work process of the Open Futures Search on the Finnish engineering education on 29.-30.11.2006.

The researcher compiled the report of the results of the event using flip-charts and documentation received from plenary sessions and working groups. The draft report was sent for comments to the participants 18.1.2007. When asking for comments, the researcher utilized the name stickers the participants used for pointing out their special interests. Using the feedback, the researcher finalized the report. The report (Korhonen-Yrjänheikki 2007a) was published on 7.2.2007 in a seminar "Welfare from technology" that was organized by TEK and UIL at Hotel Holiday Inn, Congress Center Helsinki. Approximately 150 persons from different stakeholder groups of the Finnish engineering education were present at the conference.

3.3.3 Reliability and Validity of the Open Futures Search

The key conditions for the success of a Future Search according to Weisbord & Janoff (2000, 50 - 61) are presented below. After each precondition, the researcher presents how these principles were applied in this study.

1. The whole system, all the key stakeholders, are represented at the conference. All important aspects of the issue need to be covered. First, thanks to the diverse perceptions available, everyone can get a new picture of the whole. Second, it is important to encourage forming as many new relationships as possible.

The researcher paid a lot of attention to getting the representation of the whole system, the Finnish engineering education, to participate in the event. Weisbord & Janoff (2000) do not present any systematic process for the selection of participants. However, the researcher saw it necessary to make a thorough analysis of the relevant stakeholders (Chapter 3.1) and developed a framework for participant selection (Chapter 3.3.2).

2. The topic of the Future Search is studied in reference to society as a whole. People have to get to the same wavelength and talk about the same world.

The approach of studying the issue in reference to society as a whole was applied in historical analysis, as well as in the analysis of the business environment of the Finnish engineering education system, as suggested by Weisbord & Janoff (2000).

3. The focus in a Future Search conference is on extending the common ground and creating the future. It is not a problem-solving conference. Problems and disagreements are acknowledged but not worked upon.

The focus in the Future Search conference was on the common ground in creating the future of the Finnish engineering education. The researcher decided before the event that if problems and disagreements arise, they will be treated the way Emery & Purser (1996) describe in a Search Conference: discussed and clarified, and not only acknowledged and listed, like in the case of a typical Future Search (Weisbord & Janoff 2000). Bunker & Alban (1997, 58) also point out that more time is spent on confronting the conflicts in a Search Conference than in a Future Search. The researcher had prepared for a specific "conflict group" if needed in the action planning phase. Weisbord & Janoff (2000) argue that people are often surprised at a Search Conference or Future Search by how much they actually agree on. This was the case also at the conference described in this study. No items were listed in a specific conflict list, and thus, no specific conflict group was needed.

4. The working groups are self-managing. They decide how to collect data, to discuss and to get the work done in time. It is recommended to divide responsibilities in the groups to a discussion leader, recorder, time keeper and reporter. And furthermore, to rotate the roles during the event. However, ultimately the group decides how they want to work.

The working groups decided themselves on the organization of the work and participant roles. The self-managing role of the group work was clarified to the participants at the beginning of their workbook and the facilitator explained it also in the beginning of the event. The self-managing role was emphasized even more than in a traditional Future Search. This is because the Open Space (Owen 2008), a method with the self-steering principle at the core, was applied in the action planning phase.

5. The actual working time is two full days, but it is recommended to divide the work into three days and "to sleep twice". This is to leave enough "soak time" to understand other people's views.

6. The participants of the Future Search attend the entire meeting. This is because innovative

planning on the common ground requires experiencing the entire process.

The researcher was of the opinion that it is more important that as many of the participants as possible, including the top management (Rectors, Deans and CEOs) with a tight time schedule, are present during the entire conference than that they spend two nights at the conference site. The researcher decided to plan the event to last two full days, but so that only one night would need to be spent at the conference site. The researcher understands the arguments for soaking time by Weisbord & Janoff (2000), but thought that even more important is to get the management to participate in the entire event. The researcher assumed that three days of the valuable time of, for example, Rector or Dean would be too much to ask.

When inviting the participants to the event, the researcher highlighted that by signing up to the conference the participant agrees to participate two full days at the conference. Only two of the 53 participants were granted an exception to be present only one day. In practice the researcher estimates that 90% of the participants were present most of the time and 70% were present two full days.

7. The infrastructure of the meeting has an impact on the participants' ability to work. Therefore, it is important to have airy rooms with windows, light lunch and snacks available all the time.

The event was organized at Congress Hotel Aulanko, in Hämeenlinna. The Congress Hotel Aulanko is located 100 km from the Helsinki-Vantaa airport. Transportation was organized from and to the airport. The atmosphere in Aulanko is peaceful, the hotel has a spa and in the surroundings is a beautiful park and a lake. The main room for working was large enough to organize the plenary sessions and working groups in the same room. The room had large windows with a view to the lake. The set-up of the conference room is presented in Figure 3.5.

Participants stayed overnight in Aulanko. The conference started with a musical performance and before the dinner there was another musical performance. Meals were organized at Aulanko restaurant and refreshments were available all the time. In the evening participants had the opportunity to visit the Aulanko Spa before dinner.

8. It is important that people publicly take responsibility for the follow-up. This can be done by asking publicly what people will do next and by asking people to sign up to action groups.

At the end of the conference, there was a summary session where decisions of the follow-up were made. Participants had also 10 stickers with their own name that they used for signing up to those action groups and issues that they are especially interested in to carry forward. This assignment aimed to increase commitment of participants on the results of the event.

3.4 DESCRIPTION OF THE COLLABORATION GROUP

Selection of members of the Collaboration Group is described in Chapter 3.4.1. The operational model and participative work methods applied are presented in Chapter 3.4.2. Chapter 3.4.3 introduces the work process of the Collaboration Group. A case example on minority influence in group communication is provided in Chapter 3.4.4. The reliability and validity of the work process of the Collaboration Group is assessed in Chapter 3.4.5. For detailed description and case examples on all participative work methods applied, see Appendix 8. Members and responsibilities of the Secretariat are presented in Appendix 7.

3.4.1 Selection of the Participants

The applied definition of stakeholders is presented in Chapter 3.1. The researcher applied the same preliminary framework for participant selection that she developed for the Open Futures Search (see Figure 3.4 in Chapter 3.3.1) concerning the first three phases: creation of a stakeholder map, selection of key stakeholders by bearing in mind the purpose of the Collaboration Group, and decision on the number of participants. However, in the fourth phase, the researcher decided not to select the invited representatives of each stakeholder group but asked the President of each organization to nominate their representative.

The researcher made the decision aware of the drawback that she would not be able to influence how well participants as a whole meet the "personal qualities" list of criteria, for example, variety of expertise, critics included, and equal representation of females and males. By applying the "self-selection principle" (Owen 2008), the researcher wanted to strengthen commitment as the key criterion for participation: commitment of stakeholders as organizations and commitment of their representatives for participation.[74] As presented in the theoretical framework of the study, commitment is found to be among key factors for purposeful knowledge creation in organizational knowledge creation theories (Nonaka et al. 2000, Nahapiet & Ghoshal 1998), improving group processes (Baron & Kerr 2003, Stangor 2004), as well as for selecting participants for a face-to-face group communication process, when applying participative working methods (Brown & Isaacs 2005, Owen 2008, Scharmer 2009).

The invited stakeholder groups and their representatives in the Collaboration Group are summarized in Figure 3.7. The way of involving teaching staff was different from other identified key stakeholder groups. Representatives of the teaching staff were not invited as part of the core Collaboration Group, but they were invited to two workshops each lasting two days[75]. The workshops were focused on the development of teaching and learning in engineering education. Most of the 51 participants at the first workshop in October 2008, and 50 at the second workshop in January 2009, were staff from universities and polytechnics providing engineering education. Appendix 12 contains a list of the participants in the workshops.

If staff representatives had been invited to the core Group, the researcher thought, it would have been necessary to invite one representative from all the universities and polytechnics involved. This would have increased the number of participants by 14. Nahapiet & Ghoshal (1998) point out that the creation and maintenance of social capital, particularly its relational and cognitive dimensions, is costly. Costs are likely to be influenced by the size and complexity of the social structure in which social capital is embedded. Thus, the reasons for not inviting staff representatives to the core Collaboration Group were related to the risks of involving too many people in the Group, resulting in decreased probability of achieving a shared context (Boisot 1998, 61) needed for purposeful knowledge creation (Nonaka et al. 2000, Scharmer 2009), and increased risk of problems in group communication, like social loafing, free riding and diffusion of responsibility (Baron & Kerr 2003, Stangor 2004).

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74 An exception to the self-selection principle was selection of the Chairman of the Group. The candidate for the Chairman (Jukka Mäkelä) was selected by the researcher and approved by the Collaboration Group at the first meeting on 30.8.2007.

75Ida Mielityinen selected the participants for the workshops on development on teaching and learning in engineering education (16.-17.10.2008 and 15.-16.1.2009). The researcher instructed her to use the framework for participant selection that she developed for the Open Futures Search event, presented in Figure 3.4 (Chapter 3.3.1).

14 out of 28 participants in the Collaboration Group represented management from universities and polytechnics providing engineering education in Finland. The main objective of the Group was to frame up a national strategy for the Finnish engineering education, and therefore, it was of key importance to get managers from higher education institutions providing engineering education to commit to the work process.

All universities providing engineering education in Finland had their management representative in the Collaboration Group. With regard to polytechnics, the researcher selected 7 polytechnics out of 21 that provide engineering education. The selection criteria were volume of engineering education, coverage of different engineering disciplines and regional representativeness. The researcher approached the Rectors of the invited higher education institutions and asked them to appoint their representatives to the Collaboration Group.

The representatives of university management were Vice Presidents Kalevi Ekman (Helsinki University of Technology[76]), Markku Kivikoski (Tampere University of Technology), Ilkka Pöyhönen (Lappeenranta University of Technology), Henrik Saxen (Åbo Akademi), Dean Kauko Leiviskä (University of Oulu), Dean Ilkka Virtanen (University of Vaasa) and Vice Dean Timo Knuutila (University of Turku). Because of his retirement, Ilkka Virtanen was replaced by Matti Linna on 17.11.2008.

The representatives polytechnics management were Presidents Pertti Törmälä (University of Applied Sciences EVTEK), Markku Lahtinen (Tampere University of Applied Sciences TAMK), Anneli Pirttilä (Saimaa University of Applied Sciences), Vice Presidents Olli Mertanen (Turku University of Applied Sciences), Matti Lähdeniemi (Satakunta University of Applied Sciences and Deans Risto Kimari (Oulu University of Applied Sciences) and Kari Lehtomäki (Savonia University of Applied Sciences). When EVTEK University of Applied Sciences merged with Stadia University of Applied Sciences into Metropolia University of Applied Sciences, the new President Riitta Konkola replaced Pertti Törmälä in the Collaboration Group (since 17.11.2008).

It would have been impossible to invite student representatives from all the universities and polytechnics involved in the Collaboration Group. Chairmen of the Boards at student unions of universities providing engineering education constitute the Committee of Student Affairs at TEK. The researcher asked the Committee to appoint a representative of engineering students at universities. The student unions in polytechnics providing engineering education belong to the Union of Engineering Students in Finland IOL. IOL was asked to allocate a person to represent engineering students at polytechnics. The student representatives in the Collaboration Group were Tommi Kemppainen (Helsinki University of Technology) and Mikko Torvela (Oulu University of Applied Sciences).

The Finnish Ministry of Education, Ministry of Employment and the Economy and the Committee of Education and Culture in the Finnish Parliament represented policymakers. The Finnish Ministry of Education, and Ministry of Employment and the Economy were asked to appoint their representatives. The Finnish Ministry of Education did not want to appoint members that would participate in the actual work process but nominated two civil servants, Petteri Kauppinen and Tarmo Mykkänen, as observers that were invited to the workshops, meetings and dissemination seminars of the Collaboration Group. The Finnish Ministry of Employment and the Economy appointed Director Antti Joensuu as their representative. The researcher invited to the Group also Jari Jokinen, who worked at that time as a representative of the Finnish Ministry of Education in the Finnish Permanent Representation to the European Union. Parlamentarian Jukka Mäkelä was a key person in preparing the initiative of the Col-

76 Since 1.1.2010 part of Aalto University.

laboration Group for the Finnish Ministry of Education[77], and the researcher asked him to function as the Chairman of the Collaboration Group.

A challenge in selecting participants representing industry was how to ensure representativeness of different clusters without increasing excessively the number of participants in the Collaboration Group. Therefore, the researcher decided to invite representatives from the Confederation of Finnish Industries EK and The Federation of Technology Industries. EK has got 16 000 companies as members that produce 70% of the Finnish GDP and 95% of the value of the export[78]. From the industrial fields, technology industry is the largest employer of Finnish engineers, and 75% of R&D investments in Finland are made in the fields that the Federation of Technology Industries represents[79]. Their representatives were Advisor Marita Aho (Confederation of Finnish Industries) and Director Mervi Karikorpi (Federation of Technology Industries).

The Academic Engineers and Architects in Finland - TEK and Union of Engineering Professionals in Finland UIL represented the engineering alumni. Director of Education Hannu Saarikangas participated in preparing the initiative of the Collaboration Group for the Ministry of Education and represented UIL. The researcher as Director of Educational Affairs was the representative of TEK.

The key institutions for the funding of research are Finnish Funding Agency for Technology and Innovation TEKES and the Academy of Finland. Technical Research Center of Finland VTT is an important partner of universities of technology in research activities. Their representatives in the Group were Directors Riikka Heikinheimo (TEKES), Jorma Lammasniemi (VTT)[80] and Susan Linko (Academy of Finland).

77 Most his career Jukka Mäkelä has been involved in the development of engineering education in Finland, and has held several positions of trust related to the development of higher education. He started to work at the Finnish Association of Graduate Engineers TEK in 12/1991. During 1/1997 – 4/2007 he worked as the Director of educational affairs.

78 For more details on the Confederation of Finnish Industries see http://www.ek.fi/www/en/about_us/index.php

79 For more details on Federation of Technology Industries see http://www.teknologiateollisuus.fi/en/

80 Jorma Lammasniemi was appointed as a Member, but did not in practice participate in the work of the Collaboration Group.

DECISION MAKERS (3)
Chairman: Parliamentarian **Jukka Mäkelä**
Director **Antti Joensuu**,
Ministry of Employment & Economy
Project Manager **Jari Jokinen**, Ministry of Education

Contact persons in Ministry of Education
Advisor **Petteri Kauppinen**
Advisor **Tarmo Mykkänen**

FINNISH UNIVERSITIES & POLYTECHNICS PROVIDING ENGINEERING EDUCATION

INDUSTRY (2)
Advisor **Marita Aho**, Confederation of Finnish Industries EK
Director **Mervi Karikorpi**, Federation of Technology Industries

MANAGEMENT (14)
(U)Vice President **Kalevi Ekman**, TKK
(U)Vice President **Markku Kivikoski**, TUT
(U)Vice President **Ilkka Pöyhönen**, LUT
(U)Dean **Kauko Leiviskä**, OY
(U)Vice President **Henrik Saxen**, ÅA
(U)Vice-Dean **Timo Knuutila**, UTU
(U)Dean **Ilkka Virtanen**, UV
Virtanen replaced 17.11.2008 –
Dean **Matti Linna**, UV
(P) President **Pertti Törmälä**, EVTEK
Törmälä replaced 17.11.2008 –
President **Riitta Konkola**, Metropolia
(P) President **Markku Lahtinen**, TAMK
(P) Vice President **Olli Mertanen**, TuAMK
(P) Dean **Risto Kimari**, OAMK
(P) President **Anneli Pirttilä**, EKAMK
(P) Dean **Kari Lehtomäki**, Savonia AMK
(P) Vice President **Matti Lähdeniemi**, SAMK

STAFF
No representation in the core Collaboration Group. 40 invited representatives of staff from universities and polytechnics participated at the workshops on teaching and learning in engineering education on 16.-17.10.2008 and 15.-16.1.2009.

ALUMNI (2)
(U) Director **Kati Korhonen-Yrjänheikki**, Academic Engineers and Architects in Finland - TEK
(P) Director **Hannu Saarikangas**, Union of Professional Engineers in Finland UIL

DEVELOPMENT OF TEACHING AND LEARNING (2)
(U) Project Manager **Anu Yanar**, TKK
(P) Director **Maarit Jääskeläinen**, TAMK

STUDENTS (2)
(U) Student **Tommi Kemppainen**, TKK
(P) Student **Mikko Torvela**, OAMK

RESEARCH & FUNDING ORGANIZATIONS (3)
Director **Susan Linko**, Academy of Finland
Director **Riikka Heikinheimo**, TEKES
Director **Jorma Lammasniemi**, VTT

Secretariat: Education & employment policy unit at TEK:
Advisor **Sanna Allt**, *Assistant* **Tiina Länkelin**,
Advisors **Pirre Hyötynen**, **Ida Mielityinen**,
Jussi Nousiainen, **Jarna Savolainen**, **Anniina Takala**

Figure 3.7 Members of the Collaboration Group, contact persons in Ministry of Education and the Secretariat at TEK. Representatives of universities are marked with (U) and representatives of polytechnics with (P). Affiliations of the Members of the Collaboration Group correspond to the situation in August 2007.

3.4.2 Operational Model and Applied Participative Work Methods

Participative work methods characterized the work of the Collaboration Group. Among them, World Café (Brown & Isaacs 2005) was the most widely applied method. Other methods used were Open Space (Owen 2008), Structured Round (Rees 2005), Dynamic facilitation (Nummi 2007) and Idealogue (Nummi 2007). Appendix 8 provides a description of the participative work methods applied, including case examples. Visual tools used for brainstorming were Mind Mapping, Fishbone Diagram (Rees 2005) and Timeline (Weisbord & Janoff 2000, Rees 2005).

Participative group work as a key factor characterizing the work of the Collaboration Group was brought up already in the initial work plan (Korhonen-Yrjänheikki 2007b). In the opening speech of the first workshop of the Collaboration Group on 1.-2.10.2007, the researcher not only brought up the objectives of the workshop but formulated the ground rules of the working mode: commitment, shift from debate to dialogue, courage to dream and to aim high, as well as deviation from conventional conceptions.

During the work of the Collaboration Group, 14 workshops[81] , 4 meetings and 8 preparatory assignments for the gatherings were organized. The preparatory assignments for the workshops were anonymous and mostly carried out using webropol-software[82]. The total duration of work using participative working methods was approximately 115 hours and conventional meetings lasted total of 20 hours. Furthermore, 2 dissemination seminars (total of 13.5 hours, also participative working methods applied) and 3 press conferences. The discussions of all meetings and workshops of the Collaboration Group were documented[83]. The researcher participated in all the workshops, meetings and dissemination seminars of the Collaboration Group. A list of all the events in a chronological order including the participative working methods applied and information on facilitators and venues can be found in Appendix 9.

The dialogue in the Collaboration Group was for the most part constructive. Participants were able to discuss also difficult issues, and disagreements were dealt with constructive criticism. However, the most conflicting situation in the Collaboration Group was related to the number of degree rights that should be granted for universities and polytechnics providing engineering education. This case example of problems of face-to-face discussion in conflicting situations is presented in Chapter 3.4.4.

No substitutes were tolerated to participate in the workshops or meetings of the Collaboration Group. This was because of the need to promote trust among participants since trust plays a key role in moderating the knowledge creation context (Nonaka et al. 2000, Scharmer 2009). Moreover, the risk of groupthink may be increased if a new member becomes a member of an existing group and seeks acceptance from the group (Longley & Pruit 1980; In: Baron & Kerr 2003). Commitment of participants was a prerequisite for benefiting from the participative working methods, which was clearly brought up in the work plan of the Group (Korhonen-Yrjänheikki 2007b).

Effective infrastructure, physical location and meeting conditions are important factors for the success of a participative workshop (Bunker & Alban 1997, Weisbord & Janoff 2000, Rees 2005, Owen 2008, Scharmer 2009). “People interact more successfully in places were they feel good” (Weisbord & Janoff 2000). Spacious room, plenty of natural light, delicious food and refreshments and location that is logistically easily attainable were the guiding principles that the researcher set for selecting the venue. What

81 In two workshops on 9.2.2008 and 9.3.2008, total of 5 hours were organized as a conventional meeting for the approval of the Profile Map.

82 With the exception of preparatory assignment 4 that was focused on commenting a draft of the interim report and carried out by e-mail. And furthermore, preparatory assignment 8 that applied a virtual learning environment for defining the learning objectives for the Finnish engineering education.

83 Tiina Länkelin, Pirre Hyötynen, Ida Mielityinen, Jussi Nousiainen , Jarna Savolainen and Annina Takala from TEK were primarily responsible of documenting the discussions. Students Laura Pyyny, Ninni Lankinen and Emmi Seppänen were also documenting the discussions at the workshops on development of teaching and learning on 16.-17.10.2008 and 15.-16.1.2009. Maija Tiitinen from TEK participated in documenting the discussions at the dissemination seminar on 12.2.2008.

made the selection[84] more challenging was that the researcher thought that changing the venue would bring creative chaos promoting knowledge creation (Nonaka et al. 2000).

3.4.3 Work Process of the Collaboration Group

The work process of the Collaboration Group can be divided into two parts. The first part of the work process, between August 2007 and February 2008, was focused on preparing the principles of the national strategy for the Finnish engineering education. The work flow of the first part is illustrated in Table 3.5.

The first part of the work process consisted of 4 preparatory assignments, 5 workshops and 2 meetings. In the first preparatory assignment, the members of the Group stated their opinions on the proposals of action that were formulated during the Open Futures Search event (Korhonen-Yrjänheikki 2007a) as well as in the working group of the Ministry of Education that was led by Yrjö Neuvo (Finnish Ministry of Education 2005a). The topics of the first workshop on 1.-2.10.2007 included the analysis of the business environment and present situation as well as a preliminary formulation of the vision. Part of the workshop was spent also on action planning. This was because the Ministry of Education had asked the Group to submit comments for the National Plan of Education and Research for the years 2007 – 2012, and the deadline for comments was the end of October 2007.

The second preliminary assignment was focused on mission and scenarios that were the key topics, in addition to structural development of engineering education during the workshop on 12.11.2007. The third assignment dealt with the vision of the Finnish engineering education and structure of the strategy report. In the workshop on 29.11.2007, the discussed topics addressed vision, key strategy principles, structural development criteria, and proposals for action.

At the symposium on teaching and learning on engineering education Reflektori on 3.12.2007, a 3-hour workshop[85] was organized, focused especially on sustainable development in engineering education as well as on identifying of the themes related to engineering pedagogy that would need to be discussed in the Collaboration Group (Allt 2007b).

The workshop on 10.12.2007 focused on structural development criteria, key strategy principles and action planning. Before the workshop on 19.12.2007 that was focused on sharpening the proposals for action and strategy as a whole, the participants were asked to comment on a draft of the strategy report as a preparatory assignment of the workshop. The strategy report was finalized and approved in the meeting on 14.1.2009.

Sanna Allt was the General Secretary of the Collaboration Group. She was responsible for planning and facilitating all the workshops and analyzing the results of the preparatory assignments[86]. She also carried out the main responsibility for writing the interim report of the Collaboration Group that the researcher co-edited (Allt & Korhonen-Yrjänheikki 2008).

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84 Tiina Länkelin was responsible for selecting the venues for the Collaboration Group using the selection criteria framed by the researcher.

85 The workshop was attended by 19 teachers and developers of engineering education, including the researcher. The work method applied was World Café. The workshop was facilitated by Sanna Allt from TEK.

86 Pirre Hyötynen from TEK assisted Sanna Allt in the analysis of the first assignment.

Table 3.5 Work phases of the Collaboration Group between 8/2007 – 2/2008, up until the interim report "National Strategy for the Finnish Engineering Education" (Allt & Korhonen-Yrjänheikki 2008) was published.

Work phases of the Collaboration Group 08/2007 - 02/2008	Preparatory assignment	Workshop	Meeting	Other work	Dissemina-tion event
Work plan			30.8.2007		
Views of the Group on the proposals for action of the Open Futures Search (Korhonen-Yrjänheikki 2007) and Finnish Ministry of Education (2005a)	1				
Present situation	1	1.-2.10.2007			
Business environment		1.-2.10.2007			
Scenarios	2	12.11.2007			
Mission	2	12.11.2007			
Vision	3	1.-2.10.2007, 29.11.2007			
Comments for the national plan on education 2007 - 2012		1.-2.10.2007			Submitted for the Ministry
Structural development criteria and number of institutions		12.11.2007, 29.11.2007, 10.12.2007			
Strategy key principles		29.11.2007, 10.12.2007, 19.12.2007		Workshop for teachers 3.12.2007	
Proposals for action		1.-2.10.2007, 29.11.2007, 10.12.2207, 19.12.2007		Workshop for teachers 3.12.2007	
Finalization of the interim report	4	10.12.2007, 19.12.2007	14.1.2008		
Publication/dissemination interim report					15.1.2008, 12.2.2008

The second part of the work of the Collaboration Group was carried out between March 2008 and September 2009. The work process, described in Table 3.6, consisted of three separate themes[87]: structural development and specialization of HEIs, development of engineering education to face the challenges of sustainable development, and development of teaching and learning in engineering education.

Table 3.6 The work phases of the Collaboration Group between 3/2008 – 9/2009 resulting in publications Allt, Korhonen-Yrjänheikki & Savolainen (2009), Takala (2009) and Mielityinen (2009).

Work phases of the Collaboration Group 03/2008 - 09/2009	Preparatory assignment	Workshop	Meeting	Other work	Dissemination event
Enhancement of execution of the strategy	5	10.3.2008, 9.3.2009			
Revised work plan (3/2008 - 5/2009)		10.3.2008			
Objectives of the action plan 1: Profile Map	6	10.3.2008, 28.4.2008			
National emergency supply		26.5.2008 17.11.2008			
Good Campus Criteria		28.4.2008, 26.5.2008 17.11.2008			
Descriptions of the HEIs providing engineering education				Carried out by secretariat	
Statistics on HEIs providing engineering education				Carried out by secretariat	
Proposals for action of profile map	7	22.9.2008, 9.2.2009, 9.3.2009		In 22.9. event also group external participants from HEIs	
Publication of the Profile Map					16.4.2009, 12.5.2009
Objectives of the action plan 2: Sustainable development and engineering		26.5.2008			

87 In the workshop on 12.11.2007, the preliminary themes for action planning were defined as the development of 1) teaching and learning, 2) engineering education to face challenges of sustainable development and 3) engineering research. However, during finalization of the principles of the strategy in December 2007, it became evident for the Group that there is a need to develop further the criteria of structural development and to concentrate more thoroughly on enhancing the specialization of HEIs. Promotion of structural development was set as one of the key objectives of the work of the Group. The idea of preparing a Profile Map of the Finnish engineering education, including criteria for a Good Campus in engineering education as well as a description and statistics of all HEIs providing engineering education, was strongly supported by the Finnish Ministry of Education. The importance of preparing a Profile Map was brought up by the Minister of Education Sari Sarkomaa at a press conference on 15.1.2008 and by the Secretary of State in the Ministry of Education Heljä Misukka on 12.2.2008 at the dissemination seminar. The Group decided to drop out the development of research from the themes deserving further attention. The most important reasons for this were resource constraints. The Secretariat could not have focused on four themes in action planning with the resources and time available. Furthermore, for the Group this would have meant a need to formulate separate subgroups for universities and polytechnics because of their different focus, role and volume in research activities.

Research on sustainable development and engineering education (extensive literature review + 66 interviews)		17.11.2008		Carried out by secretariat	
Action plan 2 proposals for action		9.3.2009, 20.3.2009		Steering Group provided input	
Publication of the research and action plan 2					12.5.2009
Objectives of the action plan 3: Teaching and learning in engineering education		10.3.2008			
Preparatory material for the workshop 16.-17.10.2008: memo on learning needs				Carried out by secretariat	
Learning needs and objectives	8	17.11.2008, 9.2.2009		Workshops 16.-17.10.2008, 15.-16.1.2009 for EE community; Group interview for industry 29.1.2009	
Teaching methods and assessment		9.2.2009		Workshop 15.-16.1.2009 for EE community	
Pedagogic management		9.2.2009		Workshop 15.-16.1.2009 for EE community	
Action plan 3: proposals for action		20.3.2009			
Publication of the action plan 3					12.5.2009
Assessment of the work of the Group and next steps		22.9.2009			

The objective concerning the structural development and specialization of higher education institutions providing engineering education was to prepare a **Profile Map** containing descriptions and statistics of the higher education institutions offering engineering education, definition of the role of engineering education in ensuring national emergency supply, definition of the criteria for a Good Campus and proposals for action. The statistics were collected by Sanna Allt and Jarna Savolainen from the Secretariat.

Each higher education institution was asked to write a description of their institution based on a set of questions defined by the Collaboration Group.[88] The researcher edited the descriptions[89]. Definition of the role of the Finnish engineering education in ensuring the national emergency supply, criteria for a Good Campus and proposals for action were defined during the workshops and a preparatory assignment. Sanna Allt and the researcher were responsible for editing the results of the Collaboration Group

88 Concerning some of the institutions, the edition process required several iteration rounds together with the institution before questions formulated by the Collaboration Group were answered.

89 This is because Sanna Allt, originally responsible for the Profile Map went on maternity leave in December 2008, and due to resource constraints, there were no other options to get the work done. The descriptions of 28 institutions and their statistics are not presented as part of this study.

on the role of engineering education in ensuring the national emergency supply, criteria for a Good Campus, and proposals for action (Allt, Korhonen-Yrjänheikki & Savolainen 2009).

The objectives of the Profile Map were discussed using the preparatory assignment (6) and face-to-face workshops on 10.3.2008 and 28.4.2008. The national emergency supply was among the themes discussed in the workshops on 26.5.2008 and 17.11.2008. The criteria for a Good Campus were discussed in the workshops on 28.4.2008, 26.5.2008 and 17.11.2008.

Proposals for action were on the agenda in the workshops on 22.9.2008, 9.2.2009 and 9.3.2009. Proposals for action were also discussed in a preparatory assignment (7). Management representatives from those polytechnics that were not represented in the Collaboration Group were invited to the workshop on 22.9.2008 that was focused only on discussing the needs for structural development and specialization of universities and polytechnics providing engineering education. The preparatory assignment (7) was open to all participants in the event. 44 persons participated in the event, out of which 23 were members of the Collaboration Group. The participants of the event are listed in Appendix 10.

The objective of the work on **sustainable development and engineering education** was to find out how Finnish engineering education enhances sustainable development at present and how education should be developed to better face the challenges of sustainable development. The core part of the work consisted of a research carried out by Annina Takala, who conducted an extensive literature survey and carried out 66 interviews with experts on various aspects of sustainable development and engineering education. The research work was supported by a Steering Group. The Steering Group met six times between May 2008 – April 2009. Appendix 11 contains a list of the members and gatherings of the Steering Group including the participative work methods applied in the two workshops of the Group.

The Collaboration Group discussed the subproject related to sustainable development in four workshops[90]. In the workshop on 26.5.2008, the objectives of the research were discussed. During the workshop on 17.11.2008, the preliminary results of the research were on the agenda. The most important role of the Collaboration Group was to define the proposals for action. This was discussed in the workshops on 9.2.2009 and 9.3.2009. Proposals for action were published in the same publication with the results of the research as a whole (Takala 2009). The researcher acted as Chairman of the Steering Group of the research and as superior of Annina Takala gave feedback during the research process.

The objective of the work regarding the **development of teaching and learning in engineering education** was to define the learning objectives for the Finnish engineering graduates[91], to identify possible existing skills gaps of engineering graduates, as well as to enhance the development of teaching methods and pedagogic management. The most important part of the work was accomplished during the two workshops on 16.-17.10.2008 and 15.-16.1.2009. For the preparatory material of the first workshop, Ida Mielityinen complied a memo on the changing learning needs of engineering professionals based on a few literature sources..

44 out of 51 participants of the first workshop and 45 out of 50 participants of the second workshop were external to the Collaboration Group. Most of the participants invited were teachers from universities and polytechnics providing engineering education. Some representatives of students, administration and industry participated, as well. Participants of the workshops are listed in Appendix 12.

Because several industry representatives were prevented from participation to the second workshop, a group interview was organized for the industry representatives on 29.1.2009. Between the workshops

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90 For a reflection on the sub-project of sustainable development as part of the work of the Collaboration Group, see Takala & Korhonen-Yrjänheikki (2010).

91 Degrees B.Eng, M.Eng, B.Sc.(Tech.) and M.Sc.(Tech.).

the participants were invited to work in a virtual learning environment to specify the learning objectives. A few participants took active part in the virtual assignment, but not the majority.

The results of the first two-day workshop were discussed in the Collaboration Group workshop on 17.11.2008 and the results of the second two-day workshop in the Collaboration Group workshop on 9.3.2009. The contribution of the Collaboration Group was especially focused on formulating proposals for action. The report on the development of teaching and learning in engineering education was finalized in the meeting of the Collaboration Group on 20.3.2009.

Ida Mielityinen was responsible for the whole work process related to the development of teaching and learning. Thus, she collected the preparatory material for the first workshop, facilitated the workshops[92], carried out the group interview for industry representatives and edited the report of the Collaboration Group on teaching and learning in engineering education (Mielityinen 2009a). As a superior of Ida Mielityinen, the researcher gave feedback and proposals for development during the work.

The results of the Collaboration Group were disseminated in three press conferences on 15.1.2008, 16.4.2009 and 12.5.2009. Furthermore, two dissemination seminars were organized on 12.2.2008 and 12.5.2009. The dissemination seminars were marketed primarily for the engineering education community at higher education institutions, but all interested parties were welcome. 118 persons participated in the dissemination seminar on 12.2.2008. 101 of the participants were external to the Collaboration Group. The dissemination seminar on 12.5.2009 was attended by 144 participants. 124 of the participants were external to the Collaboration Group.

3.4.4 Case Example on Minority Influence in Face-to-face Discussion

For facilitating the discussion at the workshop on 12.11.2007, a preparatory assignment was carried out, where members of the Collaboration Group could anonymously state their opinion on the number of degree rights needed for B.Eng and M.Sc.(Tech.) degrees. Participants were also asked to present argumentation, and if they wanted to, their proposals for higher education institutions that should discontinue engineering education. Moreover, facilitator Sanna Allt had prepared statistics of primary applicants, intake, accepted students and employment of graduated engineering students in all the universities and polytechnics providing engineering education to be disseminated at the event.

18 out of 28 Members of the Collaboration Group participated in the preparatory assignment. One of the questions in the preparatory assignment was what the number of higher education institutions should be that have a right to grant B.Eng degrees, and correspondingly the number of higher education institutions that should have the right to grant M.Sc.(Tech.) degrees. The median as well as the average anonymous answer on the number of degree rights for B.Eng degrees was 12. The median as well as the average of anonymous answer on the number of degree rights for M.Sc.(Tech.) degrees was 5. Table 3.7 provides a summary of the proposals for the number of rights to grant B.Eng degrees and Table 3.8 M.Sc.(Tech.) degrees.

92 Jussi Nousiainen from TEK acted as co-facilitator in the workshops on 16.-17.10.2008 and 15.-16.1.2009 where he was responsible for the energizers during the work process.

Table 3.7 Anonymous answers in the preparatory assignment of the Collaboration Group concerning what should be the number of HEIs in Finland that have the right to grant B.Eng degrees.

Number of B.Eng degree rights	5	6	8	10	12	15	16	20
Answers (n=18)	1	1	1	4	4	5	1	1

Table 3.8 Anonymous answers in the preparatory assignment of the Collaboration Group concerning what should be the number of HEIs in Finland that have the right to grant M.Sc.(Tech.) degrees.

Number of M.Sc.(Tech.) degree rights	3	4	5	6	7	8
Answers (n=18)	3	4	8	1	1	1

In addition to the actual number of degree rights, Members of the Collaboration Group presented also plenty of argumentation and concrete proposals for which higher education institutions should discontinue providing engineering education[93].

After the facilitator Sanna Allt had presented the results of the anonymous preparatory assignment, including argumentation presented and concrete proposals to the Collaboration Group, she asked the Group[94] to vote again. Again voting was carried out anonymously, but so that based on the results of the first voting, the facilitator had selected options to choose from. The proposed options for the number of B.Eng degrees were 10 - 12, 13 – 15, 16 -18 and 19 – 21. The proposed options for the number of M.Sc.(Tech.) degrees were 3, 4, 5 and 7. A few members of the Collaboration Group did not want to participate in the voting, because they did not find voting appropriate.

11 out of 15 that stated their opinion on the number of degree rights for M.Sc.(Tech.) education were of the opinion that it should be 5, as can be observed from Table 3.10. Variation in answers concerning the number of B.Eng degrees was greater, as presented in Table 3.9. The alternative 13 – 15 degree rights was the most popular option.

93 The detailed argumentation and concrete proposals of HEIs that should discontinue to provide engineering education are not documented in this study, because the researcher would find it unethical to do so. This is because it was later decided that the Group formulates a proposal on the number of degree rights in engineering education, but is not going to make specified proposals which HEIs should discontinue providing engineering education.

94 The researcher could not find from the documentation the exact number of all participants in the workshop, but she remembers it was between 16 – 20.

Table 3.9 Anonymous answers of the Members of the Collaboration Group at the workshop on 12.11.2007 on the total number of degree rights needed for B.Eng degree in Finland.

Number of B.Eng degree rights	10-12	13-15	16-18	19-21
Answers (n=14)	3	6	3	2

Table 3.10 Anonymous answers of the Members of the Collaboration Group at the workshop on 12.11.2007 on the total number of degree rights needed for M.Sc.(Tech.) degree in Finland.

Number of M.Sc. (Tech.) degree rights	3	4	5	7
Answers (n=15)	1	1	11	2

After the facilitator presented the results of the second anonymous voting, it was time for a plenary discussion. During the discussion considerable tension between regional and educational policies as well as fear for existence of one's own higher education institution could be observed. This was the only topic and situation during the work of the Collaboration Group than can be considered to have caused a real conflict situation. The Group was not able to formulate the decision at the workshop on 12.11.2007.

At the next workshop of the Collaboration Group on 29.11.2008, the open plenary discussion continued on the number of degree rights. The facilitator Sanna Allt was prepared for a further anonymous voting process, but because of loud resistance from several participants, she decided to drop it and the process continued with a facilitated plenary discussion. The Group was again not able to formulate the decision on the number of degree rights.

It became evident that in a face-to-face situation, the Group is not going to accept the kind of formulation that anonymous answers would suggest, especially concerning degree rights for M.Sc.(Tech.) degrees, where 5 seemed to be the opinion of the Group. The final formulation of the proposal for action concerning degree rights was introduced by the facilitator and accepted at the meeting of the Collaboration Group on 14.1.2008, where the interim report of the Group (Allt & Korhonen-Yrjänheikki 2008) was approved.

The conclusion was to propose diminishing the number of higher education institutions providing engineering education so that approximately 15 institutions would have the right to grant B.Eng degrees, while at present the number of the institutions is 21. Furthermore, it was agreed that 5 – 7 institutions should have the right to grant M.Sc. (Tech.) degrees. At present the number of institutions is 7. **Concerning B.Eng as well as M.Sc. (Tech.) degrees, the final conclusion made face-to-face was higher than average or median of the anonymous answers in the first round. Concerning M.Sc. (Tech.) degrees the final decision was also higher than average or median in the second anonymous voting made after the first face-to-face discussion.**

Not all members of the Collaboration Group participated in the preparatory assignment or anonymous voting at the workshop on 12.11.2007, so it is possible that those who were of the opinion that there is a need to diminish the number of degree rights were more willing to participate that impacted the results. However, the researcher finds it more likely that this is an example of group behavior to abandon conflict in face-to-face discussions.

Levine & Kaarbo (2001) suggest that effective minorities may create change, but it is easier to block change with minority influence, like also in this case. This example of minority influence may be seen as part of the problem of groupthink as defined by Janis (1972), when members' strivings for unanimity override their motivation to realistically appraise alternative courses of action. The minority influence may also be discussed using Gilbert et al. (1998, 434) terminology as part of the problem of shift to normalization: "This desire causes group members to converge on a middle position that everyone could accept without losing face."

Those most strongly opposing the voting and representing exact figures for the number of degree rights were not representatives of the management of higher education institutions. Thus, it may be seen that their position was regarded as more valid than that of a representative of an individual higher education institution. This supports the findings of Wood et al. (1994) that "minority influence derives from the perceived validity of its position."

What is more, the minority was consistent in its position and argued for the same position in both meetings. This supports the findings that consistency of the minority increases the risk of minority influence as argued by Smith et al. (2001) and Collins and O'Rourke (2009).

The group processes in face-to-face discussion at the workshops on 12.11.2007 and 29.11.2007 were probably not optimal. The facilitator could have used small group assignments and, for example, dynamic facilitation for the whole group discussion. However, based on the observations during the workshops regarding the topic of the number of degree rights, the researcher is doubtful whether this would have helped to improve the face-to-face communication.

3.4.5 Reliability and Validity of the Collaboration Group

Since the role of the researcher was not that of a facilitator of the workshops of the Collaboration Group[95] but manager of the whole working process, leader of the Secretariat, and Member of the group[96], the researcher finds it relevant to assess the reliability and validity of the Collaboration Group work process as a whole without analyzing all the 14 workshops of the Group and the success in application of different group working methods in organizing them. However, in order to increase the transparency of the work process, the researcher describes and analyzes case examples of all the participative work methods applied. This is presented in Appendix 8.

The validity of the work process of the Collaboration Group is assessed below by estimating how objectives set in the work plan of the Group (Korhonen-Yrjänheikki 2007b) were reached, what kind of feedback was received from the Finnish Ministry of Education that funded the Group, and feedback received from the engineering community concerning some of the results of the Collaboration Group at the dissemination seminar on 12.5.2009.

Objectives in the Work Plan and How They Were Met

Below can be found the objectives of the Collaboration Group as defined in the work plan (Korhonen-Yrjänheikki 2007b) and assessment of how they were met:

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95 With two exceptions: workshop of the Collaboration Group on 10.12.2007, when Sanna Allt was ill and workshop of the Steering Group of the Research on sustainable development and engineering education on 30.1.2009, when Annina Takala was needed for documentation of the event and the researcher acted as facilitator.

96 When Chairman of the Collaboration Group Jukka Mäkelä was not present, the researcher acted as Chairman.

1) *to create a national strategy for the Finnish engineering education*

A proposal for the national strategy of the Finnish engineering education (Allt & Korhonen-Yrjänheikki 2008) was published on 15.1.2008 in a press conference, where Minister of Education Sari Sarkomaa was also present. This report was later supplemented by three action plans (Allt, Korhonen-Yrjänheikki & Savolainen 2009, Takala 2009, Mielityinen 2009a).

2) *to promote structural development of engineering education*

3) *to clarify division of work between universities and polytechnics in general and between different higher education institutions*

The strategy contained preliminary criteria for structural development of the Finnish engineering education as well as assessment of importance, usability and proposal for indicators (See Table 6.4). The criteria were later developed into criteria for a Good Campus providing engineering education (See Figure 6.2).

The publication Profile Map (Allt, Korhonen-Yrjänheikki & Savolainen 2009) contained a description of the profiles and statistics of all universities and polytechnics providing engineering education that may be used by higher education institutions themselves for development purposes, as well as by policymakers for decisions on structural development.

The publication focused on the development of teaching and learning in engineering education (Mielityinen 2009a) clarified the division of work between universities and polytechnics by differentiating the learning objectives for the Bachelor's and Master's degrees in polytechnics and universities.

4) *to prepare an action plan to execute the strategy*

Separate action plans were prepared for promoting structural development of engineering education (Allt, Korhonen-Yrjänheikki & Savolainen 2009), development of teaching and learning in engineering education (Mielityinen 2009a) and development of engineering education to face the challenges of sustainable development (Takala 2009).

5) *to make additional development proposals if needed*

The Finnish Ministry of Education asked the Collaboration Group to prepare proposals for action for the National Plan for Education and Research for the years 2007 – 12. A memo (Allt 2007a) was provided to the Ministry of Education in October 2007.

Moreover, as a final gathering[97] of the Collaboration Group, a workshop was organized in September 2009 that defined proposals for the development of higher education for the next Governmental Program of Finland 2011 – 2015 and the corresponding next National Plan for Education and Research (Mielityinen 2009b).

6) *to follow-up execution of the strategy*

The follow-up of the execution of strategy was discussed in the Collaboration Group workshops in March 2008, November 2008 and March 2009. The March 2009 workshop contained also a case example presentation prepared by Jussi Nousiainen from TEK that was part of the Secretariat of the Group. The main responsibility of Jussi Nousiainen at TEK between August 2008 and July 2009 was to promote execution of the strategy through face-to-face meetings with political decision makers, primarily Parliamentarians and Advisors of Ministers and Parliamentarians.

All Members of the Collaboration Group were asked to make individual action plans to pro-

97 The workshop was organized and funded jointly by TEK, Union of Professional Engineers in Finland UIL and Confederation of Finnish Industries EK.

mote execution of the strategy. By November 2008, almost all Members of the Collaboration Group (22 out of 28) had made their individual action plan. Thus, participants of the group expressed commitment to enhancing execution of the strategy.

7) *to promote collaboration of stakeholders of engineering education aiming to make the Collaboration Group a unique example of benefits of close co-operation between stakeholders*

The Collaboration Group was a unique example of collaboration between stakeholders in higher education. The operational model of the Collaboration Group has aroused interest in Finland and internationally. The Finnish Association for Business School Graduates SEFE benchmarked[98] the operational model of the Collaboration Group for the discipline of economics. The Finnish Association of Architects SAFA started a stakeholder process for framing a national strategy for the education of architects. The researcher met representatives of SAFA in Spring 2008 to disseminate the experiences gathered during the work process of the Collaboration Group[99].

The researcher presented the work of the Collaboration Group at the European Commission Convention to enhance industry-university collaboration in Brussels in February 2008 and at European Engineering Deans' Conference organized by SEFI in Berlin in February 2008. The researcher was also invited by the Danish Ministry of Education to present the work process of the Collaboration Group and the framed strategy to the engineering education community in Denmark in April 2010, but the volcanic eruption in Iceland prevented the researcher from participating in the event.

Although the work of the Collaboration Group for the Finnish engineering education ended in September 2009, the plan of TEK is to facilitate collaboration in the engineering education stakeholder network also in the future (Korhonen-Yrjänheikki 2009a). Workshops using participative working methods are organized annually, and the intention is to organize them in collaboration with a few partners, like the last workshop of the Collaboration Group on 22.9.2009 was organized jointly with Union of Professional Engineers in Finland UIL and the Confederation of the Finnish Employers EK.

Feedback from the Finnish Ministry of Education

The Secretary of State Heljä Misukka from the Finnish Ministry of Education stated at the first dissemination seminar of the Collaboration Group (12.2.2008) where the proposal for the national strategy was published (Misukka 2008): "I find remarkable the shared commitment that the Finnish engineering education community has made by presenting a proposal to develop a national strategy for the Finnish engineering education that resulted in an unanimous proposal for the strategy. The representation of stakeholders in the Collaboration Group is comprehensive: universities, polytechnics, students, developers of education, industry, labor market organizations and political decision makers. I hope that the operational model created can be utilized in the future also in other disciplines and in the development of the educational system as a whole. More intensive co-operation between stakeholders and open dialogue are the leading principles of the Finnish Ministry of Education in development of the national system of education."

In her speech Misukka pointed out that the Finnish Ministry of Education included several proposals from the results of the Collaboration Group in the National Plan for Education and Research for the

98 The researcher presented the work of the Collaboration Group for the Finnish engineering education for the SEFE Board in June 2009.

99 The researcher was also invited to assess the interim strategy report at the Group to the event organized on 6.5.2010, but she was unable to participate in the seminar.

years 2007 – 12. Furthermore, the results will be used in several renewals during the government period of office 2007 – 11, for example in the university legislation, steering and funding of tertiary-level education, professional adult education, anticipation of education, and preparation of the structural development program of tertiary-level education.

At the second dissemination seminar of the Collaboration Group on 12.5.2009 where action plans related to the strategy were published[100], Advisor Petteri Kauppinen from the Finnish Ministry of Education commented that the action plan for the specialization of universities and polytechnics - the Profile Map - offers excellent material for the steering negotiations with universities and polytechnics as well as the structural development program. Moreover, universities and polytechnics can utilize the Profile Map in renewing their strategies, which needs to be completed by spring 2010. (Levander 2009)

Feedback from the Engineering Community at the Dissemination Event on 12.5.2009

The dissemination seminar on 12.5.2009 contained also a polling system to monitor how the 144 participants of the event (out of which 20 were members of the Collaboration Group) representing the engineering community found some of the key aspects related to the results of the work accomplished by the Collaboration Group. 83% of the participants evaluated the presented Criteria for a Good Campus (see Figure 6.2) to be good or fairly good. The presented skills map of engineering graduates (see Figure 6.4) was either as such or to a large extent accepted by 82% of the participants.

The work carried out in the Collaboration Group for developing engineering education to better meet the needs of sustainable development was regarded as essential. 73% of the attendees were of the opinion that engineers play a substantial role in enhancing sustainable development. However, there is still plenty of work to do to fulfill the mission set by the Collaboration Group for engineering education to provide competencies, skills and innovations for the benefit of people and environment. The majority (53%) felt that at present engineering education fulfills this mission poorly. 43% were of the opinion that engineering education meets the described mission well.

85% of the engineering community members present at the seminar were of the opinion that it is important (49%) or very important (36%) that higher education institutions providing engineering education focus on their core competencies. The participants were clearly of the opinion (95%) that the Ministry of Education and policymakers are needed in executing specialization and structural development in the HEI network. Only 5% believed that higher education institutions are able to carry these out by themselves. 68% were of the opinion that higher education institutions together with the Ministry of Education and policymakers are able to take the required decisions. 27% were of the opinion that higher education institutions are not able to make the needed decisions and that the Ministry of Education and policymakers have to take them alone. An example of difficulties related to taking decisions on structural development of the HEI network is provided in this study in Chapter 3.4.4.

100 Structural development and specialization of universities and polytechnics in engineering (Allt, Korhonen-Yrjänheikki & Savolainen 2009), development of teaching and learning in engineering education (Mielityinen 2009a) and development of engineering education to face the challenges of sustainable development (Takala 2009).

4 NATURE OF ENGINEERING DISCIPLINE

This chapter discusses the nature and identity of the engineering discipline using literature as the source. The focus is on the Finnish engineering education. Chapter 4.1 discusses epistemology of engineering education. Engineering education in the context of the changing society is discussed in Chapter 4.2. The context of learning and stakeholder approach are discussed in Chapter 4.3.

4.1 EPISTEMOLOGY OF ENGINEERING EDUCATION

The origin of the word technology comes from Greek "techne" that refers to a skill. Technology contains also an element of knowledge, but at the core of technology is more "know how" than "know that" (Heikkerö 2009). Technology is human action, either creation or application of new tools, based on value-oriented decisions (Horvat 2009). The aim of engineering science is not theoretical truth like in natural sciences, but rather practical usability (Niiniluoto 1984, Hendricks et al. 2000). Engineering knowledge is not purely scientific nor purely social but rather a combination of the two (Downey & Lucena 1995). To quote an aerospace engineer Theodor von Kármán "Scientists discover the world that exists; engineers create the world that never was" (Crawley et al. 2007).

The tension between theory and practice has characterized engineering education since its formal conception in the 19th century (Jørgensen 2007, 219). Crawley et al. (2007) describe the evolution of engineering education as a function of personal, interpersonal and system building skills stressing the engineering practice, and disciplinary knowledge with the stress on science. They argue that prior to 1950s the context of engineering practice prevailed. Thereafter, science increased its importance, and by 1960s the engineering science and practice had equal importance. By 1980s the engineering science clearly dominated with a strong emphasis on engineering fundamentals. And thereafter, there has been a growing interest to increase the importance of practice.

Naukkarinen (2006) discovered in a case study on learning environments in engineering education at universities and polytechnics that views on the nature of knowledge and the role of theory and praxis differ from each other in different fields of engineering. Figure 4.1 illustrates the dimensions of engineering substance from the following perspectives as defined by Naukkarinen (2006): the role of theory and practice, nature of knowledge and educational objectives. Cases 1, 2 and 4 were major subjects in universities and 3, 5 and 6 in polytechnics. Jørgensen (2007, 224) agrees with Naukkarinen (2006) and suggests that electrical engineering is an example of an engineering field where theoretical teaching and industrially developed technologies are closer than in other domains.

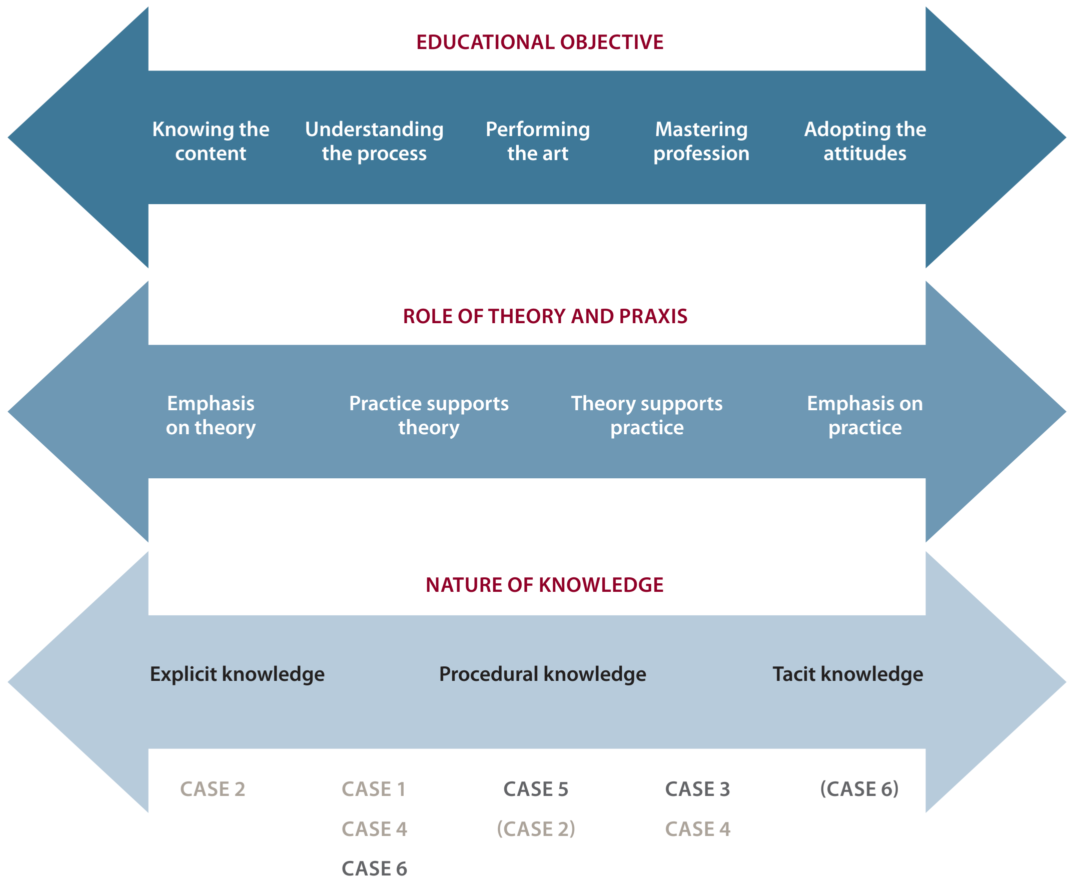

Figure 4.1 Dimensions of engineering discipline. Cases 1, 2 and 4 are major subjects from universities and 3, 5 and 6 from polytechnics (Naukkarinen 2006, 139).

Whether engineering science is applied natural sciences or a discipline with its own epistemology is a debated issue. For example, Michelsen (2000) is of the opinion that engineering sciences do not have their own epistemology but it is closely tied to natural sciences and development of technology. Hendricks et al. (2000) and Hansson (2007) argue that engineering is a science governed by its own epistemology, methodology and ontology, but it has been neglected and often treated as a spin-off of pure and applied science and their method.

Hansson (2007) claims that there are at least six features that distinguish engineering from other sciences:

- ultimate study objects are human-made rather than natural objects
- engineering design is part of technological sciences
- study objects are defined in functional terms
- study objects are evaluated with category-specific value statements
- employed idealizations are less far-reaching than the natural sciences
- exact mathematical solution is not needed when a sufficiently close approximation is available.

Vest (2005) and Jørgensen (2007) suggest that systems sciences including, for example, control theory, systems theory, systems engineering, operations research, systems dynamics and cybernetics (Jørgensen 2007) may provide the theoretical basis for engineering that goes beyond the principles of natural sciences. System sciences as a possible underpinning can be described in the context of the changing society.

4.2 ENGINEERING EDUCATION IN THE CHANGING SOCIETY

The knowledge-intensiveness of the economy, expansion of higher education, global interdependence in facing challenges of sustainable development, globalization of the economy, development of ICT, steady growth of the service sector as part of the economy - of which knowledge-intensive services constitute a growing share - aging of population in developed countries, changing values stressing quality of life and self-expression (OECD 2008), opening up of the innovation system (Chesbrough 2003 a,b) and converging of technologies (Allenby et al. 2009) may be observed as major societal trends impacting the educational system as a whole, including engineering education.

Because of the practical nature of the engineering discipline, the engineering profession reflects more than most professions[101] the immediate environment within which it operates (Allenby et al. 2009). Allenby et al. (2009) refer to the building of railroads in the US as an example of how deeply technological and societal development are intertwined. The build-up of railroads brought about the concept of coordinated time between cities, modern capital, financial instruments and markets. Thus, it fundamentally changed the American culture. A similar example could be made world-wide regarding the significance of railroad construction to the development of society and culture.

Early in the 20th century, the conception of engineers with social responsibility and heroic constructors of the structures of modern society was changed into an image of servants of industry (Jørgensen 2007, 233). The instrumentalist approach[102] to technology ruled. Vest (2005, 164 – 167) argues that, in addition to engineering science revolution that started in 1950s, like Crawley et al. (2007) also describe, another pivotal moment that had an impact on engineering education in Massachusetts Institute of Technology at the same time was the observation that a great engineering school needs to develop strong programs also in humanities and social sciences. Jørgensen (2007) dates the wider discussion and understanding of technology in societal context to 1980s and 1990s.

Heikkerö (2009) argues that up until 1970s the key obligation of engineers was to be loyal towards the employer and the customer. In 1974 Engineers' Council for Professional Development (ECPD) adopted a new professional regulation stating that the ultimate aim of engineers is to serve public safety, health, and wellbeing. This approach is during the past decades accepted widely as the mission of the engineering profession (Heikkerö 2009, 91). "Developing new and successful technologies can only take place if the technologist has a deep understanding of the motives and desires of people that will be related to the new technology and the effects of his design on society as a whole and nature (Mulder 2006, 135)."

However, as Heikkerö (2009) claims, the tension between serving the needs of industry and public good is evident in a profession where most of its representatives are employed by the private sector[103].

101 Another example of a profession with a similar kind of closed intertwined relationship with the business environment is medicine as described from the viewpoint of research by Stokes (1997).
102 There are three different approaches to discussing the relationship between technology and society (Heikkerö 2009, 53 – 57): instrumentalist, determinist and constructivist. The instrumentalist approach to technology argues that technology is a neutral tool that human beings may freely apply for their needs. Technological determinism claims that technological changes determine societal changes. At present, the most widely applied approach to technology is the constructivist approach arguing that it is not sensible to discuss technology as such since it is always dependent on the angle and interests of the viewer.
103 In Finland approximately 80 - 85% depending on the engineering degree (TEK 2010b and UIL 2010).

Engineering ethics has gained acceptance as part of the curriculum since 1970s, but is still rather limited in practice (Zandvoort et al. 2000), although the researcher argues that because of complex transdisciplinary problems related to environmental and social sustainability, and two major trends in the business environment, technological convergence (Allenby et al. 2009) and opening up of the business environment (Chesbrough 2003 a,b), would call for increased understanding and ability to take responsibility for the role of engineering as part of the society.

Company-internal R&D is no longer such a strategic asset and companies have different successful strategies in generating new ideas and bringing them to market, which has a fundamental impact on development of technology, including university research (Chesbrough 2003a,b). Rapid business model prototyping and increasing understanding of how technological innovations shape social practices require multidisciplinary and open collaboration in the value network (Chesbrough 2003b). The simplistic categorization between basic and applied research, and applied research following basic research does not work (Stokes 1997).

The researcher argues that this paradigm shift towards open innovation has a fundamental impact not only on engineering research but also on engineering education. The core challenge to overcome is the stereotype of an engineer as only a problem solver of a well-defined technical problem (Downey 2005); the constructivist approach of the relationship between technology and society calls for a multi-fold identity of engineering education (Jørgensen 2007). New types of expertise are needed in the knowledge economy, because collaborative learning, networking and creative learning have become key concepts in organizational development (Tynjälä et al. 2006). Collaborative learning skills are important in enabling shared expertise. In learning frontier technologies the constructivist collaborative learning approach is valuable because of the lack of established material, multidisciplinary nature and likeliness of new developments not yet known (Brintrup & Ranasinghe 2008).

A major driving force impacting engineering education and research is the converging of nano-, bio-, robotics, information and communication technologies as well as cognitive science, NBRIC (Allenby et al. 2009). The implications of NBRIC may be deeply fundamental, because they offer an opportunity for such complex system changes that have never been possible: "Thus, what is most challenging, perhaps, about technological convergence is not merely its effect of turning natural systems, from the carbon and climate cycles to biology at all scales, into design spaces (and commodities). Rather it also turns the human into a self-reflexive design space. In doing so, the feedback systems, and concomitant increases in system complexity, become truly daunting."(Ibidem, 9). Engineering graduates need systems understanding of technologies. This is needed in order to be able to survey the surrounding knowledge landscape of a specific technology and to envision how to integrate promising discoveries into new systems and architectures (Chesbrough 2003b).

The growth of the service sector[104] as part of the economy is may be observed as a trend in developed countries (Turner 2001, OECD 2008), including Finland (Vartia & Ylä-Anttila 2003), during the entire 20th century. The growth of service sector that is especially related to the development of the

104 Turner (2001) argues that there are two main reasons behind the growth of the service sector and one that plays a minor role. The two main reasons are the changing customer preferences to spend more on services when basic needs are met and faster increased productivity in manufacturing compared to services. The one with a minor impact has been the vertical disintegration resulting in outsourcing of non-core functions.

engineering profession is the increasing importance of knowledge-intensive business services (KIBS)[105]. The importance of system and network approach combined with the increasing importance of services in the economy, including KIBS, has led to introducing new degree programs. Master's programs in engineering with a system and service focus[106] have emerged, providing tuition in service management, engineering and design (Korhonen-Yrjänheikki et al. 2007).

A trend of increasing importance of KIBS as part of economic activity is anticipated to continue (Toivonen 2004). Engineering graduates need to be increasingly skilled in understanding value creation and management (Yannou & Bigand 2004, Spinks et al. 2007), and also specific programs are needed focusing on value management (Yannou & Bigand 2004). The researcher argues that growing importance of KIBS as part of economic activity is related also to the increasing needs to provide engineering graduates with strong interpersonal and entrepreneurial skills.

The needs to develop the abilities of engineering graduates in multidisciplinary and –cultural teamwork including communication skills is brought up in several studies in Finland (for example Korhonen 1997, Allt & Suutari 2002, Olin et al. 2002, Mäkitalo-Keinonen 2006) and elsewhere (for example Rompelman 2000, Meier et al. 2000, Graaf & Ravesteijn 2001, Martin et al. 2005, Spinks et al. 2007). Interpersonal skills[107] are among the most needed competences at daily work according Finnish engineering professionals (Allt 2006, Savolainen 2010). However, what the researcher finds worrying is that communication and interpersonal skills are brought up by Finnish engineering graduates (Allt & Suutari 2002, Vuorinen & Valkonen 2007), as well as employers[108] (Mäkitalo & Keinonen 2006), as skills where most skills gaps exist.

The identified need to develop the interpersonal skills of engineers is not new, and was brought up already in 1980s, as an example, by Lesley & Vogt (1985). However, the need to work in teams and to interact closely with customers, suppliers and other partners external to the organization means that there is a growing need to develop interpersonal skills of engineering graduates (Spinks et al. 2007). The researcher argues that basically this phenomenon in the larger societal context is related to the opening up of the innovation system and skills enabling shared expertise.

Engineering graduates are not skilled in identifying their personal strengths and limitations, although this would be important later in the labor market (Scott & Yates 2002, Vuorinen & Valkonen 2007). In a survey conducted among Finnish engineering professionals it was found that 40% are not satisfied with their capability to articulate and phrase their competence to non-engineers (Savolainen 2010). This may be regarded as a significant hindrance to realizing shared expertise, and from an individual point of view, a challenge for continuous professional development.

Because of the changing skill needs expected from engineering professionals, one of the key competencies for engineering graduates is lifelong learning (Korhonen 1997, Allt & Suutari 2002, Martin et

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105 KIBS was first used as a term in 1995 by Miles et al. (Toivonen 2004, 17). Toivonen (2004, 208-209) defines KIBS as "private service companies which sell their services on markets and direct their service activities to other companies or to the public sector. They are specialized in knowledge-intensive services, which means that the core of their services is contribution to the knowledge processes of their clients, and which is reflected in the exceptionally high proportion of experts from different scientific branches in their personnel."

106 Metropolia introduced in Autumn 2006 a Master's program in service management. At present also Aalto University provides degree programs of Service Design and Engineering as well as Service Management and Engineering.

107 Hayes (2002, 3 - 20) defines interpersonal skills: "goal directed behaviours used in face-to-face interactions in order to bring about a desired state of affairs." Interpersonal skills consist of three hierarchical components: primary (ability to select the most suitable verbal components and non-verbal cues to situation at hand), structure (ability to sequence the primary components of behavior) and style (ability to use an approach interaction that is congruent with own objectives and with the probable reactions of others involved).

108 The study is limited to employers of engineers graduated from polytechnics with a B.Eng degree.

al. 2005, Korhonen-Yrjänheikki 2009b, Keltikangas & Allt 2009). It is simply not possible to provide an engineering student with all the knowledge he might need when entering the professional practice. "A skill, an activity, a method of applying engineering, even the forms of contracting, the way in which projects happen, how they are funded – you name it, it's changing all the time."(Spinks et al. 2007). A survey conducted among Finnish engineering professionals indicates that on average 50% of tasks change every three years[109] (Savolainen 2010). Finnish engineering professionals use on average 40% of their working hours on learning (Ibidem).

The lifelong learning competence is based on the ability and willingness to learn (Korhonen 1997), thus, this competence may be regarded to consist of a skill as well as a value component. Attitudes related to lifelong learning skills are willingness and courage to change and improve, internal entrepreneurship and willingness to serve customers (EK 2006). Graaf & Ravesteijn (2001) argue that active learning methods, like problem- and project-based learning, are essential in order for the student to learn to take responsibility for their own learning, which is a necessity in order for the student to acquire an attitude of lifelong learning. The researcher argues that from the viewpoint of social constructivism, arguing that learning is acculturation into knowledge communities through reflective inquiry (See for example Vygotsky 1978), the ability for lifelong learning is closely related to collaborative learning.

Downey (2005) suggests the introduction of five different tracks in engineering curriculum – science, design, management, policy and general - , and accepting that what the tracks lack in depth and breadth should be complemented with continuing education depending upon one's career choice. Spinks et al. (2007) suggest that these roles of an engineering graduate as specialist, integrator and change agent cannot be separated, although it is evident that any single person cannot fulfill all the three roles at the same time and equally capably. Operating in a complex global business environment requires a systems approach, and industry looks for engineering graduates with a combination of technical expertise, strong interpersonal skills and awareness of commercial realities.

To summarize, engineers today need to handle non-standardized social and technical processes where problems are undefined and new ways of combining interdisciplinary knowledge are needed (Graaf & Raavesteijn 2001, Downey 2005, Jørgensen 2007, Allenby et al. 2009). A solid knowledge of natural sciences and expertise in technology need also in the changing society to form an essential part of engineering education, but focus on science and technology and deep technical expertise in a narrow field of technology is simply not enough (Korhonen 1997, Graaf & Ravesteijn 2001, Scott & Yates 2002, Kerns et al. 2005, Vest 2005, 2007, Crawley et al. 2007, Spinks et al. 2007, Keltikangas & Martinsuo 2009).

Convergence of technologies (Allenby et al. 2009) and opening up of the business environment (Chesbrough 2003 a,b) call for increased interdisciplinarity and understanding of systems architechture, but this is only part of the challenge. Engineers need to understand the broader societal context of their work (Zandvoort et al. 2000, Johnston et al. 2000, van de Poel 2001, Graaf & Raavesteijn 2001, Spinks et al. 2007, Allenby et al. 2009). If engineering is to serve the welfare of people and environment including enhancing sustainable development, engineers need to be able to take responsibility for the social, economic, and environmental implications of technology (Johnston et al. 2000, van de Poel 2001, Graaf & Raavesteijn 2001, Allenby et al. 2009).

The paradigm shift to open innovation (Chesbrough 2003a,b) integrates engineering professionals into value networks where they need to be able to work closely with customers, suppliers and other

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109 The pace of change varies during the course of the career. The younger the engineering professional, the faster the change of tasks. In the age group of 32-years, the change rate is 50% every two years, while in the age group of 58 years the pace of change is 50 % every five years. (Savolainen 2010: Note that study is limited to M.Sc.(Tech.) professionals)

stakeholders, understand customer needs, value creation and business (described through the approach of changing skill needs for example by Graaf & Raavesteijn 2001 Yannou & Bigand 2004, and Spinks et al. 2007). Technology has no value per se, and it remains latent until technology is commercialized (Chesbrough 2003b). Managers of R&D play an important role in the development and execution of the business model[110] (Chesbrough 2003b), and for that, engineering graduates need commercialization and business skills.

Strong interpersonal, communication and teamwork skills, ethical responsibility and tolerance are needed in order to be able to work in multicultural and virtual contexts characterized by uncertainty, constant change and a need for the whole-systems approach (see Schamer 2009 for the description of increasing dynamic, social and emergent complexity). Behavioral- and value-related abilities and skills are part of the core of the engineering competence. Expertise and becoming an expert is best described as a phenomenon of knowledge creation combining individual knowledge acquisition and the socio-cultural perspective suggesting that it is a social phenomenon (Helle et al. 2006). The researcher argues that in this business environment the ability for continuous professional development and collaborative learning skills allowing to enhance individual and shared expertise is absolutely necessary.

How to educate these future engineers to meet the needs of the changing society? It is not always possible to add new subjects to the curriculum. Moreover, all skill needs cannot be met only by adding separate courses, such as ability for lifelong learning and strong interpersonal skills. Furthermore, as Spinks et al. (2007, 333) point out, "it is not clear to what extent all of the skills sought by industry can be developed solely at university…there was also a strong support amongst the interviewees for ensuring that undergraduates gained relevant industry experience, including vacation work, prior to graduation." Keltikangas & Martinsuo (2009) also argue that in professional socialization not only the education in the learning context of university plays an important role but also job opportunities in the industry.

And above all, we cannot even know what kind of skills are needed in the future, when today's students graduate. The researcher agrees with Vest (2005, 2007) with the priority of developing the context of learning to emphasize learning methods that activate and empower students over the changes in the engineering curriculum: "Although we cannot know exactly what they should be taught, we can focus on the environment and context in which they learn, and the forces, ideas, inspirations, and empowering authentic situations to which they are exposed… In the long run, making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering milieus is more important than specifying curricular details" (Vest 2005, 161). Unfortunately pedagogy is not among the present core strengths of the engineering discipline.

4.3 CONTEXT OF LEARNING AND STAKEHOLDER APPROACH

Several reasons are suggested to underlie the undeveloped engineering pedagogy. Naukkarinen (2006, 164) argues based on her empirical observations during case studies on learning environment in engineering education that the blurred identity of engineering science is the key reason behind undeveloped engineering pedagogy: "Although most of the people familiar with the discipline acknowledge and appreciate the both, theoretical and practical side of this knowledge, it is still rather unclear when and how to teach these knowledge elements to engineering students in such a way that they interconnect and

110 Business model consists of articulation of the value created for users, identification of market segment, definition of value chain required to create and distribute the offering, specification of revenue generation mechanism, positioning of the company within the value network, and formulation of competitive strategy (Chesbrough 2003b, 64 – 65).

support each other in the best possible way."

Malmi (2005) suggests more practical reasons hindering the development of research on engineering pedagogy. First, the traditional view on teaching and learning is mainly transfer of knowledge from teachers and study material to students. Second, due to the lack of pedagogic studies, teachers do not even have capability to question the dominant view of teaching and learning. Third, although good and inspiring teachers exist, they do not always have enough theoretical and methodological knowledge and skills in order for to carry out rigorous research on engineering education.

The growing interest to research and develop the engineering pedagogy is a world-wide trend. Manifestations of the increasing interest in engineering education research in Europe are the setting up of the working group of engineering education research year 2008 in the European Association of Engineering Education SEFI, and the first special issue of European Journal on Engineering Education on engineering education research year 2009 (Baillie & Bernhard 2009). Journal of Engineering Education, published by the American Society of Engineering Education ASEE in US, provided a special issue on development on engineering education research in 2005 aiming, to support the development of engineering education research as a rigorous discipline (Lohmann 2005).

Problem- and project based learning, and a combination of them, are spreading in engineering education communities allover the world (Graaf & Kolmos 2007). The development of the learning context towards problem-based learning aims to increase the motivation of students to learning and to enhance the development of interdisciplinary skills and collaborative learning. Graaf & Kolmos (2003) call these the three main learning principles of PBL: learning approach (motivation), contents approach (interdisciplinarity) and social approach (team learning).

Some researchers, like Savin-Baden (2000) and Prince & Felder (2006) see problem- and project-based learning as different approaches. Others, such as Boud (1985: In Savin-Baden 2007) and Graaf & Kolmos (2007), think that they are part of the same phenomenon. What is common to both approaches is that students are at the center of the learning process. The researcher is of the opinion that the definition of Graaf & Kolmos (2007,1) of problem-based learning captures the essence: "A method to organize the learning process in such a manner that the students are actively engaged in finding answers themselves."

The researcher finds the suggestion by Margetson (1991) relevant, concerning the recommended preference of problem-oriented learning over of problem-based learning. There is a need to make obsolete the assumption in higher education pedagogy – including engineering education - that knowledge is certain. The term problem-oriented learning emphasizes the open-ended nature of problems.

Conway & Little (2000) suggest that problem-based learning is applied in two ways: as a basis of the whole curriculum design or an instructional strategy as one teaching approach among others. The researcher suggests that in addition to these two approaches, there is a third category, the most far-stretched version of problem- and project-based learning where the organizational and management structure of the institution as a whole is planned to support problem- and project-based learning. Using the terminology of Kolmos & Graaf (2007, 34 – 35), this is the approach emphasizing both the changing of the curriculum layer, as well as the organizational and values layer.

Below are examples of all of these approaches. The CDIO-approach described below is an example of problem- and project-based learning as a basis for the whole curriculum design. Olin College in the US in an example of the most fundamental change where the whole organization is devised to support problem- and project-based curriculum. Aalto University in Finland is an example of an university that is committed to develop student-centered active learning methods, and thus may be regarded as an institution applying participative learning methods, including problem- and project-based learning, as an instructional strategy.

From the approach of this study, it is interesting that in addition to the strong emphasis on the development of the learning context towards active experiential learning emphasizing interdisciplinarity, all of the described three examples share a strong emphasis on the collaboration of stakeholders in developing engineering education. Students, staff, industry and alumni, either as a separate stakeholder group or part of the industry, collaborate for the development of engineering education. In case of CDIO, there is also a strong emphasis on collaboration of higher education institutions.

The CDIO-approach[111] was originally developed by four universities collaboratively: Chalmers University of Technology, Royal Institute of Technology KTH, Linköping University of Technology, and the Massachusetts Institute of Technology MIT. At present there are more than 20 universities world-wide collaborating in the initiative (Crawley et al. 2007, 4). The CDIO-approach aims to develop the context of learning to solve the conflicting pressures of the multi-fold identity of engineers between science versus practice, and specialist versus generalist (Ibidem). It is primarily planned for Bachelor's programs in engineering but may be applicable to Master's programs as well (Gunnarson 2007). Discipline-specific skill needs and interpersonal and system building skills are combined in an integrated curriculum aiming to educate students that are able to "conceive, design, implement and operate complex, value-added engineering products, processes and systems in a modern, team-based environment"(Crawley et al. 2007, 1). Engineering fundamentals are still at the core of the curriculum, but through project- and problem-based learning, the students develop also their interpersonal and system building skills, and how engineering contributes to the development of the society.

In the CDIO-approach, stakeholders are directly involved in setting the learning objectives of engineering education. The key stakeholders are identified to be students, industry, university faculty, and society at large. The alumni are viewed as part of the stakeholder group of industry (Crawley et al. 2007). The researcher argues that also another principle in the CDIO-approach, the open source approach and collaboration of higher education institutions for reforming the engineering education, is an essential part of the stakeholder-approach in CDIO, although Crawley et al. (2007) do not recognize this system-level collaboration as part of it.

Olin College[112] in Massachusetts in US, established in 2001, is an example of an institution applying problem- and project-based learning as a guiding principle in the curriculum as well as an organizational structure and management system as a whole. There are no academic departments in the Olin College, but the faculty members work in interdisciplinary teams. Requirements for the pedagogic skills of the faculty are high, and they are expected to constantly develop them in addition to carrying out rigorous research in their own field. The curriculum is designed to educate not only a technological specialist, but a whole person that has "a superb command of engineering fundamentals, a broad perspective on the role of engineering in society, the creativity to envision new solutions to problems and the entrepreneurial skills to bring these visions into practice (Kerns et al. 2005, 106)". Students are involved 20 – 60% of their time in interdisciplinary project work during every semester. During the four years of Bachelor studies the share of project work increases. Students are allowed a lot of flexibility and choice in study contents, but they are also accountable for meeting the demanding learning objectives. (Kerns et al. 2005)

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111 For more information on the CDIO-initiative see Crawley et al (2007) or www.cdio.org

112 The researcher visited the Olin College in the formation stage of the higher education institution in November 2001 and had the chance to discuss the principles of Olin as an institution as well as the curriculum with the founding President Richard K. Miller.

In case of Olin College, the entire curriculum is designed with a broad stakeholder approach and the continuous improvement principle involves university-internal and -external stakeholder groups. In the formation stage of the curriculum, faculty groups of two or three visited 31 higher education institutions and 23 corporations and government agencies. Consultants were brought to campus to discuss specific topics regarding curriculum development. 30 Olin student partners were recruited to design and test the curriculum in-between fall 2001 and fall 2002 when the first students arrived. The curriculum is based on institutionally defined learning objectives that are assessed not only by the instructor of a given course but annually also by the institution and outside evaluators. Students need to pass so called "gates" at the end of every year, where they need to show that they master both theory and practice in interdisciplinary assignments. During their studies, students gather extensive industrial experience, thus industry is an essential part of the learning environment.

An example of a new interdisciplinary initiative for developing the context of learning in the Finnish engineering education is the founding of Aalto University. It was established at the beginning of year 2010 as a result of a merger of three universities: Helsinki University of Technology (engineering), Helsinki School of Economics (business) and University of Art and Design (art). The university is foundation-based with a capital of 700 million € out of which 500 million € is donated by the Government and at least 200 million € are donated[113] by industry, alumni and other stakeholders.

The mission of Aalto University is "to change the world through top-quality interdisciplinary research pioneering education, surpassing traditional boundaries, and renewal. The Aalto University educates responsible, broadminded experts with a comprehensive understanding of complex subjects to act as society's visionaries." A student-centered culture that encourages passionate problem- and project-based learning is an aim set for the university.

Aalto consists of six schools that operate in the fields of engineering, business and art. Interdisciplinary problem- and project-based learning in co-operation with companies and other stakeholders is strongly present in three platforms combining teaching and research: Design Factory, Service Factory and Media Factory. The practical achievements and implications for the engineering curriculum and context of learning remain to be seen. (Charter of Aalto Foundation 2009, www.aalto.fi[114])

Students, staff, industry and alumni were involved in various ways in forming Aalto university. Open consultation processes were also carried out virtually. The process of founding Aalto University was challenging, requiring significant changes to the Universities Act in Finland as well as overcoming pressures from regional politics. The researcher argues[115] that without the strong commitment manifested especially by industry but also the alumni of engineering and business graduates, there would be no Aalto University. Furthermore, the researcher suggests that in international comparison an exceptionally close and long-tradition of industrial co-operation in the engineering discipline played a vital role in the foundation of the university. The relationship of the Finnish engineering education with industry is discussed further in the next chapter describing the long-term development and present state of the Finnish engineering education.

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113 The founding partners of Aalto University were Government, the foundations related to the Confederation of Finnish Industries, The Federation of Finnish Technology Industries and its 100-year Foundation, TEK and The Finnish Association of Business School Graduates SEFE. In October 2010 the collection of donations for the foundation capital from industry and other stakeholders co-ordinated by the Confederation of the Finnish Industries was still going on.

114 Strategy of Aalto University (in Finnish) http://www.aalto.fi/fi/about/strategy/AALTO_strategia_FI-II-01_korjattu.pdf

115 The researcher represented one of the founding partners, TEK, in preparing the founding charter of the foundation and participated in the stakeholder group invited to comment on the preparation of the strategy of Aalto University.

5 LONG-TERM DEVELOPMENT AND PRESENT OF THE FINNISH ENGINEERING EDUCATION

This chapter discusses the long-term development and present of the Finnish engineering education.

Chapter 5.1 discusses the relationship between the Finnish engineering education and industry – theory and practice. The development of the formal system of engineering education in Finland is described in Chapter 5.2. The engineering education system at present is described in Chapter 5.3. Chapter 5.4 provides an overview of the statistics describing the long-term development and present of the Finnish engineering education.

Empirical results of the study analyzing the history and present of the Finnish engineering education in the stakeholder processes of the study are depicited in Chapters 5.5 – 5.6. The history of the Finnish engineering education was analyzed at the Open Futures Search event and results are presented in Chapter 5.5. Results of the analysis regarding the present state of the Finnish engineering education in the stakeholder processes Argument Delphi, Open Futures Search and Collaboration Group are presented in Chapter 5.6.

A summary of the long-term development and present of the Finnish engineering education is presented in Chapter 5.7. The summary synthesizes also the key findings from Chapter 4 that are relevant from the viewpoint of analyzing the Finnish engineering education.

5.1 FINNISH ENGINEERING EDUCATION AND INDUSTRY INTERTWINED

The beginning of the engineering profession in Finland can be dated to the 17th century. Architect-engineers in the Middle Ages had the technical knowledge and skills to be called the first representatives of the engineering profession. However, organized education and professional organizations were still missing and architect-engineers operated more as individuals than representatives of engineering profession (Michelsen 1999).

In the 17th century, engineers were responsible for developing the artillery and fortresses. They had a lot of strategic military power, but their power was invisible since they were the loyal servants of kings and emperors. Engineers did not identify themselves with the profession but with the estates.(Ibidem)

The job description of engineers broadened heavily in the18th century. However, engineers did not have an independent professional status and most of them were employed as civil servants. Most engineers in Finland got their basic knowledge in natural sciences in Swedish universities and learned engineering skills through learning at work. Surveyors formed the first group in Sweden and Finland that can be called the engineering profession. Technical experts in the sawmills and ironworks were the first engineers that worked for the private industry. (Ibidem, 60 - 85).

Before industrialization, engineers struggled between lawyers dominating administration and farmers dominating production (Ibidem, 84 – 91). The origin of the modern engineering profession[116] is closely connected to industrialization and construction of the needed infrastructure that started in 1850s (Aunesluoma 2004).

116 The oldest professional organization of engineers in Finland is the association of Swedish-speaking engineers Tekniska Föreningen i Finland (TFiF) that was founded in 1880. One of the predecessors of the present professional organization of engineers graduated from universities with Finnish as their mother tongue, Academic Engineers and Architects in Finland - TEK, was founded in 1886 and called the Association of Finnish Technicians STS (Aunesluoma 2004). The origins of the present professional organization of engineers graduated from polytechnics, Union of Professional Engineers in Finland UIL, date back to 1919, when the Society of Technicians in Tampere was founded.(www.uil.fi)

The profession of engineers in Finland differs from other academic professions like doctors or teachers in the way the profession was formed (Michelsen 1999). The modern engineering profession was not developed by administrative decisions on the engineering education, but rather as a co-operation of industrial stakeholders and research and teaching of natural sciences. Among the key features shaping the Finnish engineering education has been the close co-operation with industry (Hautala et al. 1995, Orelma 1996, Michelsen 1999, Aunesluoma 2004). Hautala et al. (1995) suggest that actually Finnish engineering education has not been perceived as part of the education system, but rather as an industrial support function.

The tight co-operation with industry characterizing the Finnish engineering education has provided strengths but also drawbacks. Michelsen (1999) argues that because of that, during the formation stage of the Finnish engineering education, Finnish engineers became appliers and transferors of technology, not developers. During 1875 – 1914, 72% of all patents in Finland were granted to foreigners (Kero 1987 in Michelsen 1999, 177).

Despite of the efforts of teachers and professional organizations, only in 1922 Helsinki University of Technology got appropriation for the establishment of the laboratory in electronics and the plan on building laboratories also in machinery, textile, paper and mechanical wood industry (Michelsen 1999, 259 – 260). Compared to other countries in Europe, Finland was a developing country in engineering research. During 1908 – 1932 only three engineers got their PhD in Helsinki University of Technology. Some enterprises, like Valio, had their own laboratory, but on average the research intensiveness of the industry was low, and the innovation system as a whole undeveloped (Michelsen 1999).

The close co-operation with the industrial practice has provided also a lot of strengths. As Table 5.1 indicates, IMD (2009) ranks[117] knowledge-transfer between universities and industry in Finland as the second best in the world. Among different disciplines in Finnish universities, engineering is considered to be an example of very good R&D co-operation with industry that for example business schools are trying to learn from (Keso et al. 2003). The researcher suggests that perhaps it is not a coincidence that in the field of electrical engineering , in which the relation between theoretical teaching and industrially developed technologies is especially close (Jørgensen 2007, 224), the leading innovator of mobile phones in the 1990s, Nokia, came from Finland.

117 The survey targeted to top and middle management of the enterprises in the 57 economies covered by the World Competence Yearbook. In 2009, approximately 4 000 managers participated – on average 70 per country. The questions only concern the country in which the executives work and have resided in for the past year (IMD 2009, 474).

Table 5.1 International comparison of how developed knowledge transfer is between universities and companies (IMD 2009, 467).

Knowledge transfer between universities and companies (IMD 2009)					
Ranking	**Country**	**Ranking**	**Country**	**Ranking**	**Country**
1	Switzerland (7.01)	16	Hong Kong (5.75)	31	Jordan (4.32)
2	Finland (7.00)	17	Japan (5.58)	32	Thailand (4.27)
3	Singapore (6.84)	18	Taiwan (5.43)	33	Korea (4.25)
4	Denmark (6.76)	19	Belgium (5.36)	34	Hungary (4.15)
5	Netherlands (6.64)	20	India (5.10)	35	Czech Republic (4.00)
6	Sweden (6.61)	21	Luxembourg (5.07)	36	Estonia (4.00)
7	Israel (6.47)	22	Turkey (5.00)	37	Poland (3.89)
8	Canada (6.33)	23	Qatar (4.99)	38	France (3.85)
9	Ireland (6.26)	24	United Kingdom (4.81)	39	Brazil (3.85)
10	Germany (6.09)	25	Philippines (4.72)	40	Peru (3.75)
11	Norway (6.00)	26	New Zealand (4.68)	41	Italy (3.68)
12	USA (5.91)	27	Portugal (4.52)	42	Argentina (3.67)
13	Austria (5.90)	28	Chile (4.51)	43	Kazakhstan (3.66)
14	Malaysia (5.85)	29	Lithuania (4.43)	44	South Africa (3.59)
15	Australia (5.80)	30	Romania (4.32)	45	Bulgaria (3.53)

In 2009 the share of university funding from enterprises in fields other than engineering was on average 3.7%, while in engineering the share was 11.2%. The total share of funding external to the state budget at universities was in fields other than engineering on average 32.6%. The corresponding share in engineering was 47.3%. (KOTA-database)

The most common ways of co-operation between polytechnics and industry are traineeships and Bachelor's theses. Mäkitalo-Keinonen (2006) found in a study consisting of interviews of 52 organizations representing employers of B.Eng that 4 out of 5 large companies, and every other SME, had also other forms of co-operation. 4 out of 5 had also organized company excursions, and 3 out of 5 had provided a guest lecture. R&D co-operation was carried out in 2 out of 5 organizations. Interviewees were mostly satisfied with the co-operation with polytechnics, but suggested that co-operation could still be more systematic.

The amount of work experience is an important factor in the recruitment of graduates in Finland (Kivinen et al. 2002). Roughly 50% of M.Sc.(Tech.) and B.Eng graduates begin their career in an organization where they completed their thesis or traineeship (TEK 2008, Koivumäki 2008). Figure 5.1 illustrates that M.Sc.(Tech.) graduates have on average two years of work experience related to their studies, which is roughly 80% of all work experience gathered during studies. The median amount of work experience related to studies is lower, in 2009 approximately 1.5 years. However, engineering students at universities often get work experience also during their Master's thesis (median duration 8 months), which is not included in the figures presented on work experience. Thus, the researcher estimates that almost two years of studies-related work-experience illustrates a typical Finnish M.Sc.(Tech.) graduate .

Only one in four students writes his or her Master's thesis for the university. 3 out of 5 students complete their Master's thesis for the private industry or services. Roughly 2 out of 3 students get salary during their Master's thesis. The median salary of those graduated in 2008 and 2009 was roughly 2 000 € per month. Only 8% of those graduated in 2008 and 12% of those graduated in 2009 did not acquire any funding for their Master's thesis (TEK 2010a).

Work experience of M.Sc.(Tech.) graduates years 2000–2009

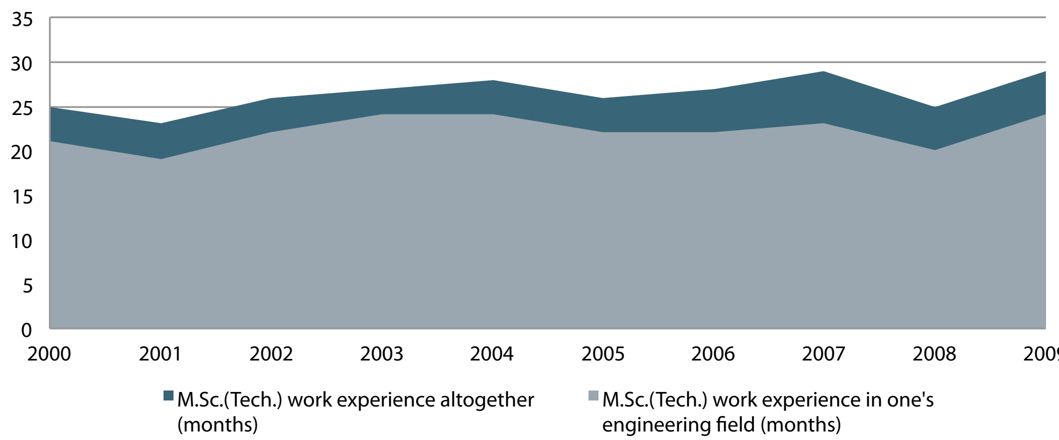

Figure 5.1 Work experience of 2000 – 09 graduated M.Sc.(Tech.) students at the time of graduation. Source: TEK surveys 2000 – 09 on recently graduated M.Sc.(Tech.) students[118].

Figure 5.2 illustrates that B.Eng graduates have on average roughly 1.5 years of work experience related to their studies, when they graduate (UIL surveys 2000 – 09 on recently graduated B.Eng students[119]). In addition to studies-related work experience, they have a considerable amount of other work experience. Roughly 50% of the gathered work experience is not related to one's engineering field. It is noteworthy that between average and median work experience, there is a considerable difference. In 2009 the average amount of studies-related work-experience was 20 months and the median 12 months. The amount of work experience related to B.Eng thesis is not included in work experience. Thus, it may be concluded that a typical B.Eng graduate has studies-related work experience 1 – 1.5 years.

118 Statistics not published. Available for TEK members only at www.tek.fi . Results from the surveys 2000 – 07 compiled by Jarna Savolainen, years 2008 - 09 by the researcher.
119 Not published. Statistics obtained from UIL (Aila Tähtitanner).

Work experience of B.Eng graduates years 2000–2009

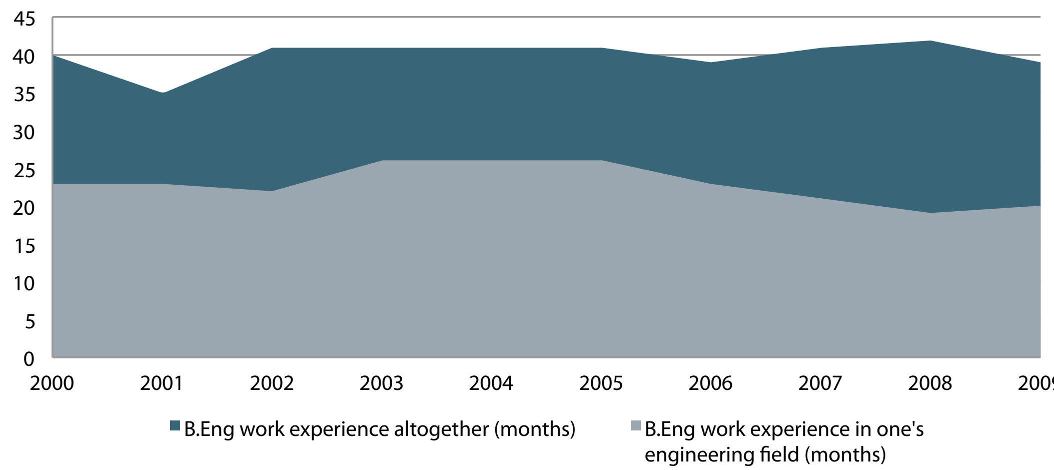

Figure 5.2 Work experience of 2000 – 09 graduated B.Eng students at the time of graduation. Source: UIL surveys 2000 – 09 on recently graduated B.Eng students.

The researcher suggests that the share of graduates that get employed after graduation through contacts created during practical training or thesis work, may be used as one factor for assessing the interaction with practice in engineering education. Hautala et al. (1995) call this indicator the labor market intensity of engineering education.

Upon examination of the labor market intensity of the Finnish engineering education during 1960 – 2009, presented in Table 5.2, one may observe that it follows a similar pattern that Crawley et al. (2007) describe as general evolution of the engineering education, but the stressing of science over practice after the second world war until 1980s never was as dramatic as they illustrate.

In 1960 the labor market intensity of the Finnish engineering education was 0.4. It decreased fast during 1960 – 70[120], and was 0.2 – 0.3 until the beginning of 1980s. Thereafter, it has increased and reached the level of 1960s in the beginning of 1990s (Hautala et al. 1995). Between 2007 – 09 the labor-market intensity was 0.5[121] (TEK and UIL surveys on 2007 – 09 graduated engineers).

120 Year 1969 the administrative steering of the Finnish engineering education was transferred from the Ministry of Trade and Industry to the Ministry of Education, which illustrated the separation from the industry.

121 Except for 2008, when labor-market intensity of M.Sc.(Tech.) engineers was 0.56 (TEK research on recently graduated engineers 2009), but because among B.Eng graduates the figure was 0.52 (UIL research on recently graduated engineers 2009), among all engineering graduates this rounds off to 0.5.

Table 5.2 Labor-market intensity of the Finnish engineering education during 1960 – 2009. Sources: 1960 – 1990 Hautala et al. (1995, 46). 2007 - 09 TEK and UIL surveys on recently graduated engineers.

Year	Labormarket intensity
1960	0.4
1970	0.2
1980	0.3
1990	0.4
2007	0.5
2008	0.5
2009	0.5

Bearing in mind the labor market intensity index, the formation of the Finnish engineering education rather as part of industry than the educational system (Hautala et al. 1995), and ranking of Finland as the second best in the world in the knowledge transfer between universities and industry (IMD 2009), the researcher argues that the relationship between industry and engineering education is in international comparison exceptionally close.

However, despite the close co-operation with stakeholders, the researcher claims that Finnish engineering educators have not succeeded optimally in integrating the learning environment at the higher education institution and practice in industry. As suggested by Naukkarinen (2006), based on case studies on learning environments in the Finnish engineering education, the combination of theory and practice is often left for the student to do, and curriculum and pedagogic management does not enhance integration of theory and practice. This may explain why studies aimed at employers (Mäkitalo- Keinonen 2006) as well as Finnish B.Eng graduates themselves (Vuorinen & Valkonen 2007) suggest that education does not provide enough practical orientation, although studies of UIL on work experience of B.Eng graduates during 2000 – 09 show that the typical B.Eng graduate has 1 – 1.5 years of work experience related to studies.

Allt & Suutari (2002) report similar problems in integrating theory and practice in the M.Sc.(Tech.) education in a survey directed to M.Sc.(Tech.) graduates, although the typical M.Sc.(Tech.) graduate has 1.5 – 2 years work experience related to studies (TEK research on recently graduated engineers between 2000 – 09). One third of M.Sc.(Tech.) graduates brought up that their education was too theoretical, and four out of ten were of the opinion that their education was too separated from working-life, although almost all were of the opinion that the education provided good qualifications for employment (Allt & Suutari 2002).

The researcher argues that the skills shortages of engineering graduates in meeting the labor market needs especially in interpersonal, teamwork, communication and management skills in the multidisciplinary and –cultural business environment, discussed in the framework of the changing society in Chapter 4.2, is one factor behind the criticism for the lack of practical-orientation.

5.2 DEVELOPMENT OF THE FORMAL SYSTEM OF EDUCATION

The key features impacting on identity of the profession and its development are the established system of education and generally recognized degrees (Aunesluoma 2004). According to the theoretical approach, applying Boisot (1998), only formal education enables the functioning of the four-stage social learning cycle[122] and enhances systematically the development of engineering knowledge.

The pre-phase of the formal engineering education were the Sunday and evening schools that were regulated by tsar Nikolai 1 in 1842 (Orelma 1996). The beginning of the formal engineering education in Finland dates back to 1849, when the Technical Schools of Helsinki, Turku and Vaasa were founded.

The legislation concerning the industrial schools was prescribed in 1885 (Orelma 1996, Aunesluoma 2004). Industrial schools providing engineering education in Finnish were established in Kuopio, Tampere and Viipuri and in Swedish in Helsinki and Vaasa. The established industrial school in Turku provided engineering education in Finnish and in Swedish (Aunesluoma 2004).

Depending on the extent of prior education, the required practical work experience in a technical field was 12 – 24 months. The practical working experience was emphasized also during studies. In order to leave enough time for work, the academic year lasted only 6 months. The studying time was two years and 60 – 70% of the admitted students passed the school. The graduated students were technicians working, for example, as foremen and engine drivers. (Orelma 1996)

In 1911 the studying time in industrial schools was prolonged to three years. At the same time the Technical Institute of Tampere was founded. The studying time in the technical institute was also three years, but the academic year lasted nine months instead of six in industrial schools. The aim of the education was also more demanding than in industrial schools: many-sided technical education for professionals working for example as production and planning engineers. The founding of Tampere Technical Institute can be interpreted as the start of the professionally-oriented Bachelor-level engineering education in Finland. (Orelma 1996)

The three-level structure of technical education was finalized in the 1930s (Michelsen 1999, 297 – 298). Technical schools educating foremen represented the lowest level. The second level consisted of technical institutes – nowadays called polytechnics – and on the third level was the University of Technology in Helsinki. The Ministry of Trade and Industry was responsible for the administration of the technical education until 1969 (Hautala et al. 1995). In 1948 the studying time of technicians and Bachelors of Engineering was prolonged to four years (Orelma 1996).

In 1985 the industrial schools and technical institutes merged into technical colleges, but the three-level structure in degrees still remained. Technical colleges educated technicians and Bachelor-level engineers, and universities of technology Master-level engineers. (Orelma 1996)

The next major change in the Finnish higher education system that affected also engineering education was introduced in the 1990s, when polytechnics were introduced as part of the tertiary-level education. Former vocational and higher post-secondary colleges were merged into larger entities, called polytechnics. The piloting of polytechnics started during the term 1991 – 1992 and the first permanent polytechnics were established in 1996 (The Finnish Ministry of Education 2000a, 2006). At the same time it was decided to change the three-level structure of technical education to two-level structure, thus compatible with the Bologna process. Educational programs of technicians were finished in 1999 and changed to production-oriented Bachelor-level engineering education programs in polytechnics. (Finnish Ministry of Education 2000b).

122 See the theoretical framework of the study, Figure 2.6, illustrating I-Space of Boisot (1998).

Except for the termination of the technician education, the introduction of polytechnics to the higher education system did not change the professional engineering education as much as in several other fields of education (Hautala et al. 1995, Orelma 1996). Engineering education was already before the reform classified in ISCED classification[123] as belonging to the Bachelor-level. 2/3 of the engineering teachers in multidisciplinary institutions did not notice any change in the operations of the institution after the reform, whereas 2/3 of teachers in other disciplines noticed a change (Hautala et al. 1995).

Pilot programs in polytechnics aiming at the Master of Engineering degree were introduced in 2002 (Act 645/2001). Pilots were introduced in welfare technology. Master's degrees in polytechnics were permanently included in the educational system in August 2005 (Ojala & Ahola 2008).

The Finnish engineering education has followed the German dual-model of higher education including polytechnics (Fachhochschulen) and research-oriented universities (Michelsen 1999). The history of the research-oriented engineering education in Finland dates back to early 20th century. In 1908 the Helsinki Polytechnic Institute, founded in 1872, gained university status and the name was changed to Helsinki University of Technology TKK (Michelsen 1999, Orelma 1996). Åbo Akademi began to provide Master-level engineering education programs in Swedish in 1920.

Almost 40 years passed before the research-oriented engineering education spread further regionally. The University of Oulu was established in1959 and engineering education was provided in its faculty of technology. Tampere University of Technology TUT began to provide engineering education programs as a branch of TKK in 1965, and gained an independent status in 1972. Furthermore, Lappeenranta University of Technology LUT was founded in 1969.

Although the studies of Finnish Ministry of Education (2001, Estola 2002) indicated that in order to ensure the quality of the Finnish engineering education, the critical mass in education and research needs to be secured and no new degree rights should be granted, the pressure of regional politics was too heavy. The University of Vaasa and the University of Turku gained the right to grant M.Sc.(Tech.) degrees in 2004.

5.3 ENGINEERING EDUCATION SYSTEM AT PRESENT

This chapter provides a description on the engineering education system in Finland at present, including the provided degrees.

The higher education system in Finland consists of two complementary sectors: universities and polytechnics[124]. The key difference between the functions of universities and polytechnics is their role in conducting research and the relationship between research and education. Research is a core function in universities, whereas in polytechnics research is application-oriented and serves primarily the regional business life and its development needs. Education in universities is theoretically-oriented, whereas in

123 The International standard classification of education (ISCED) is used to describe different education levels and fields to allow international comparisons to be made. For further information on ISCED classification in general see http://www.unesco.org/education/information/nfsunesco/doc/isced_1997.htm For further on information (in Finnish) on application of ISCED to the system of education in Finland see http://www.stat.fi/tk/tt/luokitukset/popup/iscedaste.html

124 In English the term "application-oriented universities" is also used to describe polytechnics, whereas other universities are called "research-oriented universities". The Finnish Ministry of Education recommends to use the translation "polytechnics", and therefore, the researcher decided to apply it (Finnish Ministry of Education 2005b).

polytechnics the aims of education are more practically-oriented[125]. (Acts 558/2009 and 564/2009; Finnish Ministry of Education 2008a).

In the reform of the Universities Act and Act on Polytechnics in 2009, lifelong learning was added to the mission of both institutions. According to the Universities Act (558/2009, section 2): "The mission of universities is to promote free research and academic and artistic education, to provide higher education based on research, and to educate students to serve their country and humanity. In carrying out their mission, universities must promote lifelong learning, interact with the surrounding society and promote the impact of research findings and artistic activities on society…" The Act on Polytechnics (2003/351, section 4) states that among functions of polytechnics is to support continuing professional development of graduates, and in carrying out their mission, polytechnics have to enhance lifelong learning.

The new Universities Act (558/2009) also increased the autonomy of universities, minimum representation of external stakeholders in the Board, and enabled foundation-based universities. The foundation-based Aalto University was established as the result of the merger of Helsinki University of Technology TKK, Helsinki School of Economics, and University of Art and Design at the beginning of 2010. Similarly, Tampere University of Technology changed into a foundation-based university. The rest of universities, total of 15, are state-owned.[126]

The number of polytechnics is 27[127], out of which 25 belong to the administrative branch of the Finnish Ministry of Education. 14 of them are private organizations, 4 institutions are maintained by local authorities, and 7 jointly by local authorities.

At present, engineering education is provided by 7 universities (Statutes on University Degrees 1136/2009) and 21 polytechnics (Finnish Ministry of Education 2009a). There is no accreditation system for degree programs in higher education, but the right to grant degrees, degree programs available and degree targets are regulated centrally on national level. Finnish Higher Education Evaluation Council FINHEEC carries out regular evaluations of universities and polytechnics. During the term 2010 – 13 FINHEEC is planning to clarify if there is a need to join the EUR-ACE initiative and start to accredit engineering programs in Finland (FINHEEC 2010).

The degrees within the theoretically-oriented engineering education provided by universities are Bachelor of Science in Technology, Master of Science in Technology, Licentiate of Science in Technology, and Doctor of Science in Technology (Statutes on University degrees 1136/2009).[128] Practically-oriented degrees of engineering education provided by polytechnics are Bachelor of Engineering and Master of

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125 The Universities Act (558/2009) defines the mission of universities as "to promote free research and academic and artistic education, to provide higher education based on research, and to educate students to serve their country and humanity. In carrying out their mission, the universities must promote lifelong learning, interact with the surrounding society and promote the impact of research findings and artistic activities on society." The mission of polytechnics is to educate professional experts that meet the needs of the continuously developing labor market as well as research, art and culture. Furthermore, polytechnics need to support continuing professional development and conduct applied research and development that serves the needs of education, labor market as well as regional business life and its development. (Act on Polytechnics 564/2009)

126 One of the 17 universities, the National Defence University, does not belong to the administrative branch of Ministry of Education and Culture and is not regulated by the Universities Act.

127 Including also Police College of Finland which belongs to the administrative branch of the Ministry of the Interior and Åland University of Applied Sciences that operates in the autonomous Åland Islands.

128 In the field of technology, Aalto University, Tampere University of Technology and University of Oulu provide also a degree program in architecture. Aalto University provides also a degree program in Landscape architecture. The corresponding degrees are Bachelor of Science in Architecture / Landscape Architecture, Master of Science in Architecture / Landscape Architecture, Licentiate of Science in Architecture and Doctor of Science in Architecture. Universities providing engineering have also the right to grant Doctor of Philosophy degree. (Statutes on University Degrees 1136/2009)

Engineering (Statutes on Polytechnics 352/2003)[129].

Bachelor of Engineering and Master of Science in Technology are well-established degrees in the Finnish labor market. The Bachelor of Science in Technology and Master of Engineering degrees were added to the degree system in 2005. Admission to the M.Eng program requires three years of work experience after completing B.Eng degree. Employers are still often unfamiliar with the Master's degree provided by polytechnics (Ahola & Galli 2010). The B.Sc.(Tech.) degree can be regarded as an intermediate degree towards the M.Sc.(Tech.) degree. This is because general studies in mathematics, natural sciences and IT form a large part of the degree, and field-specific engineering studies are to a large extent introduced in M.Sc.(Tech.) studies. (Erkkilä 2009)

The extent of the Bachelor of Engineering degree is 240 ECTS that includes 30 ECTS of compulsory practical training. The extent of the Master of Engineering degree is 60 ECTS. The Bachelor of Science in Technology degree consists of 180 ECTS and Master of Science in Technology 120 ECTS (Statutes on degrees of universities 794/2004). The Statutes on University Degrees (794/2004) does not regulate the extent of postgraduate degrees but only what are the required parts of the degree. For example, in Aalto University, postgraduate studies[130] consist of studies of 60 ECTS in addition to the independent scientific research work. In Tampere University of Technology TUT the extent of postgraduate studies is 60 or 70 ECTS depending on whether the student follows the old or new degree structure[131] (TUT degree regulations 12.11.2007 and 7.12.2009). The optimum studying time for the Licentiate of Science in Technology degree is two years and for Doctor of Science in Technology four years, which corresponds to the studies of 240 ECTS (Ahvenniemi et al. 2009).

The universities providing engineering education are Aalto University (in presented statistics referred as TKK[132]), Tampere University of Technology (TUT), Lappeenranta University of Technology (LUT), University of Oulu (OY), University of Turku (UTU) and University of Vaasa (UV). Aalto and TUT are the two largest educators of university engineers. UTU and UV are small engineering educators that obtained the right to grant engineering degrees in 2004. Both of them provide less than 1 % of the M.Sc. (Tech.) degrees. Figure 5.3 illustrates the volume of engineering education in different universities. Appendix 16 contains a Table providing statistics from 2009 on universities offering engineering education.

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129 In the field of technology, Oulu, Jyväskylä, Metropolia, Novia and Pirkanmaa University of Applied Sciences provide also the degree of Bachelor of Laboratory Services. Metropolia, Oulu, TAMK, Turku, Saimaa, Savonia, Novia and HAMK University of Applied Sciences provide degree programs aiming at the Bachelor of Construction degree. The extent of the Bachelor of Laboratory Services and Bachelor of Construction degree is 210 ECTS. Novia, Satakunta and Kymeenlaakso University of Applied Sciences provide also degree programs in Maritime Management aiming at the degree of Master Mariner (Sea Captain). The extent of the Master Mariner (Sea Captain) degree is 270 ECTS. Additional work experience as a ship officer is required to receive a Sea Captain CoC (Certificate of Competency). (Finnish Ministry of Education decisions on degree programs 2009a)

130 General Degree Regulations of the Aalto University School of Science and Technology. 2009.
http://www.tkk.fi/en/studies/study_councelling/degreeregulations/ts_englanti_141209_eng.pdf

131 Postgraduate students admitted before 1.1.2010 are allowed to follow the old degree structure.

132 Helsinki University of Technology TKK, Helsinki School of Economics and Helsinki University of Art and Design merged and formed Aalto University on 1.1.2010. In the presented statistics Aalto University is referred to as TKK since all the statistics describe the situation before 1.1.2010.

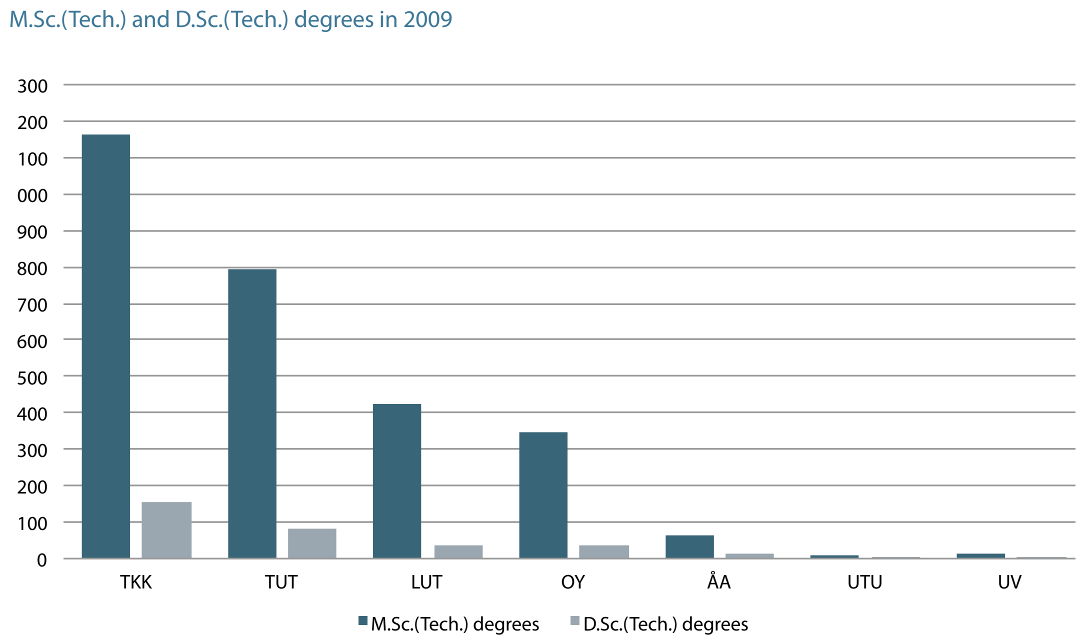


Figure 5.3 The number of M.Sc.(Tech.) and D.Sc.(Tech.) degrees in 2009. Source: KOTA-database.

Engineering education at polytechnics is provided by Metropolia University of Applied Sciences (Metropolia), Tampere University of Applied Sciences (TAMK), HAMK University of Applied Sciences, Oulu University of Applied Sciences (OAMK), Turku University of Applied Sciences (TuAMK), Jyväskylä University of Applied Sciences (JAMK), Savonia University of Applied Sciences (Savonia), Satakunta University of Applied Sciences (SAMK), Mikkeli University of Applied Sciences (MAMK), Seinäjoki University of Applied Sciences (SeAMK), Kymenlaakso University of Applied Sciences (KyAMK), Central Ostrobothnia University of Applied Sciences (K-PAMK), Vaasa University of Applied Sciences (VAMK), Saimaa University of Applied Sciences (Saimaa), Rovaniemi University of Applied Sciences (RAMK), North Carelia University of Applied Sciences (P-KAMK), Novia University of Applied Sciences (Novia), Kemi-Tornio University of Applied Sciences (K-TAMK), Kajaani University of Applied Sciences (KAJAK) and Arcada University of Applied Sciences (Arcada).

Metropolia University of Applied Sciences (Metropolia) is the largest educator of engineers in polytechnics. The number of B.Eng an M.Eng degrees provided by each polytechnic in 2009 can be found in Figure 5.4.

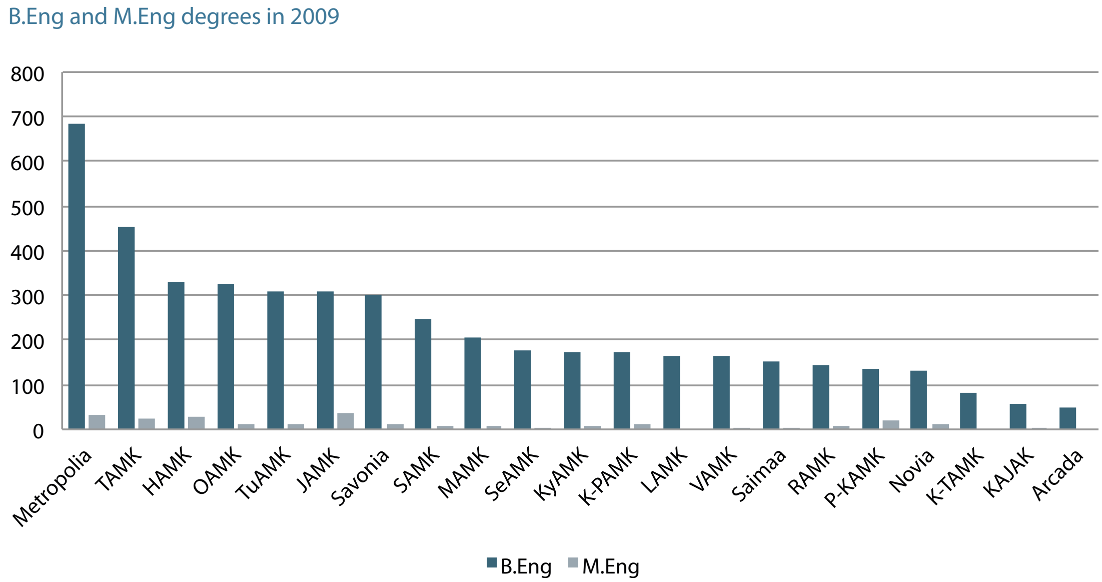


Figure 5.4 The number of B.Eng and M.Eng degrees in 2009 including both youth and adult education. Source: AMK-database.

The four largest degree programs in engineering at universities in 2009 were ICT, industrial management, mechanical engineering and electronics that accounted for 60% of the intake[133]. In polytechnics the four largest degree programs were ICT, construction engineering, mechanical engineering and electronics that accounted for 63% of the intake in Bachelor of Engineering studies. Figure 5.5 provides an overview of the intake in M.Sc.(Tech.) and B.Eng studies in 2009. Appendix 17 contains a detailed Table describing what are the higher education institutions providing degree programs.

133 The statistics include only intake through joint selection system of universities.

Degree programs in engineering and intake in 2009

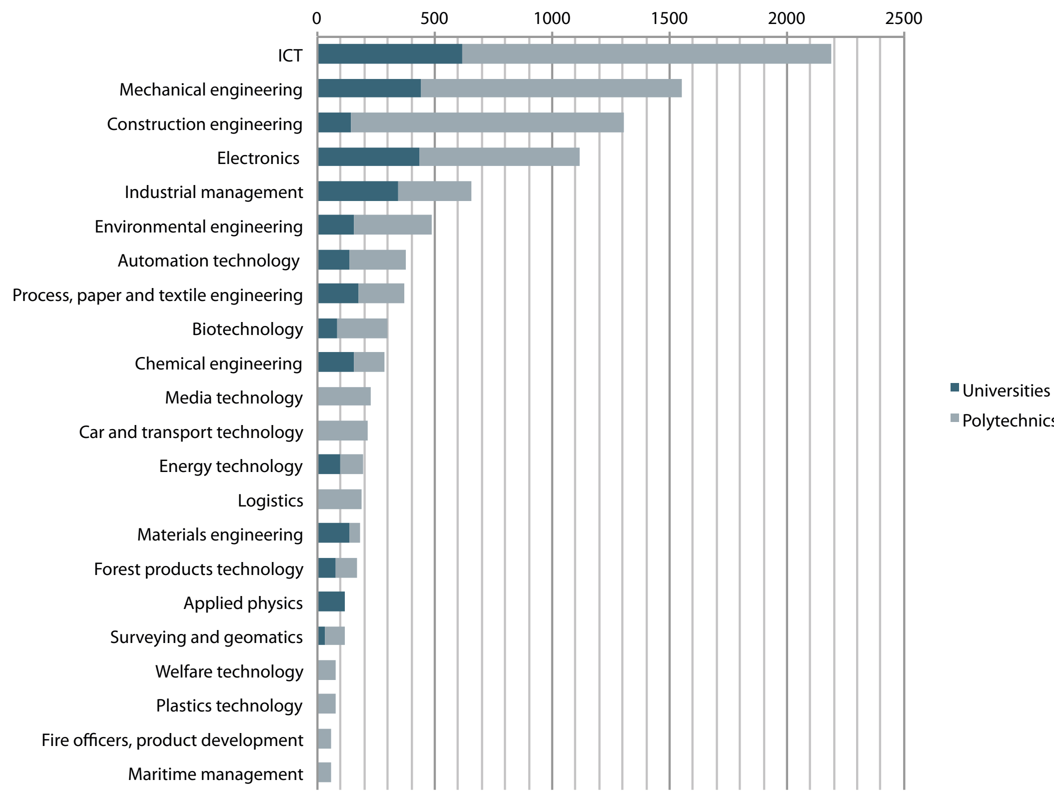


Figure 5.5 The degree programs in engineering and intake in 2009 (Data from Allt, Korhonen-Yrjänheikki & Savolainen 2009, 139 - 160). See Appendix 17 for detailed information on HEIs providing the degree programs.

5.4 STATISTICS DESCRIBING LONG-TERM DEVELOPMENT AND PRESENT

This chapter provides a statistical overview of the long-term development and present state of the Finnish engineering education. Statistics related to recruitment and volume of education are presented in Chapter 5.4.1. Resources of education are discussed in Chapter 5.4.2. Chapter 5.4.3 focuses on student progress in their engineering studies. Internationalization of students and staff is discussed in Chapter 5.4.4. Chapter 5.4.5 provides a description of the employment of graduates[134]. And finally, continuing education is discussed in Chapter 5.4.6.

The most important sources of statistics are the KOTA- and AMKOTA-databases of the Finnish Ministry of Education and Culture, Statistics Finland and researches carried out at Academic Engineers and Architects in Finland - TEK.

134 Note that co-operation with working life and the related statistics are presented in Chapter 5.1, discussing the role of industry in the Finnish engineering education.

5.4.1 Recruitment and Volume of Engineering Education

As Figure 5.6 illustrates, the intake within engineering education in universities grew fast in the late 1990s. In 1989 the number of undergraduate engineering students was 17 779, while in 2009 the number of undergraduate engineering students was 30 356. This was 21% of all the undergraduate students in universities. The share of women of undergraduate engineering students at universities was 20%. In 2009 the number of postgraduate students in engineering was 5 265, which is 26% of all postgraduate students. The share of women of postgraduate students in engineering was 28%. (KOTA-database)

M.Sc.(Tech.) students and degrees during 1987–2009

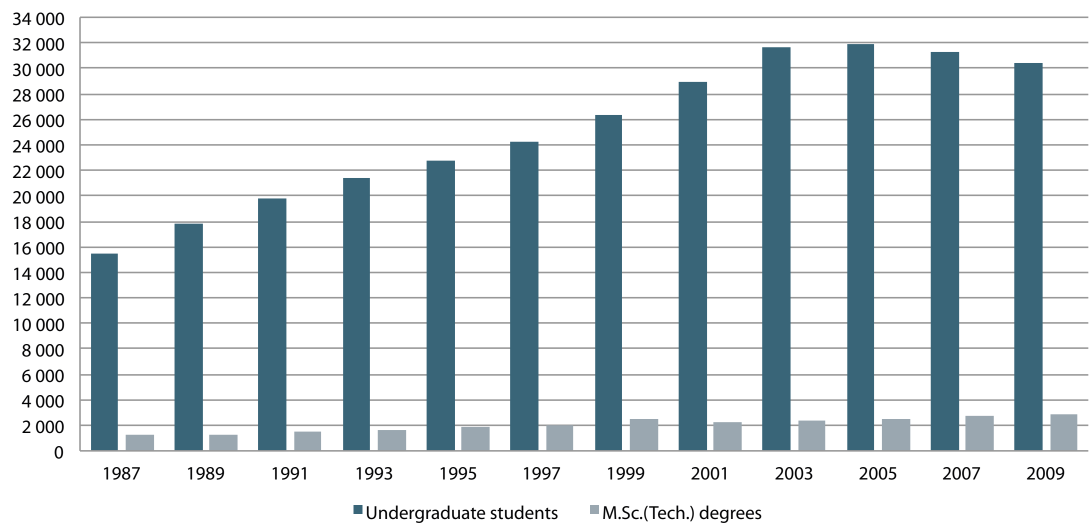


Figure 5.6 The number of M.Sc.(Tech.) students and degrees during 1987 – 2009. Source: KOTA-database.

The number of engineering students at polytechnics almost doubled between 1997 – 2009, as Figure 5.7 shows. In 1997 the number of B.Eng students was 20 079, while the corresponding figure in 2009 was 38 386[135], which was 30% of all Bachelor's students at polytechnics. 16% of B.Eng students in 2009 were women. The share of women during the past ten years has remained fairly stable. Between 1997 – 2009 the maximum share of women was 18% in 2002. (AMKOTA-database)

135 Absent students (4 575) are also counted in order to be able to compare the number of students in universities and polytechnics. This is because the KOTA-database describing statistics on universities does not enable data search limited to students present during the term, unlike the AMKOTA-database on polytechnics. Number of FTE students in universities is available in KOTA-database since 2003.

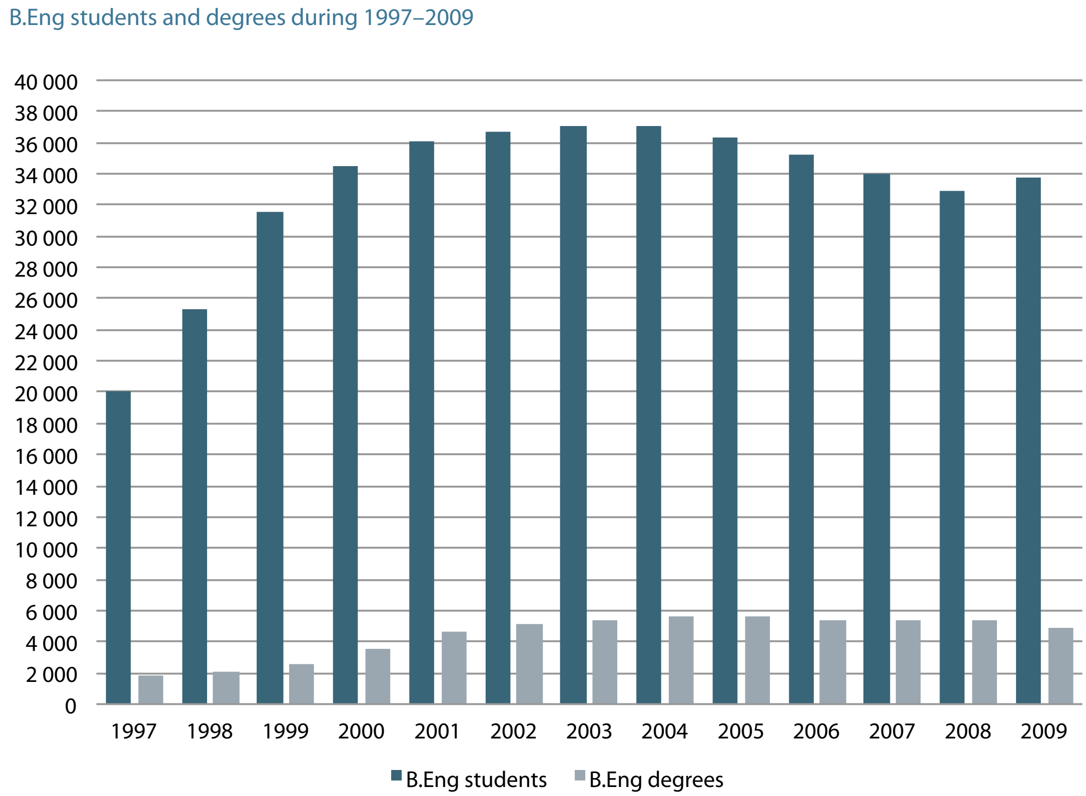


Figure 5.7 The number of B.Eng students and degrees during 1997 – 2009 including both youth and adult education. Source: AMKOTA- database.

The number of people interested in studying engineering has decreased during the 21st century. The present gap between accepted and entered M.Sc.(Tech.) students is worrying. While 97% of the accepted M.Sc.(Tech.) students entered engineering studies in 1997, the corresponding share in 2009 was only 68%. Figure 5.8 provides statistics on accepted and entered M.Sc.(Tech.) students between 1991 – 2009.

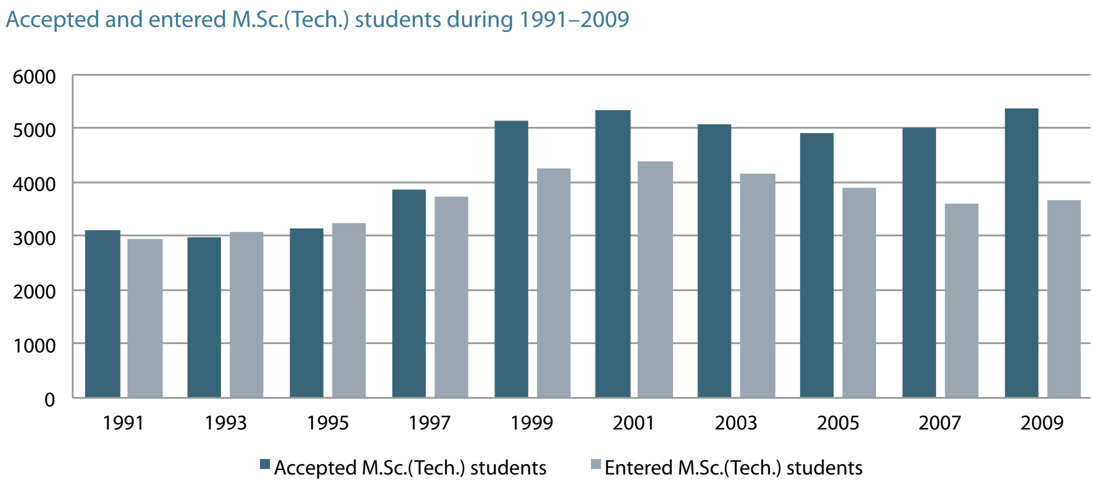
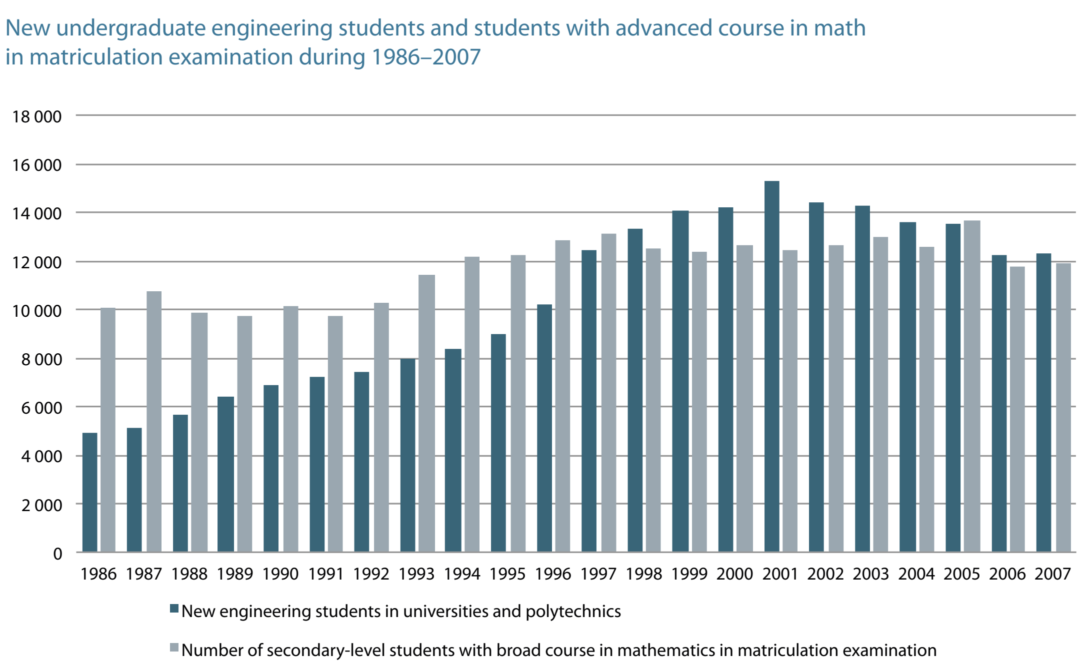


Figure 5.8 Accepted and entered M.Sc.(Tech.) students during 1991 – 2009. Source: KOTA-database.

Compared to the volume of engineering education in universities and polytechnics, there is lack of secondary-level students that take the advanced course of math in matriculation. As illustrated in Figure 5.9, the yearly intake within the undergraduate engineering education in universities[136] and polytechnics exceeded the number of secondary-level students taking the advanced course in math in 1998.



136 Note that this figure contains only new M.Sc.(Tech.) students that were selected through the joint recruitment system. Universities have also other admission systems of their own.

Figure 5.9 New undergraduate engineering students and students with advanced course in math in matriculation examination during 1986 – 2007. Sources: KOTA-database, Statistics Finland, Finnish Matriculation Examination Board.

The number of M.Sc.(Tech.) graduates in 2009 was 2 812 (KOTA-database). Roughly every tenth graduate in 2009 had completed also the B.Eng degree in polytechnics before studies at the university (TEK 2010a). The number of postgraduate degrees in 2009 was 396, including 64 Lic.Sc.(Tech.) degrees and 332 D.Sc.(Tech.) degrees (KOTA-database). The number of B.Eng graduates in 2009 was 4 765 (AMKOTA-database). The number of M.Eng degrees completed was 234.

According to the statistics of IMD(2009)[137], presented in Table 5.3, the availability of qualified engineers in the labor market in Finland is the best in the world.

Table 5.3 Availability of qualified engineers in the labor market (IMD 2009).

Availabilility of qualified engineers in the labor market IMD (2009)					
Ranking	**Country**	**Ranking**	**Country**	**Ranking**	**Country**
1	Finland (8.47)	16	Taiwan (6.74)	31	Italy (5.85)
2	Israel (7.81)	17	Philippines (6.67)	32	Argentina (5.81)
3	Ireland (7.75)	18	Malaysia (6.64)	33	Qatar (5.74)
4	India (7.68)	19	Belgium (6.57)	34	New Zealand (5.66)
5	Singapore (7.58)	20	Japan (6.55)	35	Hungary (5.59)
6	Sweden (7.54)	21	Norway (6.44)	36	Russia (5.58)
7	Chile (7.26)	22	USA (6.37)	37	Czech Republic (5.53)
8	Switzerland (7.25)	23	Netherlands (6.30)	38	Slovak Republik (5.52)
9	Turkey (7.20)	24	Lithuania (6.29)	39	Spain (5.51)
10	Canada (7.13)	25	Thailand (6.27)	40	Luxembourg (5.37)
11	Denmark (7.12)	26	Austria (6.24)	41	Brazil (5.32)
12	Portugal (7.04)	27	Germany (6.16)	42	United Kingdom (5.30)
13	France (7.01)	28	Greece (6.09)	43	Mexico (5.04)
14	Jordan (6.95)	29	Australia (6.06)	44	Peru (4.99)
15	Hong Kong (6.89)	30	Colombia (5.97)	45	Poland (4.97)

5.4.2 Resources of Engineering Education

Although the number of engineering students in universities and polytechnics has increased significantly during the past 15 years, the number of teaching staff has not increased correspondingly. This has resulted in a weakened teacher / student ratio[138]. In polytechnics the teacher / B.Eng student ratio was

137 The survey targeted to the top- and middle management of the enterprises in the 57 economies covered by the World Competence Yearbook. In 2009 approximately 4 000 managers participated – on average 70 per country. The questions only concern the country in which the executives work and have resided in for the past year (IMD 2009, 474).
138 The number of teachers is the amount of teaching man years.

1:10 in 1997, while year 2009 it was 1:22[139] (AMKOTA-database). In universities the teacher / student ratio has deteriorated since 1980s. In 1983 the teacher / undergraduate engineering student ratio in universities was 1:12 and year 1993 1:18. In 2009 the corresponding figure was 1:25.[140] (KOTA-database)

Unfortunately the KOTA-database does not enable data search of public funding per undergraduate engineering student before 1997. This would be interesting since the number of undergraduate engineering students increased by 57% between 1987 – 1997. During 1997 – 2009 the average public funding per undergraduate engineering student[141] increased from 3 045 € to 4 143 €. The average total expenditure increased from 3 277 € to 4 644 €. The figures on funding per FTE undergraduate engineering student are available only since 2003. During 2003 – 07 the average total expenditure per FTE undergraduate engineering student increased from 5 201 € to 6 295 € and the average total funding from 5 690 € to 7 056 €. The development of public funding and total expenditure per undergraduate engineering student and per FTE student in universities during 1997 – 2009 is presented in Figure 5.10.

Notable differences exist between universities concerning the total expenditure and public funding per undergraduate engineering student[142]. In Helsinki University of Technology and Tampere University of Technology that provided altogether 70% of the M.Sc.(Tech.) degrees in 2009, public funding per undergraduate engineering student was roughly 4 000 € and total expenditure 4 500 €.

In Lappeenranta University of Technology that provided 15% of the M.Sc.(Tech.) degrees, the corresponding figures were 3 600 € and 4 000 €. However, in University of Oulu that provided 12% of M.Sc.(Tech.) degrees (345), the public funding per undergraduate engineering student was approximately 5 800 € and total expenditure roughly 6 000 €.

Åbo Akademi, which provided slightly over 2% of the M.Sc.(Tech.) degrees, was the most funded institution per undergraduate engineering student. The public funding per undergraduate engineering student was approximately 6 100 € and total expenditure 6 800 €. The least funded were the University of Turku (UTU) and University of Vaasa (UV) that provided altogether less than 1% of the M.Sc.(Tech.) degrees. The corresponding figures in UTU were 2 300 € and 2 600 € and in UV 3 100 € and 3 300 €.

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139 Counted only B.Eng students that announced to be present year 2009. If all B.Eng students were counted, the ratio would be even weaker, namely 1:25. Statistics from 1997 do not allow data search of only present students. However, if estimated that the share of absent students is 5% like in 2000, this would result also in a 1:10 ratio.

140 The number of undergraduate students includes B.Sc.(Tech.) and M.Sc.(Tech.) students. In order to be able examine the long-term development, the ratio includes only publicly funded teaching staff. According to the KOTA-database, the externally funded teaching staff was introduced in 1994, when it was 29 man years. If externally funded teaching staff is counted, in 2009 the ratio was 1:23. If using the number of FTE undergraduate engineering students the corresponding figures were 1:17 and 1:15 in 2009. Teaching man years / all FTE engineering students -ratio at universities was in 2009 1:19 or 1:17, depending on whether teaching staff external to public funding is counted.

141 Note that the figure contains also public funding granted to research directly related to undergraduate education.

142 See Appendix 16 for the figures on funding per FTE undergraduate student in 2009.

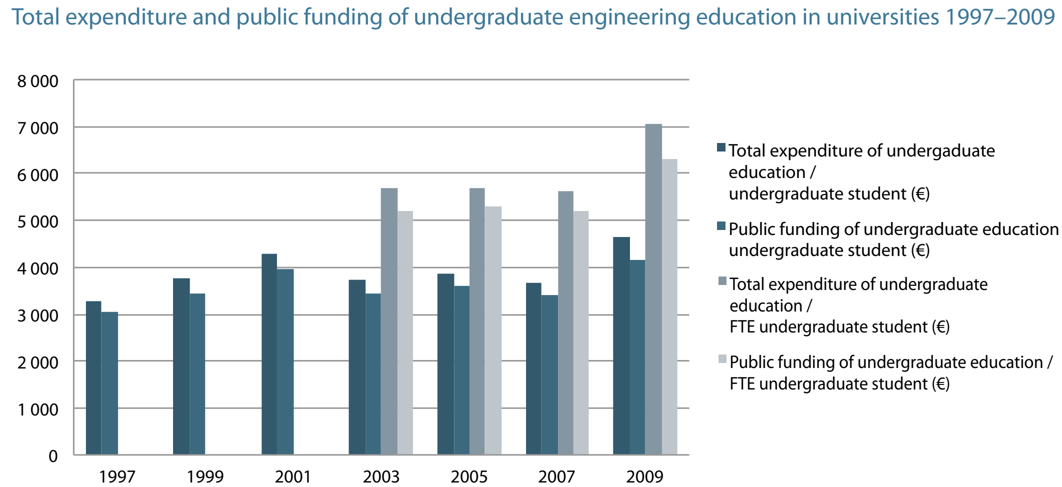

Figure 5.10 Total expenditure and public funding of undergraduate engineering education in universities 1997 – 2009. Source: KOTA-database.

5.4.3 Advancing in Engineering Studies

According to the KOTA-database, the average time taken to complete the M.Sc.(Tech.) degree in 2007 was 6.5 years[143]. In 1993 the average was also 6.5 years. During years 2000 – 05 the average was 6.0 years. When examining the statistics provided by TEK[144], it seems that during the past few years the average studying time extended to approximately seven years. According to TEK, the average studying time of M.Sc.(Tech.) engineers graduated in 2008 was 6.9 years (median 6.5) and year 2009 7.4 years (median 7.0).

Several factors impact the average studying time (See especially Erkkilä 2009; also Rantanen & Liski 2008, Sammalisto 2009). Based on surveys among M.Sc.(Tech.) students, Rantanen & Liski (2008) and Sammalisto (2009) suggest the most important reasons for slowing down studies are the lack of motivation, poor teaching methods and organization of studies as well as difficulties in time management. Economic fluctuations increasing unemployment of graduates increase the average studying time (Rantanen & Liski 2008). The introduction of the two-cycle degree structure may also be among factors that have extended the studying time during the past years (Erkkilä 2010). Also the amount of work beside studies, positions of trust, and family reasons have got some, but minor impact (Sammalisto 2009).

In a survey by Sammalisto (2009), 40% of M.Sc.(Tech.) students felt that the course contents are overloaded compared to the amount of ECTS received. A strong feeling of community among engineering students enhances study progress (Ibidem). Erkkilä (2009) observed that the learning context in the Finnish universities providing engineering does not favor fast progress if aiming at deep-approached understanding of the issue under study, including its interrelations to the curriculum as a whole. Also the average time taken to complete the B.Eng degree has increased in the 21st century, as Figure 5.11 shows.

143 The Figure contains also M.Sc.(Archit.) degrees, because the KOTA-database does not allow information search of only M.Sc.(Tech.) degrees. This is likely to raise the average slightly.
144 Statistics from the years 2008 and 2009 were not available from the KOTA-database in July 2010. Statistics obtained from TEK research on recently graduated M.Sc.(Tech.) students.

In 1999 the average time was 4 years, while in 2009 it was 4.4 years. The number of M.Eng graduates in 2009 was 234.

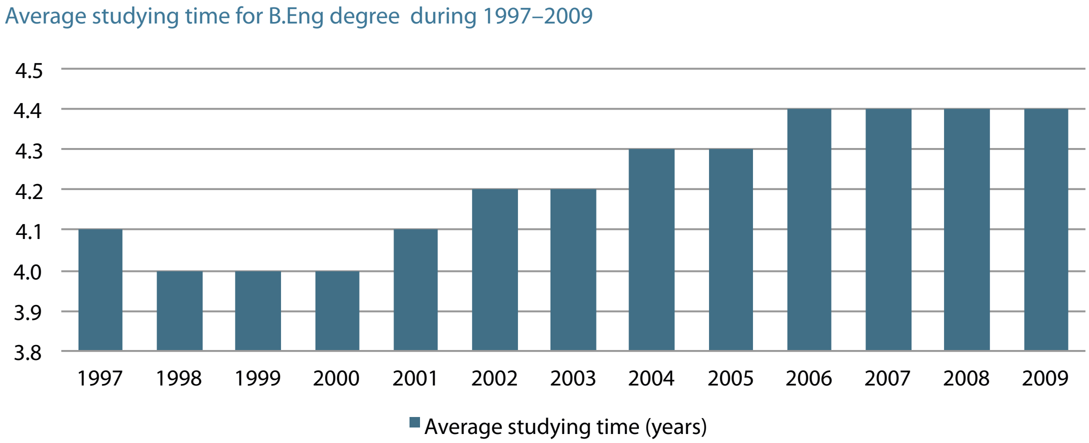

Figure 5.11 The average time taken to complete the B.Eng degree during 1997 – 2009. Source: AMKOTA-database.

Statistics directly describing the drop-out rate of engineering students in universities are hard to find. However, by comparing the number of M.Sc.(Tech.) degrees and the intake seven years earlier[145] it seems that roughly 35 – 40% of students drop out. New M.Sc.(Tech.) students and degrees during 1987 – 2009 are presented in Figure 5.12.

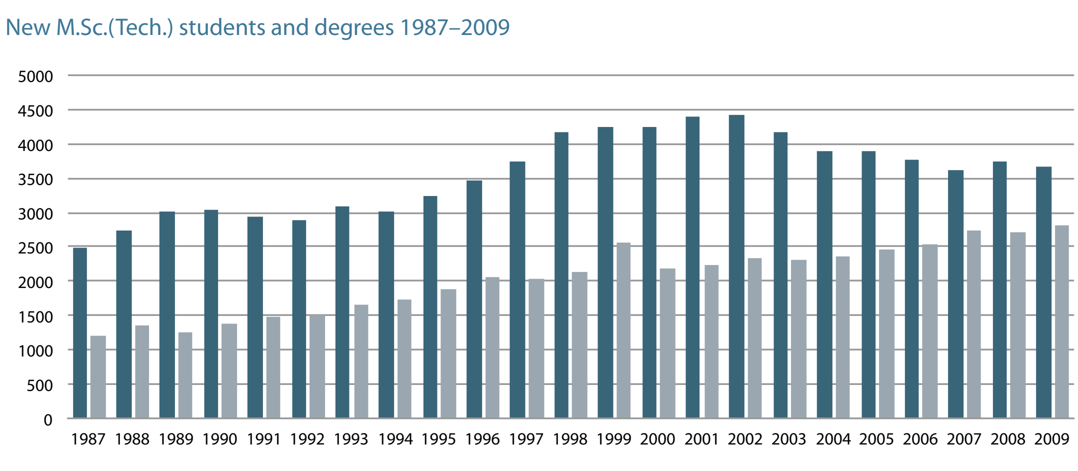

Figure 5.12 New M.Sc.(Tech.) students and degrees during 1987 – 2009. Source: KOTA-database.

145 The average studying time to complete M.Sc.(Tech.) degree varied between 6 – 7 years during 1987 – 2009. (KOTA-database, TEK research on graduate students).

The high drop-out rate is a problem also in engineering studies at polytechnics. For example, of the 9 969 students that began their B.Eng studies in 2002 only 5 410 had completed the degree by the end of 2009. This means that the drop-out rate is roughly 45%. (Statistics Finland in AMK-KOTA database)

5.4.4 Internationalization of Students and Staff

As Figure 5.13 illustrates, internationalization of staff at universities providing engineering education decreased during 1994 – 2008. In 1994, the share of staff man years abroad was 3.4%, while the corresponding share in 2008 was 2.1%. The share of foreign staff man years in 1994 was 6.2%, while the corresponding share in 2008 was 4.8%. (KOTA-database)

The share of international undergraduate engineering students[146] at universities has slightly increased during 1998 – 2008. In 1998 the share of international students was 0.8%, while the corresponding share in 2008 was 2.2%. The interest of Finnish undergraduate engineering students to study abroad has remained stable during 1998 – 2008. In 1998, 2.3% of undergraduate engineering students participated in student exchange. The corresponding share in 2008 was 1.9% (KOTA-database). The share of undergraduate students abroad annually and the share of international students of undergraduates during 1998 – 2008 is presented in Figure 5.14.

21% of M.Sc.(Tech.) graduates in 2008 and 22% of graduates in 2009 had studied a month or more abroad during their engineering studies (TEK 2010a). The corresponding figures of those that took a traineeship abroad was 11% and 13%. The median studying time abroad of M.Sc.(Tech.) graduates in 2008 was 7 months and 6 months in 2009. The corresponding medians for a traineeship abroad were 3 months in 2008 and 4 months in 2009.

Internationalization of staff at universities providing engineering during 1994–2008

Figure 5.13 Internationalization of teaching and research staff at universities providing engineering education during 1994 – 2008. The share of Finnish staff abroad and foreign staff in Finland. Source: KOTA-database.

146 Including both degree-oriented and exchange students.

Internationalization of students at universities providing engineering during 1998–2008

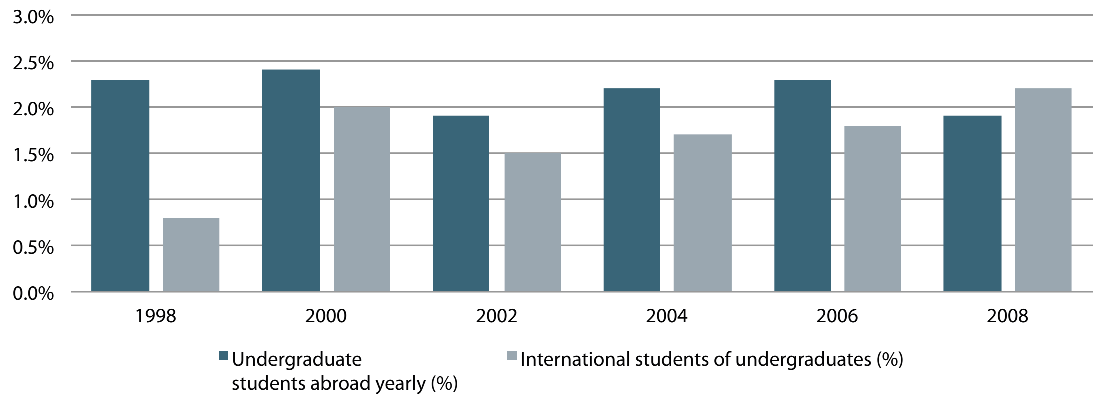

Figure 5.14 Internationalization of students at universities providing engineering during 1998 – 2008. The share of undergraduate students abroad annually and the share of international students[147] of undergraduates. Source: KOTA-database.

In 2009 in polytechnics providing engineering education the share of staff man years abroad of total Finnish staff man years was 2.1%. The share of foreign staff man years was 2.0%. Germany was the most common destination of Finnish staff as well as the country of origin of the foreign staff. (AMKOTA-database)

In 2007 the share of B.Eng students[148] that participated in student exchange varied between 0.2 – 4.0%. In HAMK, Satakunta and Savonia University of Applied Sciences the share of B.Eng students abroad was 3.4 – 4.0%. In Kajaani, Kemi-Tornio, Seinäjoki and North Carelia University of Applied Sciences the share was considerably lower, namely between 0.2 – 0.6%. In other polytechnics the share of B.Eng students abroad was 1.1 – 2.9%.

5.4.5 Employment of Graduates

In 2008, 90% of the B.Eng graduates from the year 2007 were employed by the private sector and 9% by the state or municipality. The most important employers in the private sector were industry (36%), engineering offices (22%) and IT and commerce services (21%). (Koivumäki 2008)

The corresponding data from the employment sectors of M.Sc.(Tech.) graduates is not available. In 2009, 79% of all M.Sc.(Tech.) professionals worked in a private company, 18% in public sector, 2% were entrepreneurs and 1% worked in an association (TEK 2010b).

M.Sc.(Tech.) graduates are more satisfied with the adequacy of employment than B.Eng graduates. In a study on employment of engineering graduates from the year 2002 three years after graduation, Vuorinen & Valkonen (2007) found that 3% of M.Sc.(Tech.) graduates were not satisfied with the adequacy of their employment, while the corresponding share of B.Eng graduates was 13%.

B.Eng graduates are also more dissatisfied with their education than M.Sc.(Tech.) graduates. In a study by Vuorinen & Valkonen (2007), 72% of M.Sc.(Tech.) graduates were of the opinion that educa-

147 The number of international students consist of degree-oriented students and exchange students that spend more than a month at a Finnish university.
148 Adult education excluded.

tion provided them with good skills for succeeding in the labor market, while the corresponding share of B.Eng graduates was 48%.

Results from TEK (2010a) on employment of M.Sc.(Tech.) graduates from the years 2008 and 2009 are similar to Vuorinen & Valkonen (2007), namely 97% of employed M.Sc.(Tech.) graduates were of the opinion that their employment was adequate (76%) or fairly adequate (21%) compared to the degree.

When comparing the results of Vuorinen & Valkonen[149] (2007) to the results of UIL survey on employment of B.Eng graduates of the year 2007 (Koivumäki 2008), it seems that adequacy of employment is weakening[150]. Namely, one out of four of B.Eng graduates of the year 2007 were of the opinion that their employment was inadequate, mostly because the requirements of their position corresponded to that of a blue-collar worker (Koivumäki 2008). Graduates in construction, electronics and car and transport technology were most satisfied with the adequacy of their employment.

The unemployment rate of the year 2007 M.Sc.(Tech.) graduates at the end of 2008 was 2.4 %. The unemployment rate of all Master's degree graduates from universities was 4.2%. The unemployment rate of B.Eng graduates was considerably higher than M.Sc.(Tech.) graduates, and also higher than average unemployment rate of all Bachelor graduates from polytechnics. 5.4 % of the year 2007 B.Eng graduates were unemployed at the end of 2008, while the average unemployment rate of Bachelor graduates from polytechnics was 4.7 %. (Statistics Finland 2010)

When examining statistics on the unemployment rate of B.Eng engineers that graduated between 2003 – 2007, considerable differences can be observed between different polytechnics. The average unemployment rate of B.Eng graduates between 2003 – 2007 at the end of 2007 was 4.0%. However, five polytechnics[151] reported an unemployment rate of at least 6.0% and seven polytechnics[152] below 2.8%. The average unemployment rate of all Bachelor graduates between 2003 – 2007 at the end of 2007 was 4.5%.(Statistics Finland in AMKOTA-database). The number of degree programs reporting an over 10% unemployment rate one year after completion of the B.Eng degree (employment situation of the year 2005 graduates at the end of 2006) is presented in Figure 5.15.

149 Employment B.Eng graduates of the year 2002 in 2005.

150 Note that direct comparison of these studies contains several possible sources of error. However, the results concerning M.Sc.(Tech.) graduates were similar, while difference exists in adequacy of employment of B.Eng graduates.

151 These were North Carelia University of Applied Sciences (8.2%), Kajaani University of Applied Sciences (7.6%), Saimaa University of Applied Sciences (6.8%), Kemi-Tornio University of Applied Sciences (6.3%) and Keski-Pohjanmaa University of Applied Sciences (6.0%).

152 These were Arcada University of Applied Sciences (1.0%), Svenska YH University of Applied Sciences (1.2%), YH Sydväst University of Applied Sciences (1.7%). EVTEK University of Applied Sciences (2.4%), Helsinki University of Applied Sciences Stadia (2.4%), Tampere University of Applied Sciences (2.7%) and Vaasa University of Applied Sciences (2.7%) Svenska YH and YH Sydväst have merged into Novia University of Applied Sciences. EVTEK and Stadia have merged into Metripolia University of Applied Sciences.

Number of B.Eng degree programs reporting over 10 % unemployment rate one year after graduation. Graduates year 2005.

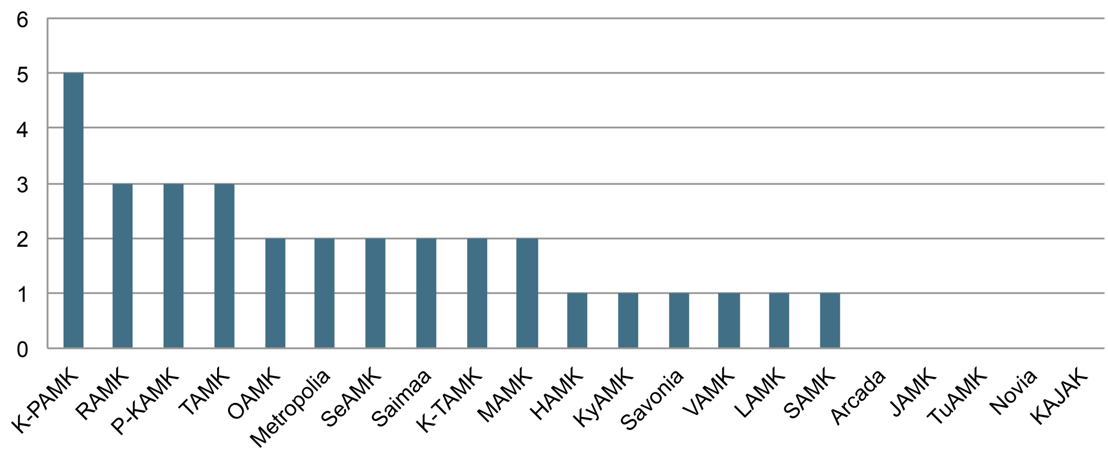

Figure 5.15 The number of degree programs reporting an over 10% unemployment rate one year after completing the B.Eng degree. Graduates of the year 2005. Source: Statistics Finland in Allt, Korhonen-Yrjänheikki & Savolainen (2009).

The average unemployment rate of M.Sc.(Tech.) graduates between 2003 – 2007 at the end of 2007 was 1.8%. Helsinki University of Technology and Åbo Akademi reported an unemployment rate of 1.1% or below. The unemployment rate of graduates from Tampere University of Technology and University of Oulu was roughly 2%. The unemployment rate of engineering graduates from Lappeenranta University of Technology was 3%. (Statistics Finland in AMKOTA-database)

5.4.6 Continuing Education

Despite of the growing needs for continuing professional development among engineering professionals (Korhonen 1997, Allt & Suutari 2002, Allt 2002, Martin et al. 2005, Korhonen-Yrjänheikki 2009, Keltikangas & Allt 2009), during 2000 – 2009 the amount of continuing education provided at universities offering engineering decreased rapidly as Figure 5.16 shows. When the amount of continuing education provided in 2000 was approximately 112 000 hours, the corresponding amount in 2009 was 54 000 hours. Table 5.4 presents an overview of continuing education in 2009 provided by the universities that are engineering educators.

Number of participants and amount of provided continuing education in universities providing engineering during 1991–2009

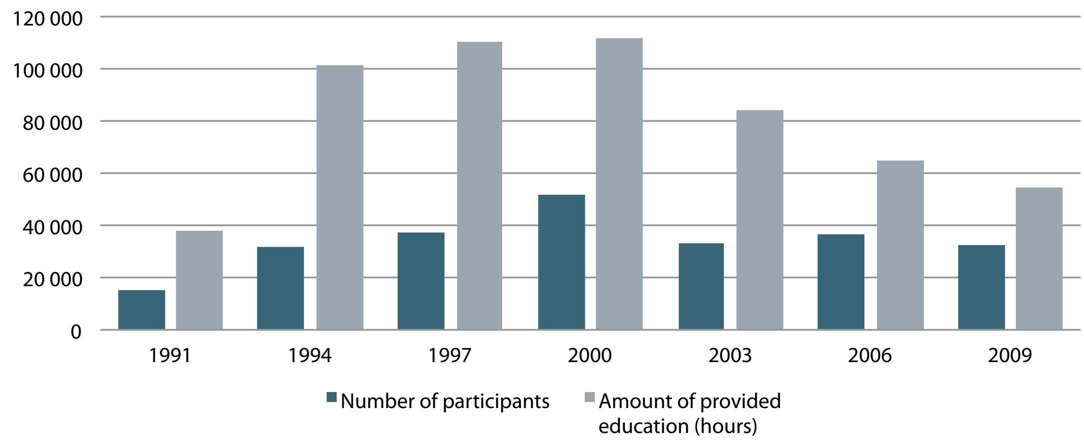

Figure 5.16 The number of participants in continuing education and amount of provided continuing education (hours) in universities providing engineering education during 1991 – 2009. Source: KOTA-database.

The degree-oriented postgraduate education is by law free-of-charge (Universities Act 558/2009). It seems likely that postgraduate engineering education is often used for the purposes of continuing education without actually aiming to Lic.Sc.(Tech.) or D.Sc.(Tech.) degree (Korhonen-Yrjänheikki & Allt 2004)[153]. The number of postgraduate students increased rapidly during 1989 – 2009. In 1989 there were 2 363 postgraduate engineering students, while the corresponding number in 2009 was 5 265. However, the number of completed degrees decreased only by some 200. In 1989 the number of postgraduate degrees - including both Lic.Sc.(Tech.) and D.Sc.(Tech.) degrees – was 186, while in 2009 it was 396 degrees (KOTA-database).

Table 5.4 Continuing education of universities providing engineering education in 2009. The number of participants, total expenditure and share of funding external to the budgetary funding from the state. Source: KOTA-database

Statistics 2009	TKK	TUT	LUT	OY	ÅA	UTU	UV
Number of participants in continuing education	7 681	2 235	1 380	4 249	8 840	6 759	1 000
Continuing education expenditure in engineering discipline (1 000 €)	10 794	2 691	244	217	27	128	1
Continuing education expenditure total (1 000 €)	10 794	2 691	2 703	3 625	3 777	5 928	2 089
Continuing education share of external funding	77%	51%	65%	81%	51%	67%	42%

153 Similar interpretation in general in Finnish higher education was made by the Finnish Ministry of Education (2008c).

Continuing education in the field of engineering is in polytechnics even a minor activity than in universities. However, the number of participants increased during 1999 – 2009 from roughly 500 to 2 300 as presented in Figure 5.17. In 2009 the number of participants in open polytechnics education in the field of engineering was 2 312. The amount of completed studies was 10 028 ECTS. 99% of the students and completed studies in ECTS were in B.Eng studies. The amount of completed ECTS per participant was 4.3.

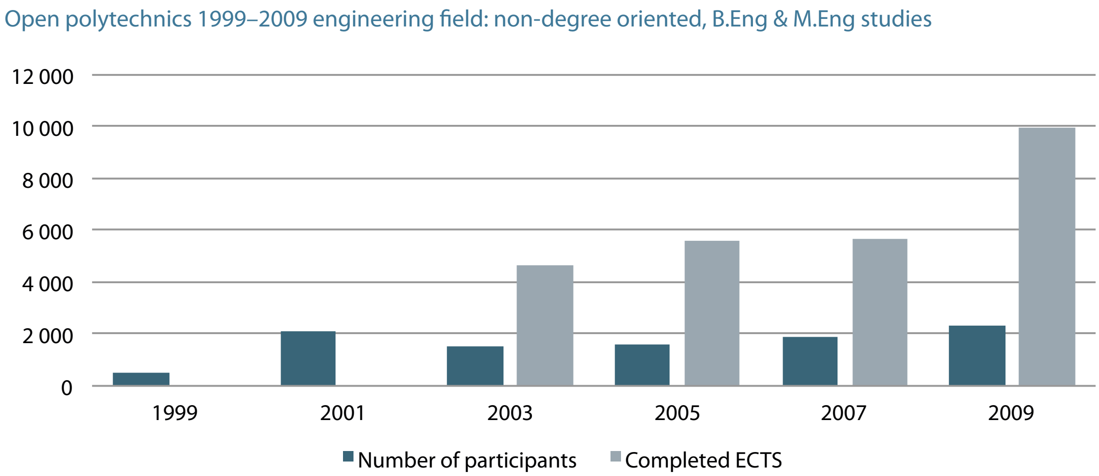

Figure 5.17 The provided open polytechnics education[154] *in the field of engineering including non-degree oriented, B.Eng and M.Eng studies during 1999 – 2009. Source: AMKOTA-database.*

Finnish engineers find work-based learning, networking and independent reading the most suitable ways for continuing professional development (Keski-Heikkilä 2002, Savolainen & Taukojärvi 2004, Allt 2006, Savolainen 2010). To face the growing demand for continuing professional development of the workforce with higher education, as part of the reform of adult education in Finland (Finnish Ministry of Education 2008c, 2009b), development work is on-going for introducing recognized professional qualifications drawing from work-based learning. One of the pilot projects aims at developing qualifications for M.Sc.(Tech.) graduates (Ihalainen 2009).

5.5 RESULTS OF THE HISTORICAL ANALYSIS AT THE OPEN FUTURES SEARCH

This chapter provides a summary of the results of the historical analysis at the Open Futures Search event. The analysis was focused primarily on years 1960 – 2006. A summary of the working groups 4 and 8 analyzing the development of the Finnish society and of working groups 1 and 7 focusing on analyzing the historical timeline of the Finnish engineering education during 1960 – 2006, is presented in Table 5.5.

Working groups 2 and 3 focused on examining the personal history of the participants. Working group 3 compared the life story of “large age cohorts” born around year 1950 and “next generations”

154 At least 95% of the students and completed ECTS in B.Eng education, except for 2005, when the share was 87% of participants and 83% of completed ECTS.

born around year 1980 presented in Table 5.6. Working group 2 decided to write an imaginary story of Elina, illustrating the timeline that is presented in Table 5.7. Working groups 5 and 6 were asked to formulate a synthesis of all the three timelines: society, engineering education, and individual history of the participants. The synthesis of working group 5 is provided in Table 5.8 and that of 6 in Table 5.9.

Table 5.5 Development of the Finnish society and engineering education during years 1960 – 2006. Results of the working groups.

Years	Finnish Society	Finnish Engineering Education
Before 1960s	4: Reconstruction after the Finnish - Russian War and large age group. Finnish industry based on forest and metal. Strong belief that society will develop. 8: Reparations and reconstruction decisive for the development of education and industry.	1: TKK founded 1849, became university 1908. Polytechnic Helsinki 1881 and Tampere 1912. M.Sc.(Tech.) in Helsinki, Tampere, Oulu, Åbo. 7: TKK rules in engineering education of universities. Technical schools. Low volume. Engineers as owners and lords.
1960 - 70	4: Urbanization and migration to Sweden. Emergence of regional policy. Gender equality becomes an issue: work as an option for women. Regional universities founded. Regional and educational policy mixed. 8: Strong industrialization. Importance of agriculture decreases. Urbanization and emigration to Sweden.	1: Otaniemi (TKK campus) and campus life. First computers. TUT and LUT founded. Interdisciplinarity of engineering and economics: degree program of industrial management. 7: TKK moves to Otaniemi. New universities providing engineering: Oulu, TUT, LUT. Strengthening of engineering fields of civil engineering, mechanics and electronics.
1970 - 80	4: Inflation and devalvation: interesting way to take care of the economy. Inflation paid residential loans. Comprehensive school. Large generation into working life. Finland becomes wealthier. 8: Oil crisis. Diversifying of educational system. Mass education. Social and gender equality. Nordic welfare state.	1: Reform of degrees. Give up B.Sc.(Tech.) until 21st century. Active students. More technical schools. Problems in co-operation with industry. Teaching of IT. 7: Politics to HEIs. Banned co-operation with industry (except TUT). Technical schools as vocational higher education. From elite to mass education.
1980 - 90	4: Internationalization becomes an issue of discussion, but no practical consequences. Environmental awareness grows. Dissemination of PCs. 8: Opening up of economy. ICT. Sustainable development.	1: Increased volume of education. PCs. TEKES founded. Improved co-operation with industry. Engineering from profession to education. Researchers, increased external funding of research, more co-operation partners. Information Society. 7: Intensified technonlogy policy. IT. Stable economic growth. Share of external funding increases. Extension of studying times.

1990 - 2000	4: Years 1990 - 95: Deep recession. Destruction of Sovjet Union. Polytechnic reform. Years 1995 - 2000: IT boom, mobile technology and internet. ICT becomes key industry for Finland. End of monopoly in communication networks. Structural unemployment. Increase in immigration. 8: Collapse of socialism. Recession. Change of values:"all for me now". EU. Emphasis of knowledge and skills.	1: Recession and growth. Massification of engineering education and difficulties in recruitment. Polytechnic reform. End of technician education. Top institutions. LLL. Economic crisis and first steps of strategy work at HEIs. EU, internationalization and teaching in English. 7: Polytechnics emerge. Fast increase of M.Sc.(Tech.) volume. Internationalization and EU-programs. Performance steering of universities. Entrepreneurship. Systems engineering.
2000 - 06	4: Globalization, climate change and aging of population. European Song Contest Champion 2006. 8: Economy of quarters and fluctuation of economy. Multuculturalism. Diminishing age groups.	1: Bologna process. Intensified internationalization. Global competition. Assessment. PhD volume increases. Interdisciplinarity. Polytechnics reform stabilized & M.Eng . Year 2005- fundamentals lost. Need to brainstorm together + move from planning to action. Structural development. Quality. 7: Bologna process visible. Several new universities apply for a right to grant M.Sc.(Tech.). Deepening globalization, but also regional policy. Global competition also on students. Incresed co-operation between sciences, but not really interdisciplinarity. Structural development.

Table 5.6 A working group 3 synthesis of the timeline describing life stories and memorable events of workshop participants. Comparison of life of two age groups: large age cohorts born around 1950 and next generations born around 1980.

	Large Generations	Next Generations
Born	Around 1950	Around 1980
School	From primary to secondary school	Organized childhood / free time comprehensive school + matriculation
Environment	Children of country side	Urbanization
Studying	Engineering degree from technical school is highly appreciated. M.Sc.(Tech.) is a Boss. First generation with education.	M.Sc.(Tech.) & PhD, fairly common; individualized curriculum and way of studying.
Labor market	Employment of engineers good. Career development is self-evident. Work secured until pension.	Internationality, multiculturalism, employment is not self-evident, continuous professional development.
Family	nuclear family	?
Other	mobile phone is a status symbol and rare	Creativity, openness to new, mobile phone, lap top, internet, mobility

Table 5.7 A life story of an imaginary engineer "Elina" that was born in 1960s. The story is a synthesis of working group 2 from the timeline describing life stories and memorable events of workshop participants.

Life story of Elina

Elina spent her childhood in simple circumstances in Janakkala. She was interested in reading, crosscountry skiing and jogging. The teacher in primary school was patriotic and interested in sports. Elina's parents encouraged her to study in order to lead a better life. In 1970 Elina became the first in the family that took the matriculation examination. Despite the astonishment of all, and thanks to the encouragement of her teacher in mathematics, Elina began to study engineering at Helsinki University of Technology TKK.

The rising political awareness in society inspired Elina, with a talent in music, to join a communist choir. The summer internship at Finlayson in 1973 was a memorable period for Elina: she was offered an opportunity to complete her Master's thesis at Finlayson and she met her husband. Right after completing her thesis Elina was sent as an expatriate to a demanding sales position in Germany.

In 1980's Elina developed herself and learned more about PCs. Two children and the 3.5 year break from working life slowed down Elina's career development and she decided to change the company. After professional development, a new career began in 1990. Positions changed fast – most of them related to international project management. The organization was under constant re-construction and Elina decided to acquire PhD and continue to focus on research.

Elina divorced and married again. A new career focused on new technology and moving to China changed again Elina's life. The children stayed in Finland and continued to study multimedia and communications.

Table 5.8 Results of the working group 5: synthesis of all three timelines: society, engineering education and personal history.

Synthesis from all three timelines (working group 5)

- As a result of deepening globalization, the traditional sense of community is developed into a global sense of community that underlines individuality.
- The conception, organization and management of work is from the age of taylorism, although the business environment would require a different approach.
- Finland has succeeded in assessments of national competitiveness as well as of educational systems (PISA results). Our strength is that most Finns are flexible, creative and reactive to change in the business environment.
- More systematic anticipation of the needs of education and research is needed, as well as conclusions based on anticipation. Structural development of education and research lags behind other societal development.

Table 5.9 Results of working group 6: synthesis of all three timelines: society, engineering education and personal history.

Synthesis from all three timelines (working group 6)

Societal policy has steered educational policy. Development of educational policy is backward. The challenge is to steer societal development through educational policy.

In the 1960s there was a change from individualism to collective co-operation. In the 21st century people are individuals, but in a global community. There are great needs for individual communication. This has boosted development of internet and mobile ICT.

The volume of engineering education has grown. At the same time the technological development has accelerated. The interest in engineering among youth has decreased resulting in problems of recruitment. The competition on talented students between engineering and other disciplines is fierce. The best students are not necessarily interested in engineering. The high volume of engineering education only makers matters worse.

Below is a summary of the key findings during the historical analysis at the Open Futures Search event.

Development of the network of HEIs and volume of education

- Before 1960 TKK ruled in research-oriented engineering education. Research-oriented engineering education was provided in Swedish also in Åbo Akademi. A network of technical schools. Around 1960 three research-oriented universities providing engineering education founded. Thereafter, no new units providing research-oriented engineering education until beginning of 21st century, when several universities apply degree rights for M.Sc.(Tech.) degree. In 2004 two more degree rights granted. Between 1970 – 1980 an increased number of technical schools. During 1990 – 2000 polytechnics reform.
- Before 1960 low volume of education. During 1990 – 2000 massification of engineering education. As a result problems with recruitment and resources.
- Increase of PhD volume in the 21st century.

Co-operation with industry and other external stakeholders

- Patriotism and strong belief in societal development after the second world war. Reparations and reconstruction decisive for the development of industry and education.
- Homogeneity of the Finnish culture and society and small size of the county have intensified stakeholder co-operation and provided several benefits for the Finnish engineering education. In future, homogeneity of the Finnish culture may be a challenge for society and system of education because of deepening globalization and increased multiculturalism.
- Well-developed industrial co-operation has characterized Finnish engineering education except for the years 1970 – 80, when industrial co-operation was banned.
- 1980s characterized by intensified technology policy. TEKES founded. Increased external funding of engineering research. More co-operating partners.

Development of the engineering profession and discipline

- The engineering profession has developed during modern engineering education from an owner and a lord (before 1960) into a manager (1960 – 90) , and thereafter a wide variety of careers increasingly in expert positions.
- The nature of the labor market of engineers changed 1960 - 2006: from self-evident career development and secured work until pension to a wide variety of careers, more experts than managers, and unemployment is a relevant risk. Continuous professional development became a must.
- Strengthening of civil engineering, mechanics and electronics 1960 - 70. First computers to campus. Teaching of IT increases importance 1970 – 80.
- The definition of the engineering discipline and profession is changing. It is difficult to define a typical engineering career. Strongly profession-oriented education – including Bachelor's and Master's education taken in the same discipline – accompanies a lot of strengths. However, the two-cycle degree structure may meet well the more individualized needs and variety of engineering careers.
- Systems engineering emerged 1990 – 2000. After 2000, increased interdisciplinary connections also to other disciplines, like economics and education for instance, is becoming more important. However, not yet really reached interdisciplinarity.

Internationalization

- Internationalization became an issue 1980 – 90, but had no practical consequences. Internationalization at higher education institutions, including, for example, teaching in English and EU-programs, starts increasing during 1990 – 2000. Intensified internationalization and co-operation in Europe in higher education in the Bologna process.

Environmental awareness and climate change

- Environmental awareness starts growing 1980 – 90, but climate change becomes more widely recognized only at the beginning of the 21st century.

Relationship between educational and regional policy

- Structural development of the educational system lags behind the societal development. Regional and educational policies are mixed in 1960s. Thereafter, societal policy, including regional policy, has steered the educational policy.
- In the 21st century two opposite trends, deepening globalization and re-intensified regional policy have characterized the societal development. The challenge is how to steer societal development through educational policy.

Quality assessment, specialization and structural development

- Strategy work starts at higher education institutions and performance steering of universities is introduced 1990 – 2000. During 1990 – 2000 severe recession, after which exceptionally fast growth.
- Specialization of higher education and structural development of the higher education institutions on the agenda since the beginning of the 21st century. At the same time, quality of education and quality assessment increasingly on the agenda. Deepening globalization and increased competition.

5.6 ANALYSIS OF THE PRESENT IN THE STAKEHOLDER PROCESSES

This chapter provides an analysis of the present state of the Finnish engineering education based primarily on the results of the Open Futures Search event (OFS) and work process of the Collaboration Group. Although focus in the Argument Delphi panel (AD) was limited to future development, interviews and presented argumentation in the second round revealed factors related also to the present. They are also brought up in this chapter. The sources of the Collaboration Group are further specified into workshops of the Collaboration Group (CGW), workshops on teaching and learning in engineering education (TLW), and research on sustainable development in engineering education (SDR).

The structure of the higher education system, functions of higher education institutions and specialization are discussed in Chapter 5.6.1. Chapter 5.6.2 focuses on co-operation with stakeholders. Management, funding, anticipation and quality assurance are discussed in Chapter 5.6.3. Chapter 5.6.4 deals with recruitment and the role of technology in society. The degree system is discussed in Chapter 5.6.5. And finally, Chapter 5.6.6 discusses curriculum, teaching and learning.

5.6.1 Structure of the System, Functions and Specialization

During AD it was found that Finnish engineering education lacks a national vision, which hinders co-operation between higher education institutions, especially between universities and polytechnics. Two scenarios that are very different by nature "New parallel model" and "Parallel in theory – overlapping in practice", were found to be probable (see Chapter 6.3.1 for the scenarios). The need for creating a national vision was brought up by the researcher as a result of AD. Later the need was acknowledged also in OFS and CGW that resulted in creating the mission and vision (see Chapter 6.2).

Results from AD, OFS, CGW and TLW suggest as a strength the availability of two different tracks in engineering: practically- and theoretically-oriented. However, the results of AD, CGW, OFS and TWL suggest a need to define differences more clearly in the functions of higher education institutions and the curriculum. In other words, differences need to be clearly observed in the learning objectives (CGW, TLW).

OFS and CGW suggest that regional and educational policies have been mixed, which has resulted in a scattered structure of the system, too small institutions, and degree programs in engineering, which is a risk for the quality of education and research, and financially inefficient.

Leading of structural change of higher education is accompanied with substantially conflicting interests on the system level (OFS, CGW). Several factors, including need to focus on improving the quality of education due to tightening global competition, diminishing age groups, and need to increase efficiency because of limited state budget, are among reasons that emphasize the need for structural development of the higher education system and specialization of institutions providing engineering education (CGW).

CGW suggests that the system of continuing education of engineers is undeveloped compared to the increasing and fast-changing skills needs that increase pressure for continuing professional development. This is supported also by AD and OFS regarding the fast-growing demand for continuing education.

Co-operation in recruitment through a centralized system for recruitment is suggested by CGW as a strength. Poor specialization of higher education institutions providing engineering education and unclear division of work between universities and polytechnics are proposed by AD, OFS and CGW as factors hindering co-operation between higher education institutions. Another interrelated problem is that the funding system of neither universities nor polytechnics encourages co-operation between higher education institutions (CGW).

5.6.2 Co-operation with Stakeholders

The results from OFS suggest that patriotism for enhancing welfare in Finland is a factor that enhances willingness of stakeholders to co-operate. OFS and CGW suggest that in a small homogenous country the key co-operation partners are often familiar with each other, which has provided several benefits for developing the Finnish engineering education. In future this may, however, create a challenge because of the deepening globalization and increased benefits of multiculturalism (OFS).

The results from AD, OFS, CGW and TLW suggest that close co-operation with industry, stemming from long traditions is a specific strength of the Finnish engineering education. The results indicate that co-operation with industry functions well especially in practical training of students and final thesis assignments. OFS and CGW suggest that also research co-operation of universities with industry is well developed. Despite a lot of benefits provided by close industrial co-operation, there are also worries that short-term needs of the labor market are stressed too much when developing engineering degrees (TLW), and there is not enough funding for academic basic research at universities (OFS). And also, there is room for improvement in integrating practical training as part of the learning process (TLW).

TLW argues that considerable differences exist among teaching staff in the relationship with the labor market: some have very tight co-operation, while others have barely none. Furthermore, close industrial co-operation is mostly poorly documented, and therefore difficult to prove, for example, in international quality assessments. Lack of documentation does not enhance systematic development and organizational learning. (OFS, CGW)

Results of OFS indicate that a strong culture of co-operation characterizes also relations with associations and research organization. However, direct alumni co-operation is not identified as a specific strength (OFS, CGW).

A relatively low hierarchy enables student participation in governance (OFS). Strong student culture and active students is a strength in the Finnish engineering education (OFS, CGW).

AD, OFS, CGW and TLW propose as a weakness that the teaching function at universities is not appreciated. This affects the position of the teaching staff. Also co-operation between teaching and research is insufficient (OFS, CGW, TLW). The internal funding system at higher education institutions does not encourage internal co-operation, for instance, between departments and degree programs (OFS, CGW).

5.6.3 Management, Funding, Anticipation and Quality Assurance

OFS and CGW argue that the collegial management system of universities is accompanied with severe problems: it does not enable professional management and strategic development. There is a need for a fundamental reform of the Universities Act[155]. CGW suggests that different types of management problems exist in polytechnics, namely, management and steering of polytechnics owned by the municipalities is problematic. Often short-term objectives rule out long-term development of education.

Several problems related to funding of universities and polytechnics providing engineering education can be identified. OFS and CGW argue that the funding of engineering education in Finland is too low compared to the number of students, the key role of technology in the national strategy (CGW), as well as if compared internationally (OFS, CGW). The considerable share of funding external to the state budget at universities providing engineering education[156] is found as a strength, but also a challenge,

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155 The new Universities Act that increased autonomy of universities and changed the management system was accepted in July 2009.

156 In 2009 in the engineering discipline at universities on average 47%, while the corresponding share in other disciplines was 33% (KOTA-database).

because it may weaken opportunities for long-range research and education (CGW).

AD, OFS and CGW criticize the funding systems behind universities and polytechnics for stressing too much volume of education compared to the quality of education. Therefore, funding systems do not encourage development of teaching (CGW, TLW). Moreover, neither the funding system of universities nor polytechnics encourages co-operation between higher education institutions (CGW).

Pros and cons are brought up concerning the present system that does not allow tuition fees for degree-oriented education except in limited cases for non-ETA residents in selected Master's programs. The strength is that the availability of higher education is not dependent on the economical status of students (AD, OFS, CGW). However, Finnish higher education institutions are handicapped in developing export of education, although market demand increases (OFS, CGW). And what is more, it is not possible to provide Master's programs with a tuition fee, which might be an option for continuing education.

Results of the AD, OFS and CGW suggest that the systematic anticipation of skills needs is undeveloped. Also, utilization of the results from the anticipation and follow-up systems for the development of education is insufficient (AD, CGW).

With regard to quality of teaching, OFS, CGW and TLW define it as a weakness that teaching lacks proper quality criteria. TLW also suggests that assessment methods are not utilized optimally to support reaching learning objectives.

5.6.4 Recruitment and Role of Technology in Society

OFS, CGW and SDR argue that lack of understanding of the role of technology in society is a key problem related to engineering education. Often the image of technology is machine-centered and technology is expected to develop without considerable effort and resources (CGW, SDR). Especially people with a non-engineering background tend to think that way (SDR). They also define the role of engineers in society narrowly (SDR). Neither the Finnish engineering education nor individual higher education institutions providing engineering education have a strong brand that would attract young people to study engineering (OFS, CGW).

As a general rule, teachers in primary and secondary education do not recognize the role of technology in enhancing welfare of society, and therefore, do not mediate this understanding to students (OFS, CGW). Understanding the role of technology in enhancing welfare could increase the number of young people interested in engineering, especially women (CGW).

OFS and CGW suggest that the volume of engineering education is too high compared to the resources available for teaching, motivated students, and skills in mathematics and natural sciences provided during primary and secondary education, needed later in engineering education. Decreased interest to study engineering is manifested in weakening entered/admitted –ratio (CGW).

There are considerable differences in mastery of mathematics and natural sciences between entering engineering students (OFS, TLW). OFS and TLW suggest that on average the acquired knowledge is insufficient for engineering studies. SDR results indicate that primary and secondary education does not provide a comprehensive foundation for understanding the basic aspects of sustainable development that would be essential for further learning in engineering education.

Results from OFS and CGW suggest that at present the learning environment and pedagogy in primary and secondary education does not enhance phenomenon-oriented experiential learning of natural sciences. Teachers often lack the skills needed for facilitating experiential learning.

5.6.5 Degree System

The listed positive consequences of introducing the two-cycle degree structure are better international comparability, enabling of later specialization, and smoother transfer between practically- and theoretically-oriented engineering education tracks (CGW, TLW). OFS and CGW suggest as a negative consequence of the B.Sc.(Tech.) degree the decreased amount of compulsory practical training at universities. This may be a risk in terms of quality of education since practical training is an important source of experiential learning.

OFS suggests that there is such a wide variety of degree program titles that employers do not always understand the differences between them. Another problem is that although the polytechnics reform was carried out during late 1990s and the beginning of the first decade of the 21st century, employers still do not always understand the difference between degrees - as an example, what is the qualification provided by the M.Eng degree (OFS).

While B.Eng and M.Sc.(Tech.) degrees are well-established and appreciated degrees in the labor market (CGW), the B.Sc.(Tech.) degree is regarded primarily as an intermediate degree towards the M.Sc.(Tech.) degree (CGW).

5.6.6 Curriculum, Teaching and Learning

Contents of the curriculum

Results from the OFS and CGW suggest that employers are mostly satisfied with the engineering skills of graduates. Strong practical problem solving skills of graduates in problems of mainly technical origin are among strengths of engineering graduates. They are developed through the learning context that is a mixture of the university and industry (OFS, CGW, TLW).

The participants of AD and TLW are of the opinion that the content of the undergraduate engineering curriculum is overloaded and there is room for prioritization. The participants of TLW also argue that students would need to spend more time on studying than at present.

An overall problem related to the curriculum suggested by TLW is that, in general, higher education institutions providing engineering education do not question the content of the present curriculum. However, problems related to the context of learning are more severe than the content of the curriculum (TLW).

Results from OFS and CGW suggest that the curriculum enables individual choices, which is seen as important (AD, OFS, CGW). However, this does not lead to a sufficient level of interdisciplinary skills. Lack of interdisciplinary skills of engineering graduates is a considerable problem (OFS, CGW, TLW, SDR). According to TLW, the most severe skills gaps exist in shared expertise and collaborative learning, competencies and skills related to the ability to cope in a multicultural environment, business and entrepreneurial skills, and skills and qualities related to enhancing sustainable development. Results from OFS indicate that the present curriculum does not meet the needs of the increasing role of services in the economy.

Results from SDR suggest that systemic and life-cycle thinking of engineering graduates is not sufficient. Findings from SDR indicate that engineering education is too much focused on single-problem solving, while focus should be more on searching and defining complex problems that are solved in multidisciplinary teams. The results of TLW support these findings.

Part of the teaching staff is familiar with the approach of defining learning objectives on the course level, which enhances wider introduction of the approach of learning objectives (TLW). However, mostly a broader application of the approach on the level of degrees is still missing (TLW). A practical hindrance to developing engineering pedagogy proposed by OFS, CGW and TLW is the poor student/teacher –ratio.

Results from OFS suggest that the spirit of engineering students is a strength and an essential part of the learning environment, especially in universities, but also in polytechnics. A wide variety of extracurricular activities provided by students themselves enhance the development of several key skills needed later in working life, such as communication skills and teamwork (OFS).

Results from SDR show that there are plenty of teachers and researchers that are enthusiastic about sustainable development. There are also plenty of separate solutions enhancing sustainable development. However, a shared systemic understanding of enhancing sustainable development is missing. Furthermore, in several cases, a core group of persons with decision-making power is missing that would be required in order to make a systemic change. Figure 5.18 provides a summary of the analysis of the present situation on sustainable development in the Finnish engineering education as suggested by SDR.

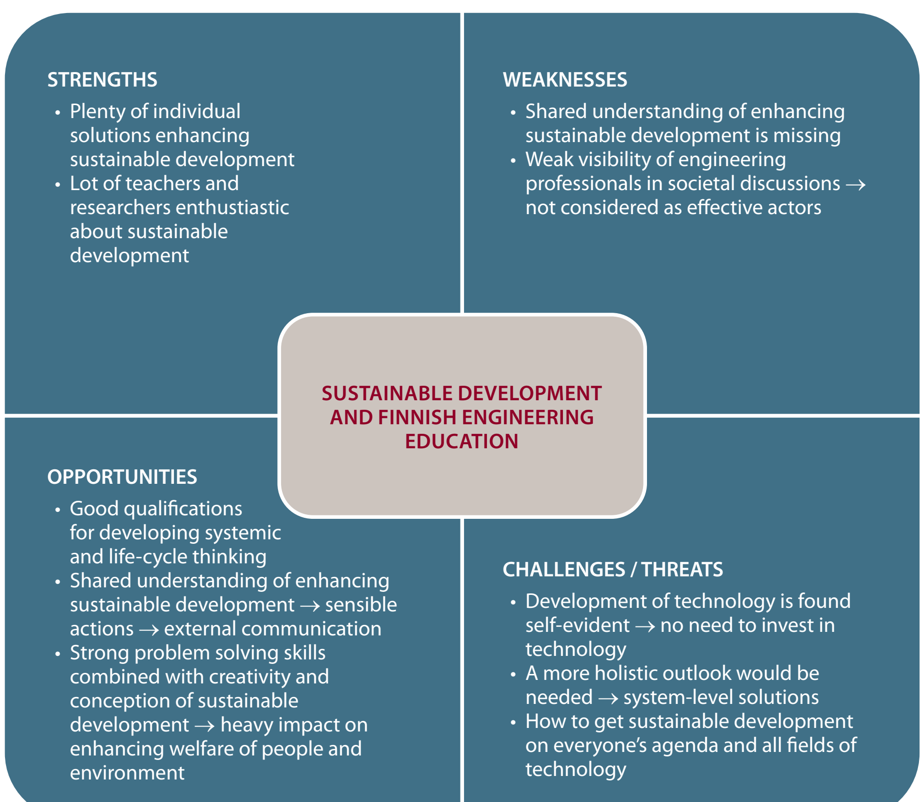

Figure 5.18 Analysis of the present situation on sustainable development and Finnish engineering education (Takala 2009, 98).

The results from SDR and TLW suggest that the context of learning in engineering education revolves too much around single problem solution, while the focus would need to be on creative critical thinking enabling the definition and analysis of complex problems that require a multidisciplinary approach. This is especially important from the viewpoint of enhancing sustainable development that is by its very nature complex and multidisciplinary (SDR).

A persistent problem of the learning environment is the lack of female students (AD, OFS, CGW). AD, OFS, CGW and TLW suggest as a major deficit also the lack of international students and staff as well as low mobility of Finnish students and staff. In addition, OFS and CGW propose that the context of learning does not enhance in an optimum way the development of students with an extraordinary talent.

Results from OFS and CGW indicate that one weakness in the context of learning is that the laboratory equipment is often out-dated, because of all the available resources are being used for fixing acute resourcing problems in undergraduate education. CGW argues that out-dated laboratory equipment combined with weak student/teacher –ratio impair instruction in laboratory work, which is an essential part of engineering education.

OFS and TLW suggest that one of the special problem areas concerning engineering pedagogy is the basic studies of mathematics and natural sciences that would require considerable development. Low appreciation of teaching at universities is proposed by AD, OFS, CGW and TLW as a major hindrance to developing engineering pedagogy. Participants of AD are pessimistic about the situation improving although almost all would find it desirable. Only one third of panelists finds it probable.

OFS, CGW and TLW argue that the high drop-out rate of students is a major problem. Among the underlying reasons are the lack of teaching resources compared to the number of students, and poor pedagogy intertwined with learning difficulties and motivation problems. Students may originally not have been interested in engineering, but applied because of easy entry (OFS).

5.7 SUMMARY OF THE LONG-TERM DEVELOPMENT AND PRESENT

This chapter provides a summary of the long-term development and present state of the Finnish engineering education. The summary is a synthesis of the results of stakeholder processes of the study, literature and statistics describing the Finnish engineering education presented in this chapter as well as of the engineering discipline and changing society presented in Chapter 4.

The following abbreviations are used regarding the sources of stakeholder processes in the study: The Argument Delphi panel = AD, Historical analysis at the Open Futures Search event = OFS history, Analysis of the present at the Open Futures Search event = OFS, The Collaboration Group's workshops = CGW, Workshops on teaching and learning as part of the Collaboration Group = TLW and Research on sustainable development as part of the Collaboration Group = SDR.

The summary is presented in the form of a Table 5.10 synthesizing the strengths and opportunities as well as weaknesses and challenges. The summarized aspects are:

- Engineering profession and discipline in the Finnish society
- Network of institutions: structural development and specialization
- Dual model and degree system
- Co-operation with industry and other stakeholder co-operation
- Management of higher education institutions
- Resources and funding system

- Internationalization of higher education institutions
- Anticipation and quality assurance
- Recruitment and volume of education
- Skills of engineering graduates
- Learning context, pedagogy and proceeding of studies
- Post-graduate and continuing education

Table 5.10 Summary of the long-term development and present state of the Finnish engineering education.

	Strengths / opportunities	Weaknesses / challenges
Engineering profession and discipline in the Finnish society	Patriotism, homogeneity of the society, and small size of the country have provided several benefits for the Finnish engineering education (OFS history, OFS, CGW). Environmental awareness starts growing in 1980s, but climate change a widely recognized issue in 21st century (OFS history). **Engineering education plays a key role in facing challenges of sustainability including climate change, which may increase attractiveness of education** (CGW,SDR). **Engineering reflects more than most professions the immediate environment within which it operates** (Allenby et al. 2009).	< 1960s owner, 1960-90 manager, 1990 - wide variety of careers increasingly in expert positions. 1960-70s strengthening of civil engineering, mechanics and electronics. IT increases importance since 1970s. Growing importance of **systems engineering** since 1990s. 2000- observed need for further interdisciplinarity. (OFS history). **Opening up of the innovation system** (Chesbrough 2003a,b), **technological convergence** (Allenby et al. 2009), **steady and increasing growth of service sector, increasingly KIBS** (Toivonen 2004, OECD 2008), **deepening globalization and global interdependence in economy and sustainable development** (OECD 2008). **Nature of profession and requirements for EE changing. Multifold-identity of engineers** (OFS history). Lack of understanding of the societal role of technology and machine-centred image (OFS, CGW, SDR). **Non-engineers define role of engineer narrowly and expect technology to develop without considerable effort/resources** (SDR).**In future homogeneity of the society may be a risk** (OFS history).
Network of institutions: structural development and specialization	**In historical approach, wide regional coverage of HEIs has provided also benefits, although in the present knowledge society it is turning into weakness and challenge** (OFS history, CGW). Structural development of the HEI network and specialization started, but still in its infancy compared to societal development (OFS history, CGW)	Regional policy steered educational policy 1960 - 2000. 2000- two opposite trends: intensified global and local aspects. **Structural development of the HEI network lacks behind societal development** (OFS history, OFS, CGW). **Too scattered structure of the system, poor specialization of institutions, too small institutions and degree programs are a risk for the quality of education, and financially inefficient** which is especially problematic because of growing pressure of educational needs in society (OFS, CGW).
Dual model and degree system	Availability of two tracks is a strength. (AD,OFS, CGW, TLW). **Clear roles of B.Eng and M.Sc.(Tech.) degrees** (CGW) **and appreciation of M.Sc.(Tech.) degree** (CGW, Allt & Suutari 2002) **and B.Eng degree** (CGW) **in the labor market**. B.Sc.(Tech.) considered as an intermediate degree (CGW). **Two-cycle degree structure** improves international comparability of degrees, enables later specialization, easier switch between theoretical and practical-oriented track as well as speeds up time-to-market (CGW,TLW)	**The division between basic and applied research is not categorical** (Stokes 1997) **and does not fit into open innovation system** (Chesbrough 2003 a,b), which **makes distinction of universities and polytechnincs in reasearch roles challenging**. **Finnish EE lacks a national vision** (AD, OFS, CGW). **Need to define more clearly differences in functions of HEIs and curriculum** (AD, OFS, CGW, TWL), especially learning objectives between B.Sc.(Tech.) and B.Eng.(CGW, TLW). **Employers still often unfamiliar with provided qualification of M.Eng** degree (OFS, Ahola & Galli 2010). **Too many degree program titles** (OFS).**Compulsory training decreased with B.Sc.(Tech.), which may be a risk** (CGW). **Two-cycle degree structure may lengthen studying time** (TEK 2010a, Erkkilä 2010)

Co-operation with industry and other stakeholder co-operation	**Close industrial co-operation among core strengths at present** (AD, OFS, CGW; Statistics: share of external funding, labormarket intensity index, amount of work experience of graduate students, knowledge transfer between university and industry) **and key features shaping Finnish EE in the long-term** (Hautala et al. 1995, Orelma 1996, Michelsen 1999, Aunesluoma 2004, OFS historical analysis) except for a short period 1970 - 80 when it was banned (labor market intensity index, OFS). **Co-operation well developed in practical training and thesis assignments** (AD, OFS, CGW, TLW) and **R&D co-operation** (OFS, CGW, Keso et al. 2003). **Non-hierarchial organization culture encourages student participation** (OFS). **Strong community of students** (OFS, CGW, Sammalisto 2009). **Smooth co-operation with associations and research organisations** (OFS).	**Not systematic/strategic**(OFS,CGW). A challenge is that the **role of practice is not similar in different fields of engineering** (Naukkarinen 2006, Jorgensen 2007). **Despite close co-operation, skill shortages in meeting labor market needs** (see column skill needs). Co-operation is mostly **poorly documented, which hinders organizational learning** (OFS, CGW). **Differences between teachers in frequency of industrial co-operation are remarkable** (TLW). Worries that short-term needs of the labor market are stressed too much (TLW) and there is not enough funding for basic research at universities (OFS, CGW). **Historical evidence suggests that risk for not enough focus on academic basic research is relevant** (Michelsen 1999).**Problems in co-operation between HEIs:** not focused institutions and unclear division of work between universities and polytechnics (OFS, CGW). **Insufficient co-operation between research and teaching** (OFS, CGW, TLW). Alumni co-operation fairly undeveloped (OFS, CGW).
Management of HEIs	Stakeholders represented in the board (CGW). **New Universities Act (558/2009) increased autonomy of universities, minimum representation of university external stakeholders in the board and enabled foundation-based universities**. Two largest educators of M.Sc.(Tech.) engineers, TKK as part of Aalto and TUT became foundation-based.	**Not professional and strategic. Lack of management competences in HEIs.** Collegial management system in universities is accompanied with severe problems(OFS, CGW; note finding before Universities Act changed in 7/2009). **Short-term objectives rule out too often in management of polytechnics owned by the municipalities** (CGW).
Resources and funding system	**Thanks to close industrial co-operation plenty of external funding for R&D**.(CGW) Because there are no tuition fees, **availability of higher education is not dependent on economical status** (AD, OFS, CGW)	**Not enough incentives in the funding system to improve quality of education** (AD, OFS, CGW) or **co-operation between HEIs** (CGW). **Internal funding system in HEIs does not encourage co-operation** between departments and degree programs (OFS, CGW). Because tuition fees allowed only very limitedly, **HEIs are handicapped in developing export of education and not able to develop Masters' programs with tuition fee as an option for continuing education**. (OFS, CGW)

Internationalization of HEIs	Became an issue in 1980s, but no practical consequences until 1990s, when **EU-programs and more tuition in English** available (OFS history). **Intensified opportunities in 2000s through Bologna process**. (OFS history; Note that statistics on internationalization in KOTA and AMKOTA do not support grasping of the opportunity.)	**Poor internationalization of the learning context is among core problems** (AD,OFS,CGW,TLW; KOTA: share of foreign staff man years at universities providing EE decreased 1994-2008. Share of international students increased between 1998-2008 from 0.8% to 2.2%, but still very low. No increase in mobility of Finnish students between 1998-2008. TEK 2010a: in 2009 22% of graduated M.Sc.(Tech.) engineers had studied abroad a month or more. AMKOTA: in 2009 the share of foreign staff man years 2.0%, share of staff man years abroad of all Finnish staff man years 2.1%. Remarkable variations between polytechnics in mobility of students: in 2009 share of students abroad varied between 1.1 - 4.0%)
Anticipation and quality assurance	Finnish Higher Education Evaluation Council FINHEEC carries out **regular evaluations of universities and polytechnics**. In the FINHEEC plan 2010 - 2013 **clarification of possible need for EUR-ACE accreditations brought up** (FINHEEC 2010).	**Systematic anticipation of skill needs** (AD,OFS,CGW) **and utilization of the results of anticipation and follow-up systems** (AD,CGW) **is undeveloped**. **Teaching lacks proper quality criteria** (OFS, CGW,TLW) and **assessment methods do not support optimally reaching of the learning objectives** (TLW). **Non-existent accreditation system may become a challenge** (minority of AD).
Recruitment and volume of education	**Understading the role of technology in enhancing welfare of people and the environment could attract plenty of young people, especially women** (CGW). Due to the high volume of EE (KOTA, AMKOTA: 21% of all undergraduate students in universities study engineering and 30% in polytechnics) **availability of qualified engineers best in the world** (IMD survey 2009). **Despite high volume of EE, employment of M.Sc.(Tech.) graduates still adequate** (Vuorinen & Valkonen 2007, TEK 2010a).	**Neither Finnish EE as a whole nor individual HEIs have a strong attractive brand** (OFS, CGW). **Volume of EE too high** (OFS history, OFS, CGW; KOTA: 71% growth in number of M.Sc.(Tech.) students between 1989 - 2009; AMKOTA: 91% growth in number of B.Eng students 1997 - 2009) **compared to available resources for teaching** (for statistics see column learning context), **students with motivation and sufficient skills** (OFS, CGW; Since 1998 intake to undergaduate EE exceeds number of secondary level students taking advanced math KOTA, Statistics Finland, Matriculation Examination Board). **Considerably weakened entered/admitted ratio** in universities (KOTA: in 1997 97% and in 2009 68 %). **Problems in adequacy of employment of B.Eng graduates** (Vuorinen & Valkonen 2007, Koivumäki 2008). **Learning context in primary and secondary school does not enhance phenomenon-oriented experiential learning of natural sciences** (OFS, CGW) **or provide a comprehensive foundation for understanding basic aspects of sustainable development** (SDR).

Skills of EE graduates	**Strong problem-solving skills** is a general strength of Finnish engineering graduates (Korhonen 1997, OFS, CGW, TLW). **Scientific thinking and technical expertise may be regarded as a strength of M.Sc.(Tech.) graduates** (Korhonen 1997, Vuorinen & Valkonen 2007). **Technical expertise is also a strength of B.Eng graduates, although variation exists** (Mäkitalo-Keinonen 2006). **Professional socialization of engineering graduates develops through combining theory and practice in university and industry** (Keltikangas & Martinsuo 2009), thus **due to the close labor market relation opportunities exist for better exploiting this advantage**. **Curriculum enables individual choices**, but in practice does not lead to sufficient level of interdisciplinary skills (OFS, CGW).	**Technical expertise is important, but narrow focus on technology is simply not enough** (Korhonen 1997, Graaf & Raavesteijn 2001, Scott & Yates 2002, Kerns et al. 2005, Vest 2005, Crawley et al. 2007, Spinks et al. 2007). **Systems understanding of techology is needed** (Allenby et al. 2009, Chesbrough 2003 b) & **ability to understand broader societal context and implications of technology** (Johnston et al. 2000, van de Poel 2001, Graaf & Raavesteijn 2001, Allenby et al. 2009). Open innovation paradigm (Chesbrough 2003a,b) implies that graduates need to be **able to interact with various stakeholders and understand value creation and business** (see e.g. Yannou & Bigand 2004, Graaf & Raavesteijn 2001, Spinks et al. 2007), and **increasingly also in services including KIBS** (OECD 2008, Toivonen 2004). From socio-cultural aspect expertise is a social phenomenon (Helle et al. 2006), **which emphasizes importance of interpersonal, communication, teamwork & collaborative learning**. **Systemic and lifecycyle thinking is insufficient and too much focus on single problem solving** (SDR,TLW). **Skill shortages also in interpersonal, communication, team work, ability to deal in multicultural environment, business and entrepreneurial skills** (Korhonen 1997, Allt & Suutari 2002, Olin et al. 2002, Mäkitalo-Keinonen 2006, Vuorinen & Valkonen 2007, TLW) & **collaborative learning enabling shared expertise** (TLW).

Learning context, pedagogy and proceeding of studies	**Plenty of practical work experience during studies** (TEK:M.Sc.(Tech.) typically 1.5 - 2 years, UIL: B.Eng typically 1 - 1.5 years) **enhances learning of engineering practice and interdisciplinary skills**. Plenty of individual teachers and researchers that are enthusiastic about possibilities of **enhancing sustainable development in engineering education and examples of good practices exist** (SDR). **Spirit of engineering students and a lot of extracurricular activities** provided by students themselves, especially in universities, but also in polytechnics that **enhance development of several key skills like communication and teamwork** (OFS). **Strong feeling of community enhances proceeding of studies and improves learning** (Sammalisto 2009).	**Combining theory and practice is not systematic and is left too much for students alone** (Naukkarinen 2006). **Learning objectives not set for practical training periods** (TLW). **HEIs do not question present curriculum** (TLW). **Most severe problems in the context, pedagogy and pedagogic management** (TLW, Erkkilä 2009), because **meeting of interdisciplinary skill requirements would require active learning methods** (see e.g. Graaf & Kolmos 2003, 2007) and **intertwining of learning environment in university and industry** (Spinks et al. 2007, Keltikangas & Martinsuo 2009) and because actually **we cannot even know skill needs of the future** (Vest 2005). **High drop-out rate** (KOTA, AMKOTA: 40 - 45 %). **Learning context does not favor in depth learning orientation** (Erkkilä 2009). **Shared understanding and management support for enhancing SD missing** (SDR). **Undeveloped pedagogy of natural sciences tuition** (OFS,TLW). **Low appreciation of teaching and lack of incentives for improving quality** (AD, OFS,CGW,TLW). **Students with extraordinary talent ignored** (OFS, CGW). **Lack of women and international students** (AD, OFS, CGW, TLW). **Poor teacher/student ratio** (OFS, CGW,TLW; AMKOTA: 1997 1:10, 2009 1:22; KOTA: 1993 1:18, 2009 1:25). **Outdated lab equipment** (OFS, CGW). **Poor teaching & lack of students' motivation slow down studies** (Rantanen&Liski 2008, Sammalisto 2009). **Students don't study enough** (TLW,Rantanen&Liski 2008).
Post-graduate and continuing education	**Enhancing LLL included in the mission of HEIs** (558/2009, 351/2003) **since 2009**. **A clear majority of engineering graduates recognizes the need for CPD** (Allt&Suutari 2002, TEK studies on CPD 2002-2010). **Started development of recognized professional qualifications for higher educated** to meet the increasing CPD needs and to develop **work-based learning** (Finnish Ministry of Education 2009b). **Collaboration of HEIs and labor market organizations in developing recognized professional qualifications for engineers.** (Ihalainen 2009).	**Continuing education system of engineers is undeveloped compared to increased needs** (CGW, OFS, AD, KOTA & AMKOTA statistics, TEK CPD studies 2002-10). **Fast growth of post-graduate students, but not degrees** (KOTA: Year 1989 2 363 post-graduate students and 186 degrees, year 2009 5 265 post-graduate students and 396 degrees) **may indicate using PhD courses for CPD, especially because degree-oriented education is by law free of charge**.

6 STAKEHOLDER VIEWS ON THE FUTURE OF THE FINNISH ENGINEERING EDUCATION

The focus of this chapter is on the future prospects of the Finnish engineering education. The results presented in this chapter are based on the three stakeholder processes of the study: the Argument Delphi panel, Open Futures Search event and work process of the National Collaboration Group for the Finnish engineering education.

Chapter 6.1 analyzes the key factors in the business environment impacting the future of the Finnish engineering education. The mission and vision of the Finnish engineering education are discussed in Chapter 6.2. Scenarios describing the future of the Finnish engineering education are presented in Chapter 6.3. The chapter concludes with the discussion on the future prospects of the Finnish engineering education and presented proposals for action during the three stakeholder processes in Chapter 3.2.3.

6.1 ANALYSIS OF THE BUSINESS ENVIRONMENT

This chapter is a summary of the analysis of the business environment impacting the Finnish engineering education in three stakeholder processes: the Argument Delphi panel (AD), the Open Futures Search event (OFS) and the Collaboration Group workshop 1.-2.10.2007 (CGW). With regard to sustainable development, some aspects are also brought up from the interviews (Takala 2009) supporting the sustainable development subproject of the Collaboration Group (SDR).

Scenarios for Finland 2015 framed by the researcher based on the first-round interviews in the Argument Delphi panel can be found in the questionnaire regarding the development of the business environment in Appendix 1. A summary of the panelist evaluations of scenarios is in Appendix 18. Panelist evaluations on the presented core items list on each scenario are discussed also in the analysis of the reliability and validity of the Argument Delphi panel in Chapter 4.1.3.

Deepening Globalization and Increased Competition

Deepening globalization accompanied with increased competition is identified among the key trends in all the three stakeholder processes (AD, OFS, CGW). It is intertwined with most of the key trends found, especially the development of ICT and deepening digitalization that enable the world to become a village and increased competition requiring specialization and networking with the stakeholders. The key question is who provides the best environment and services for attracting and cross-pollinating knowledge and skills (CGW). OFS and CGW argue that it is of high importance that Finland is among the leaders of Europe in developing higher education. Finland should provide the best innovation environment and engineering education in the world (CGW).

A possible risk is increased polarization (AD, OFS, CGW). If the winner takes it all, will there be a caste system of universities (CGW), how is work divided, how does it affect insecurity versus security and totalitarianism versus humanity (OFS)? Participants of AD suggest that one of our national strengths is the ability to combine the welfare state and Information Society. The researcher finds it relevant to ponder if, in practice, it is possible in a globalized economy to aim to enhance welfare limited to national welfare, or is actually the only alternative to aim to develop welfare globally when aiming to develop a welfare state of Information Age?

Global welfare among core values may be identified as a weak signal from the results of AD. However, the most probable scenario is a society with individualistic materialistic values. Also OFS suggests possible value changes emphasizing fairness, meaningful work and less focus on materialistic values.

Part-time work may become more common. CGW suggests the growing importance of environmental and IT security as a value. Competing trends of individualistic and materialistic values versus collective welfare are raised just like in AD.

A possible weakness of the Finnish engineering education system compared to the change of the business environment introducing "winner takes it all" and importance of extraordinary talent is suggested by OFS and CGW: there are no degree programs of excellence enhancing development of extraordinary talent, which may be a serious deficit in the globalized knowledge economy.

For higher education the deepening globalization means a global higher education market and increased pressure to develop quality of education (OFS, CGW). This calls for internationalization, decrease in the number of higher education institutions and campuses, need to find the right networks, focusing, and specialization (OFS, CGW). The importance of quality assessment in higher education institutions grows (CGW). Asian education may become an extremely strong competitor in higher education (OFS). There is a risk that weak internationalization and lack of multiculturalism turn into a bottleneck for Finland (AD, OFS).

Also pressures for conformity of the education (CGW) and degree (OFS) system increase. The dual model is envisioned as the desirable future in all the three stakeholder processes (AD, OFS, CGW). The growing pressure for conformity of educational systems as a result of deepening globalization may be identified most clearly from the discussions of CGW. A weak signal in the discussions of OFS is that the monopoly of higher education institutions to grant degrees may possibly vanish in the future.

Risks of global terrorism and its possible major effect on society in all sectors is raised by AD and OFS. Growing nationalism and effects on logistics are also brought up in both stakeholder processes. If terrorists are able to disrupt the internet, the world economy collapses (AD). One of the wild cards identified among top three in AD is an Islamic revolution starting from the Middle East.

Networking, Specialization and Stakeholder Dialogue

It is likely that stakeholder dialogue becomes more important (AD, OFS, CGW). Increased importance of stakeholder dialogue is linked to increased need for the systems approach, interdisciplinarity and deepening globalization enhancing competition that forces nations, regions, organizations – including higher education institutions – and individuals to specialize and focus on their core competencies (AD, OFS, CGW). Stakeholder co-operation of higher education institutions with industry will further tighten. This provides a lot of strengths but also threats for research – what happens to creative geeks at universities (OFS)?

Analysis of OFS suggests the growing importance of social media as part of networking with the stakeholders. The consequences of social media to learning are not discussed in the analysis of business environment, but the researcher argues that this item should be discussed also in relation to the changing context and pedagogy of engineering education.

As part of the specialization trend on the level of the individual is the need to individualize the curriculum in engineering education, to legitimize part-time studying, and to brand oneself for one's career (CGW).

Pressure for Sustainable Development and Role of Technology

AD, OFS and CGW suggest a remarkably growing importance of enhancing sustainable development in society. Participants of AD are quite hesitant about how widely values enhancing sustainable development are applied in practice. In OFS and CGW, sustainable development is positioned among core trends in society. In the analysis of CGW, it is also seen as a possible source of a global crisis. Analysis of AD and OFS brings up the dual nature of technology in relation to sustainable development: depending on the angle, people see it as an opportunity or a threat.

Development of energy (AD, OFS), environmental (AD, OFS) and materials (AD) technologies are found to play an important role from the viewpoint of economic success as well as in enhancing sustainable development.

In AD as well as in SDR, local and decentralized solutions may be identified as a weak signal in energy and food production. The results of SDR suggest specifically that waste management as well as water supply and sewerage may be developing towards decentralized solutions. For engineering education this would mean the increasing importance of localized small-scale solutions in the curriculum. One more potential challenge related to sustainable development is the nutrient cycle and sufficiency of natural resources (SDR).

Development of Nano- and Biotechnology and Risk Assessment

Development of nano- and biotechnologies is introduced by AD and CGW among key trends in the business environment of the Finnish engineering education. Analysis in AD regarding the consequences is more thorough. Nanotechnology is found to provide a lot of opportunities. Biotechnology is suggested to provide opportunities, but factors of uncertainty related to ethical and moral issues, as an example fear of widespread genetic modification, may slow down the development of biotechnology.

In AD the continuous assessment of risks posed by development of technology is considered essential. CGW emphasizes especially environmental and IT security and raises an important issue, the dependence of society on technology.

AD claims that engineering sciences play an important role in developing biotechnology. Combining, for instance, electronics, theoretical physics, materials technology, and information technology with biotechnology is anticipated to result in important new innovations.

Towards Service Economy and Increased Productivity

The fast development of ICT and integration into all sectors has a heavy impact (AD, OFS, CGW). It provides opportunities and pressure for increased productivity (CGW). The development of ICT has a heavy impact also on education (OFS, CGW).

Services represent in the future a major share of the economic activity (AD, OFS, CGW) – according to CGW, 70% of the GDP. New operational and business models emerge (AD, CGW). AD finds possible the scenario that labor-intensive, not high value-added industrial production, moves to a large extent away from Finland. One third of AD is of the opinion that it is likely that the majority of the production in pulp and paper industry is going to move away from Finland. This scenario has started to become a reality impacting engineering profession in Finland (CGW).

AD suggests that the lack of entrepreneurship as part of economic activity is a probable threat scenario. Increased opportunities would exist in relation to the development of the service economy and ICT, but development is not promising.

AD proposes that the learning industry has potential to grow as a significant business cluster. Ability to collect tuition fees for degree-oriented education is seen as a factor that affects whether higher education institutions are able to grasp the potential. Also OFS and CGW suggest the growing potential of selling degree-oriented higher education.

Increased Complexity, Systems Approach and Interdisciplinarity

Increased complexity is not mentioned separately as an item in none of the three stakeholder processes (AD, OFS, CGW). However, when examining the results of the business environment analysis, it can be observed that several trends that seem contradictory are presented. These are, for example, increased individualism versus global responsibility, competition and co-operation at the same time, need to be a deeply focused specialist and generalist at the same time, spending more time on hobbies and leisure, while at the same time doing meaningful, demanding work with a continuous need for professional development.

Results from all the three stakeholder processes (AD, OFS, CGW) indicate an increasing importance of the systems approach and interdisciplinarity. The aims of specialization and multidisciplinarity are competing. The importance of all-round education grows (CGW). Technology becomes humane (OFS). Participants of AD are more skeptical than others whether a third culture could emerge between engineering and humanities, although it would be desirable. Complete solutions through teamwork – technology alone is not enough (CGW). Participants of AD and OFS emphasize the innovation potential at the interfaces of different disciplines. Design is at the core of engineering (CGW).

AD emphasizes that interdisciplinarity is important not only between engineering and other disciplines, but also between different fields of engineering. As an example, the combination of materials, information and biotechnologies provides plenty of opportunities.

Growing Importance of Collaborative, Experiential and Virtual Learning

CGW argues for a paradigm shift of pedagogy at higher education institutions: how learning takes place, enabling different learning styles and benefiting from learning technologies enabled by ICT. Deepening globalization combined with the fast development of ICT creates growing opportunities for e-learning that may have substantial consequences for higher education (OFS, CGW).

Growing and fast changing skills needs combined with the fast development of technology implies growing pressure for several careers and continuous professional development (AD, OFS, CGW). Enhancing continuing professional development of professionals may become a core activity of universities (CGW).

A question posed in all the three stakeholder processes is how to finance the growing need for updating and learning new skills. Answers may be classified into two main categories: increased importance of informal on-the-job learning and increasing variety of funding sources in higher education, including tuition fees.

6.2 MISSION AND VISION OF THE FINNISH ENGINEERING EDUCATION

This chapter discusses the mission and vision of the Finnish engineering education based on the results of the three stakeholder processes of the study: the Argument Delphi panel, the Open Futures Search event and the Collaboration Group.

Why does Finnish engineering education exist? The mission of the Finnish engineering education is defined by the Collaboration Group[157] as follows:

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157 The mission was defined using a preparatory assignment (2) and results of the workshop on 12.11.2007. (Allt & Korhonen-Yrjänheikki 2008)

The internationally recognized Finnish engineering education provides competencies, skills, research and innovations for the benefit of people and environment to meet the needs of the competitive and continuously developing society and business.

One of the key findings of the Argument Delphi panel is that Finnish engineering education lacks a clear vision. Political decision makers may be hindering the development towards the desired direction as all other stakeholder groups in the Delphi panel except political decision makers find the scenario "New parallel model" desirable. The opinions of the political decision makers on the desirability of the scenario divide. Two scenarios that are very different by nature, "New parallel model" and "Parallel in theory – overlapping in practice, are both estimated to be probable. See Chapter 8.2.1 for the contents and evaluations of the scenarios.

The participants of the Open Futures Search event formulate[158] the national vision for the Finnish engineering education as follows:

World-wide appreciated Finnish engineering education provides knowledge, skills, research and innovations for the benefit of people and environment, and to meet the needs of the globalized business-life. Widely recognized top-quality research and innovativeness enhance the competitiveness of Finland. A teaching and research environment of high quality attracts professionals from allover the world.

The vision of the Finnish engineering education for 2020 as defined by the Collaboration Group[159].

Finnish engineering education and research is internationally well-known for its excellence in developing technologies, processes, knowledge, skills, attitudes and values enhancing sustainable development. Higher education institutions providing engineering education have defined their core competencies and operate as a network of specialized institutions in co-operation with industry and other stakeholders.

Engineering education plays a key role in solving global problems. Engineering education attracts motivated students, teachers, developers and researchers from diverse backgrounds. Teaching and learning is valued.

Higher education institutions have defined their profiles and focused on their areas of strength. The management of higher education institutions is professional. As a result of structural development of the educational system, there are fewer but better higher education institutions.

Higher education institutions providing engineering education are universities (about 5), polytechnics (about 12) and merged universities and polytechnics. This means that 5 - 7 universities have the right to grant the Master of Science in Technology degree and about 15 polytechnics have the right to grant Bachelor of Engineering degree. The funding of the Finnish engineering education has been increased so as to make it internationally competitive.

The core content of the future vision defined at the Open Futures Search event is similar to the one

158 A draft for the vision of the Finnish engineering education was framed first by 8 working groups separately and finalized during action planning with Open Space (Owen 2008). A description of the Open Space method is in Appendix 8.
159 The vision 2020 of the Finnish engineering education was defined using a preparatory assignment (3) and participatory working methods at the Collaboration Group workshops 1.-2.10.2007 and 29.11.2007. (Allt & Korhonen-Yrjänheikki 2008)

defined by the Collaboration Group. The Collaboration Group specified the vision in more detail. In fact, the mission statement defined by the Collaboration Group corresponds to the vision defined at the Open Futures Search event.

6.3 SCENARIOS ON FINNISH ENGINEERING EDUCATION

This chapter deals with the scenarios on the future of the Finnish engineering education. The scenarios presented by the Argument Delphi panel are discussed in Chapter 6.3.1. Chapter 6.3.2 provides the scenarios framed by the Collaboration Group.

6.3.1 Scenarios Presented by the Argument Delphi Panel

This chapter provides an overview of the scenarios on the Finnish engineering education system in 2015. The researcher framed the scenarios based on the interviews of the Delphi panelists. In the second round of Delphi, the panelists evaluated the framed scenarios. The scope of the scenarios is limited to the structure of the higher education system in engineering, roles of universities and polytechnics, and the degree system.

Scenario 1: New parallel model

Core items: administrative mergers, clearly different aims and degree profiles, teaching highly appreciated, new start-ups based on research results, universities of technology actively participate in civic debate

The structure of the higher education system

Content-wise, the higher education system is based on a parallel model: universities and polytechnics have different duties in teaching and research. Administratively, the majority of universities (and faculties) and polytechnics providing engineering education have merged.

Enlarging the size of units has proven to be beneficial for organizing research, teaching, and administration. This way, it is believed, the institutions can better survive in the tightening competition of the global educational market. The profiles of the degrees Bachelor of Engineering (polytechnic) and Master of Science in Technology (university) have become quite distinct, as it is quite natural that an administratively merged higher education institution does not provide degree programs with overlapping contents.

The duties of higher education institutions

The aim of universities is to produce new knowledge and expertise in co-operation with business life and society. The aim of polytechnics is to apply the knowledge created at universities and make it available to society at large. Thanks to clear, different aims of universities and polytechnics, co-operation runs smoothly. The administrative merger of higher education institutions has also promoted co-operation in which the operations of the parties complement each other in research, as well as teaching, and unnecessary overlap has been cut.

Teaching has emerged alongside research as a valued activity in universities and faculties of technology. Universities and polytechnics providing engineering education invest significantly more resources in teaching and continuous development of teaching than in 2002.

Compared with 2002, entrepreneurship has a significantly more important role in higher education institutions. Thinking about how new research results can create new business and companies is a central issue. Universities providing engineering education have assumed an increasingly active role in civic debate.

The degree system

The administratively merged polytechnics and universities providing engineering education offer a practically-oriented Bachelor's program (Bachelor of Engineering) and a theoretically-oriented Bachelor's program (Bachelor of Science in Technology). Both degree programs enable the student to apply for Master's studies at universities (Master of Science in Technology). Some polytechnics that for some reason or other have not merged with a university providing engineering education, offer Master's programs for persons graduated at a polytechnic with the Bachelor of Engineering degree.

Internationally, the Bachelor of Engineering degree compares with the Bachelor of Science in Technology. However, students who have chosen the practically-oriented Bachelor's program (Bachelor of Engineering) must take 20 credits of supplementary studies if they wish to apply for Master's studies at universities (Master of Science in Technology).

Those with a Master's level degree (Master of Science in Technology) can apply for doctoral studies. In addition, many universities have a separate researcher training program leading directly to a Doctor's degree. Applying for these programs is possible directly after taking the Bachelor of Science in Technology degree. The degree between Master and Ph.D., Licentiate degree, still in the degree system of 2002, has been abolished.

16 out of 21 panelists find the scenario "New parallel model" desirable (9) or highly desirable (7). 3 out of 4 that find the scenario undesirable are political decision makers. 13 panelist are of the opinion that the scenario is probable (12) or highly probable (1).

16 out of 21 panelists are satisfied with the core items list as such. The proposed additions are "municipalities separated from polytechnics = municipalities find that the ownership of polytechnics is not part of their core functions" and "co-operation with existing and new companies is of key importance". Two panelists propose removing "teaching appreciated". One of them argues that it could be part of any of the four scenarios. One panelist would like to remove "administrative mergers", because according to the panelist, small size increases competition and quality.

15 panelists are satisfied with the contents of the scenario as such. Five panelists propose removing a chapter of the scenario. All of them propose different chapters.

Scenario 2 : Parallel in theory – overlapping in practice

Core items: co-operation between higher education institutions necessary though difficult, no clear division of tasks, degree profiles close to one another, degrees partly directly comparable, research more valued than teaching

The structure of the higher education system

Polytechnics and universities providing engineering education operate as partly parallel, partly overlapping systems. Polytechnics have attempted to gain status by making their degrees directly comparable to university degrees.

Increasing co-operation between higher education institutions has been deemed necessary because competition in the global educational market has become fiercer. However, similar profiles of polytechnics and universities providing engineering education hamper co-operation.

The duties of higher education institutions

In theory, universities and polytechnics have different aims and duties. However, in practice, the role division has become blurred. Basic research is the duty of universities, but, in practice, some polytechnics endeavor to *engage in basic research in addition to applied research. The situation is made even more confusing by the fact that applied research is anticipated to offer so much business potential that some universities focus clearly more on applied research than basic research.*

The practical nature of polytechnic studies has decreased compared with 2002. As the theoretical emphasis of the content of undergraduate studies at universities and faculties of technology has not increased, the content of a Bachelor of Engineering degree is beginning to resemble that of a Bachelor of Science in Technology -degree.

Teaching is not as highly appreciated an activity at universities as research. This has contributed to the slow development of teaching in universities.

The degree system

Polytechnics offer Bachelor's degrees (Bachelor of Engineering) and Master's degrees. The Bachelor of Engineering -degree is comparable to a Bachelor of Science in Technology -degree. If students who have taken a Master's degree at a polytechnic wish to obtain the degree of Master of Science in Technology, they have to supplement their studies with 20 credits[160] at a university and write a Master's thesis.

Bachelor of Science in Technology is the typical first degree in universities. The majority of students, however, continue their studies to become Masters of Science in Technology. Postgraduate students aim at a Doctor's degree as the Licentiate degree no longer exists in the degree system.

The Argument Delphi panel evaluates the scenario "Parallel in theory – overlapping in practice" as probable, but undesirable. 14 out of 21 panelists find the scenario probable (13) or highly probable (1). 18 out of 21 panelists evaluate the scenario as undesirable (12) or highly undesirable (6).

19 out of 21 panelists are satisfied with the core items list of the scenario as such. One representative of higher education institutions proposes adding "development of EU unclear".

17 out of 21 panelists are satisfied with the contents of the scenario as such. Three panelists propose removing 1 – 2 chapters. None of them propose the same chapter.

Scenario 3: Return to the old parallel model

Core items: polytechnics heavily practically oriented, from multidisciplinary polytechnics to polytechnics of technology, degrees not comparable, in universities teaching valued secondary to research, engineers are a silent profession in society

The structure of the higher education system

Polytechnics and universities providing engineering education operate as parallel systems. The structure of higher education has taken a step backwards. Polytechnics providing engineering education are mostly separated from multidisciplinary polytechnics. Their operations markedly resemble the engineering colleges that existed before the polytechnic reform.

The duties of higher education institutions

Universities and polytechnics have different fields of duties. Teaching in polytechnics has a heavy practical orientation. The service function is central in that polytechnics engage in applied research in close co-operation with enterprises.

The operations of universities emphasize research. Basic research and applied research are carried out side by

160 Corresponds to roughly 30 – 40 ECTS depending on the used co-efficient.

side. Teaching is secondary to research. This is clearly obvious in, for instance, recruitment criteria, investments in undergraduate teaching and the development of teaching.

On the societal level, engineers are a silent profession. Representatives of universities providing engineering education do not actively participate in civic debate.

Degree system

Polytechnics concentrate on providing practically-oriented studies aiming at the Bachelor of Engineering degree. Bachelor of Engineering studies offer the opportunity to take the intermediate degree of a technician. In addition, polytechnics provide continuing education.

Those with the Bachelor of Engineering degree who wish to continue their studies in the field of technology mostly apply to universities. Universities compensate approximately 70 to 90 credits for the Bachelor of Engineering degree, depending on the case, if a student wishes to study for the Master of Science in Technology degree. Degrees taken in polytechnics in the field of technology are not comparable to university degrees.

The majority of engineering students in universities take Master of Science in Technology as their first degree. There is also the Bachelor of Science in Technology degree, but only few students want to take it as an intermediate degree. Postgraduate degrees provided by universities are the licentiate and doctorate.

The Argument Delphi panel finds the scenario "Return to the old parallel model" improbable and undesirable. 15 out of 21 panelists evaluate the scenario as improbable (14) or highly improbable (1). Only 6 out of 21 panelists are of the opinion that the scenario is desirable (5) or highly desirable (1).

Interestingly, of those six panelists that find the scenario desirable or highly desirable, four represent industry. The majority of industry representatives find the scenario desirable, but improbable.

17 out of 21 panelists are satisfied with the list of core items of the scenario as such. A representative of industry that finds the scenario desirable, proposes adding "a more positive alternative for polytechnics" and removing "teaching secondary compared to research at universities". Two representatives of higher education institutions would like to remove "engineers a silent profession". One of them argues that it is an issue of different level than other core items.

16 out of 21 panelist do not want to change anything in the contents of scenario 3. However, three panelists are of the opinion that engineers as a silent profession should be removed from the scenario. One panelist is of the opinion that the change of polytechnics from multidisciplinary institutions to polytechnics of technology should be removed.

Scenario 4: All higher education institutions become universities

Core items: all higher education institutions become universities, no division of duties between polytechnics and universities, decentralization of resources, undergraduate and postgraduate degrees available in all institutions, degrees directly comparable

The structure of the higher education system

Polytechnics and universities providing engineering education operate as an overlapping system. All higher education institutions have become universities. It is possible to take Bachelor's and Master's degrees in the field of technology in approximately 30 higher education institutions in Finland.

The duties of higher education institutions

There is no division of duties between universities and polytechnics in the field of technology. The lack of divi-

sion of duties has made co-operation more difficult, as everybody competes for the same resources. Furthermore, the decentralization of resources has weakened the international competitiveness of the Finnish engineering education.

Both universities and polytechnics are engaged in basic research in technology. Both also engage in applied research. Differences in engaging in basic or applied research are more dependent on the individual higher education institution than general differences between polytechnics and universities. It is impossible to define on a general level the difference in duties of universities and polytechnics in research and teaching.

Degree system

Polytechnic students commonly take Bachelor's and Master's degrees, which are directly comparable to degrees taken at universities (Bachelor of Science in Technology = Bachelor of Engineering and Master of Science in Technology = Master of Engineering). It is also possible to take a Doctor's degree in some polytechnics.

Bachelor of Science in Technology and Master of Science in Technology are the first degrees in universities. The licentiate and doctorate are the postgraduate degrees.

The Argument Delphi panel finds the scenario "All higher education institutions become universities" as an improbable threat scenario. None of the panelists view the scenario as desirable. 16 panelists evaluate it as highly undesirable and 4 panelists as undesirable.

15 panelists out of 21 find the scenario improbable (12), or highly improbable (3). In every stakeholder group there is at least one representative who evaluates the scenario as probable. Two representatives of higher education institutions find the scenario probable (1), or highly probable (1).

All panelists are satisfied with the core items list describing the scenario. All other panelists, except one representative of higher education institutions, are satisfied with the contents of the scenario as such. One representative of higher education institutions proposes removing from the scenario the idea that some polytechnics would provide doctoral education.

Summary of the Scenario Evaluations

One of the key findings regarding scenarios on the Finnish engineering education system is that Finnish engineering education lacks a clear direction of development regarding the structure of the system and role division between universities and polytechnics. Two scenarios that are very different by nature, "New parallel model" and "Parallel in theory – overlapping in practice", are both estimated to be probable.

Furthermore, the Finnish engineering education system lacks a shared vision. Political decision makers seem to be hindering the development towards the desired direction for all other stakeholder groups in the Delphi panel except political decision makers find the scenario "New parallel model" desirable. The opinions of the political decision makers on the desirability of the scenario differ. Three out of five political decision makers in the Delphi panel find the scenario undesirable or very undesirable, whereas two political decision makers find it very desirable.

Majority, 13 out of 21, find the scenario "Return to the old parallel model" undesirable. However, 5 out of 6 representatives of industry find the scenario desirable, which may indicate dissatisfaction with the present system of education. Another alternative may be that the polytechnics reform was carried out just recently[161], industry representatives are unfamiliar with it, and the consequences are still unclear.

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161 Note that the second round of Delphi was carried out in 2002. The piloting phase of polytechnics started during the term 1990 – 91, and the first permanent polytechnics were established in 1996. (Finnish Minisry of Education 2000a, 2006).

Scenario "All higher education institutions become universities" is evaluated as an improbable threat description of the future development. 15 out of 21 panelists found the scenario improbable (12), or highly improbable (3). However, it is noteworthy that in every stakeholder group there is at least one representative who thinks that the scenario is probable. From representatives of higher education institutions two panelists find the scenario probable (1) or highly probable (1).

Table 6.1 summarizes panelist evaluations of the probability and desirability of the scenarios on Finnish engineering education in 2015 from the viewpoint of the structure of education and the degree system and duties of higher education institutions. In Table 6.2 each stakeholder groups' evaluations of the probability of scenarios is presented. Furthermore, Table 6.3 summarizes the desirability of scenarios as evaluated by each group of stakeholders.

Table 6.1 Median of the panelists' evaluations of the probability and desirability of the Finnish engineering education system 2015 scenarios.

Finnish engineering education system year 2015 -scenarios	Probability (median)	Desirability (median)
1: New parallel model	probable	desirable
2: Parallel in theory - overlapping in practice	probable	undesirable
3: Return to the old parallel model	improbable	undesirable
4: All higher education institutions become universities	improbable	highly undesirable

Table 6.2 Probability of the Finnish engineering education system 2015 scenarios as evaluated by each stakeholder group.[162]

Stakeholders	Scenario 1: New parallel model	Scenario 2: Parallel in theory - overlapping in practice	Scenario 3: Return to the old parallel model	Scenario 4: All higher education institutions become universities
university / polytechnics	**probable (3/6)** improbable (2/6)	**probable (4/6)** improbable (1/6)	probable (2/6) **improbable (3/6)**	probable (2/6) **improbable (3/6)**
industry	**probable (5/6)** improbable (1/6)	probable (2/6) **improbable (4/6)**	probable (2/6) **improbable (4/6)**	probable (1/6) **improbable (5/6)**
political decision makers	**probable (3/5)** improbable (2/5)	**probable (4/5)** improbable (1/5)	probable (1/5) **improbable (4/5)**	probable (1/5) **improbable (4/5)**
research organizations	probable (2/4) improbable (2/4)	**probable (4/4)**	**improbable (4/4)**	probable (1/4) **improbable (3/4)**

162 Note that in order to simplify Tables 6.2 and 6.3, evaluations of probable and highly probable are combined into probable, and improbable and highly improbable combined into improbable. And correspondingly, desirable and highly desirable are combined into desirable and undesirable, and highly undesirable into undesirable.

Table 6.3 Desirability of the Finnish engineering education system 2015 scenarios as evaluated by each stakeholder group.

Stakeholders	Scenario 1: New parallel model	Scenario 2: Parallel in theory - overlapping in practice	Scenario 3: Return to the old parallel model	Scenario 4: All higher education institutions become universities
university / polytechnics	**desirable (5/6)**	**undesirable (5/6)**	desirable (1/6) **undesirable (4/6)**	**undesirable (5/6)**
industry	**desirable (5/6)** undesirable (1/6)	**undesirable (6/6)**	**desirable (5/6)** undesirable (1/6)	**undesirable (6/6)**
political decision makers	desirable (2/5) **undesirable (3/5)**	desirable (2/5) **undesirable (3/5)**	desirable (1/5) **undesirable (4/5)**	**undesirable (5/5)**
research organizations	**desirable (4/4)**	**undesirable (4/4)**	**undesirable (4/4)**	**undesirable (4/4)**

6.3.2 Scenarios Presented by the Collaboration Group

The Collaboration Group framed[163] a desirable and threat scenario for the Finnish engineering education in 2020. These scenarios are presented below.

The Desirable Scenario: Welfare from Technology for the Benefit of People and Environment

A significant turning point in the Finnish engineering education and research took place during the latter part of the first decade of the 21st century, when higher education institutions providing engineering education began systematically to develop their core competencies. Cutting down on some degree programs and areas of research was not easy, but successful implementation considerably improved the quality of several higher education institutions.

The new Universities Act enabled more professional management and made the change process in universities easier. The structural development of the higher education system made the division of work between universities and polytechnics clear. The change of higher education legislation enabled merger of universities and polytechnics. As a result, some universities and polytechnics merged and provide both practically- and theoretically-oriented engineering education.

The funding system of higher education was modified. As a result, it encourages higher education institutions to develop the quality of education and research considerably more than before the reform. The budgetary funding of universities and polytechnics has increased steadily from 2009 onwards. Disciplines of key strategic importance for Finland are now receiving more funding, including the engineering discipline.

A remarkable change process was instigated concerning the development of teaching and learning in engineering education. As a result of new incentives, recruitment policies and budgetary funding criteria stressing the quality of education, the appreciation of teaching at universities increased considerably. Also at polytechnics the key importance of teaching quality was widely recognized. The volume of engineering education was de-

163 The desirable and threat scenarios on the Finnish engineering education were formulated using a preparatory assignment (2) and participatory working methods at the workshop of the Collaboration Group on 12.11.2007. (Allt & Korhonen-Yrjänheikki 2008)

creased and the number of teachers increased, resulting in student / teacher –ratio of roughly 10:1. The heavy investment in developing teaching stimulated students to take more responsibility for their learning.

The Finnish engineering education is an international benchmark of close and systematic co-operation with industry. Practical training enhances reaching learning objectives better than it used to. Basic and application-oriented research projects are carried out widely in co-operation with industry.

Engineering graduates have good opportunities for continuous professional development. Continuing education is considered an important activity in higher education institutions, just like undergraduate and post-graduate education. The available learning methods of continuing education are versatile, providing flexibility according to individual needs. Continuing education may easily be integrated into daily work, for example, through facilitated work-based learning.

The Finnish engineering education and higher education as a whole has internationalized rapidly. The share of international students in Master's programs is about 20%. The corresponding share in doctoral programs is 30%. Higher education institutions are allowed to collect tuition fees, which has promoted internationalization. It is also common that Finnish students, teachers and researchers travel abroad for a period of time.

The important role of technology in enhancing welfare has been realized widely in society. Technology provides solutions for global environmental problems and is perceived as humane. Studying engineering is popular. The most talented young people, regardless of gender, apply to study engineering. Who would have believed this in 2000!

The Threat Scenario: The Sunset of the Finnish Innovation System

Regional policy dominates the educational policy. The structural development of higher education has meant, in practice, only nominal administrative joining of forces. The Finnish engineering education is scattered around Finland. Weak institutions have neither the resources nor competencies to develop into noted players. Finland has not succeeded in developing strategic competence and research centers of excellence. Incentives for developing excellence in education and research do not exist. The overly emphasized equality has led to uniformity and decreased motivation for improving the quality of education and research. All higher education institutions are occupied with mediocre research. Bureaucracy increases and administration takes a growing share of resources.

The budgetary funding of education and research as a share of GDP and number of students has decreased. The budgetary funding of higher education institutions does not encourage specialization and improvement of quality of teaching and research. The external funding of research has decreased considerably.

The labor market suffers from lack of high-quality engineering professionals. When at the same time the quality of research has decreased, it is becoming more common that research-intensive operations of industry move away from Finland. Close co-operation between engineering education and industry has deteriorated. Traditional employers of engineers do not recruit. The demand for engineers in new areas of business does not increase, because innovation activities have slowed down and competent engineers are not available. The resulting consequences for the national economy are serious: unemployment has increased considerably in all sectors, the services of the welfare society have been cut down drastically, and uncertainty of society has increased.

The number of applicants to engineering education has dropped by 50% compared to 2000. Despite the decreased number of applicants, the higher education institutions are not willing to decrease the volume of education because budgetary funding of higher education institutions is almost totally dependent on the intake and number of completed degrees. Mass education suffering from lack of resources cannot sustain the good quality of education. In international comparison the quality of Finnish engineering education is far below average.

Higher education institutions are not able to recruit competent and skillful teaching staff, because of the low *level of salary they are able to offer. Teaching merits do not promote career development. And therefore, teaching staff is not interested in developing their pedagogic competencies.*

The best students and teachers go and stay abroad. They are not even interested in networking with the representatives of Finnish organizations. Internationalization has remained on the level of superficial student and research exchange. None of the Finnish higher education institutions providing engineering education is a global center of excellence neither in education nor research. The appreciation of engineering profession as well as competencies and skills of engineering professionals have crashed down. The competencies and skills of engineering graduates have deteriorated as a result of the lowering quality of education. High-educated professionals do not have opportunities for systematic development of professional competencies. Prolonged unemployment of older engineers has exploded. Finnish engineering professionals have difficulties in carrying out their tasks and are not able to succeed in international competition.

The appreciation of technology and engineering in society is low. The engineering professionals have focused on problems limited to engineering aspects and national boundaries and have been unable to face larger societal and global challenges. Stakeholders of engineering education have been unable to communicate to decision makers and the wider community the opportunities that technology provides in solving global problems and sustaining the welfare society.

6.4 FUTURE PROSPECTS AND PROPOSALS FOR ACTION

This chapter provides an analysis of the anticipated future development of the Finnish engineering education and proposals for action presented in the Argument Delphi (AD), the Open Futures Search event (OFS) and during the work process of the Collaboration Group. The sources of the Collaboration Group are specified further as workshops of Collaboration Group (CGW), workshops on teaching and learning in engineering education (TLW) and research on sustainable development in engineering education (SDR).

Chapter 6.4.1 deals with the structure of the engineering education system, functions of higher education institutions and specialization. Co-operation with stakeholders is discussed in Chapter 6.4.2. The focus of Chapter 6.4.3 is on the management of higher education institutions. Chapter 6.4.4 deals with the funding system. Anticipation and quality assurance are discussed in Chapter 6.4.5. Recruitment and role of technology are discussed in Chapter 6.4.6. Chapter 6.4.7 examines the degree system. Curriculum, teaching and learning are analyzed in Chapter 6.4.8. And finally, Chapter 6.4.9 provides a discussion on the future prospects and presented proposals for action regarding post-graduate and continuing education.

6.4.1 Structure of the System, Functions and Specialization

All three stakeholder processes (AD, OFS, CGW) suggest that higher education institutions providing engineering need to specialize and increase networking with other higher education institutions. The majority of the AD participants believe that there will be differences among universities in the stress of teaching and research. Also mergers of higher education institutions are found possible and desirable by the AD participants, as suggested in the scenario “New Parallel Model”. However, in OFS and CGW, the importance of merging higher education institutions as means of thinning out the higher education network is emphasized considerably more[164].

In CGW the discussion on possible mergers between higher education institutions emphasizes the interdisciplinary approach. However, OFS proposes that there is a need to examine the feasibility of a Finnish engineering education consortium presented in Figure 6.1. The consortium could be organized in lines of educational fields, research areas or business clusters. Regional higher education institutions would be responsible for providing educational and research services, infrastructure and opportunities for interdisciplinary co-operation. All lines would have a director and management team responsible for the volume, resources and quality of education as well as division of work and co-operation. In addition, there could be larger co-ordination groups consisting of key stakeholders.

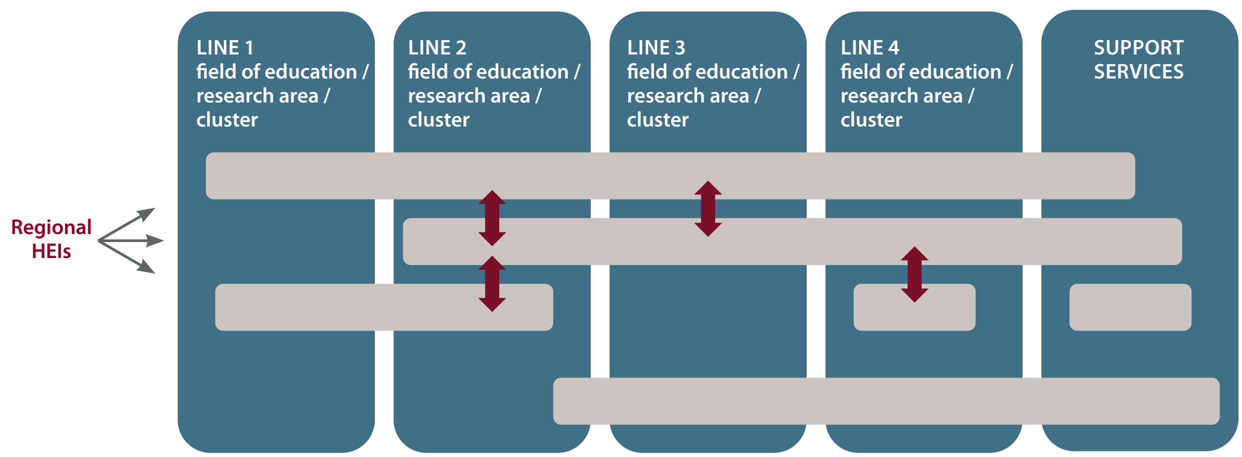

Figure 6.1 Organizational structure of the Finnish higher education consortium for engineering education as discussed at the Open Futures Search event.

A narrow majority of AD suggests that in the future higher education becomes more of a business, and many Finnish universities and polytechnics join in a multinational higher education consortia. Most of the higher education representatives in AD do not believe in the described development. In OFS and CGW the growing opportunities for selling higher education are also recognized. However, joining as part of a multinational higher education consortium as a trend is not identified.

Criteria for carrying out the structural development[165] of the higher education network providing engineering is proposed by CGW. The criteria is divided into three classes: essential criteria, important criteria and complementary criteria. The usability of each criteria is assessed using classification "ready

164 The researcher argues that the main reason behind this is that AD was carried out 3 – 4 years before OFS and 4 – 7 years before CGW and in-between the changes in the business environment led to bringing the mergers more intensively on the agenda.

165 One of the set objectives of the Collaboration Group was to contribute to the structural development of the Finnish engineering education. This topic was on the agenda throughout the whole work process. The background of the needs for structural development of the Finnish engineering education system and specialization of higher education institutions was analyzed at the workshop on 1.-2.10.2007, when analysis of the business environment was carried out. The first version of the criteria for structural development of the Finnish higher education system and proposals for action were defined at the workshops on 12.11.2007, 29.11.2007 and 10.12.2007 and meetings on 19.12.2007 and 14.1.2008. Thereafter, the Group continued to further develop the structural development criteria into a set of criteria for a Good Campus providing engineering education as well as specifying proposals for action. This was carried out during the workshops on 10.3.2008, 28.4.2008, 26.5.2008, 22.9.2008 and 17.11.2008 as well as meetings on 9.2.2009 and 9.3.2009. The work was supported by preparatory assignments 6 and 7.

for use" or "needs further development before can be applied". Also criteria that is classified as "ready for use" need to be developed, but CGW argues that it is possible to start to apply them right away. Furthermore, CGW discussed also possible problems and sources of error related to each criterion. A summary of the criteria is presented in Table 6.4.

Table 6.4 A preliminary version of the criteria for decision-making regarding structural development of the Finnish engineering education, their importance, possible indicators and present usability. (Supplemented Allt & Korhonen-Yrjänheikki 2008, 32).

Criterion	Importance	Usability	Indicators	Note
Share of employed graduates	essential	right away	Employment at the time of graduation	Online questionnaire to all graduates
Adequacy of employment	essential	right away	Subjective assessment of adequacy 2 years after graduation	Risks: dependency on individual expectations & economic fluctuations
Minimum number of students in a degree program	essential	right away	Average minimum 40 students	
Signifigance of HEI nationally for industry & society	universities: essential; polytechnics: important	right away	Employment of graduates, relation to national areas of emphasis, spin-off companies, internships, labor market co-operation	
Signifigance of HEI nationally for the industry regionally	universities: important; polytechnics: essential	right away	Employment of graduates in region, relation to regional areas of emphasis, spin-off companies, internships, labor market co-operation	
Number of primary applicants	important	right away	Number of primary applicants / intake. Criteria should be supplemented by entered / admitted.	Possible sources of error: changing trends, visa ap-plicants and force to apply (youth under 25).
Networking	important	right away	International, labor market and alumni co-operation, supply of international programs, interna-tional projects and exchange	
Graduation rate	important	right away	Graduated / entrants	Examination level: institution and discipline.
Quality of research	universities: essential; polytechnics: important	partly right away	Publications, international projects, reference indexes, bibliographic statistics, share of external funding, extent of R&D	Refereed conference publications are important publication media in engineering.
Quality of education	important	needs to be developed	Quality audits, quality of teaching and management, course supply, curricula, teaching methods	
Feedback from employers	complementary	needs to be developed	Feedback on education and research	Feedback of education needs to be analyzed in the level of degree program and HEI.
Present staff	complementary	needs to be developed	Minmum number of staff.	Need to develop HR and management of HEIs.

The criteria was later developed into a set of "Criteria for A Good Campus" presented in Figure 6.2. CGW proposes that all universities and polytechnics providing engineering education in Finland would need to fulfill the criteria in education aimed at the youth[166] by 2015. Furthermore, CGW proposes that higher education institutions providing engineering education should concentrate the education onto one campus.[167]The criteria of a Good Campus consists of two parts.

The first part consists of criteria that need to be met as a whole in all campuses providing engineering education. Exceptions should be tolerated only seldom if the profile of the higher education institution strongly justifies it. The second part consists of criteria that need to be applied depending on the institution. Thus, the relevance of the criteria depends on whether the institution is a university or polytechnics and on what are the core competencies of the higher education institution. These have an impact on which criteria are essential and which are not so important. With regard to most of the criteria, the performance should be good.

Criteria that need to be met by all campuses

Recruitment of students

- The number of applicants in relation to the targeted intake has to be above 1.5 in degree programs provided in Finnish.
- Enrolled students in relation to the targeted intake needs to be at least 1.
- The higher education institution should be required to highlight in marketing towards prospective students the possibilities of technology in enhancing the welfare of people and environment.

Number of students

- The minimum number of engineering students at the campus is 500. In addition to engineering students, there should be at least 500 non-engineering students.
- The minimum number of engineering students in a degree program should be 40, on average.
- There needs to be more that one degree program of engineering.

Number of teaching staff

- The minimum number of teaching staff at the campus is 50.
- In universities the minimum number of professors in a department is 5.
- The teacher / student ratio should be 1:10.

Internationalization

- Share of international students needs to be 5 - 10%.
- At least 50% of the students either study or work abroad during their studies.
- Of all credits taken in engineering, at least 5% are taken abroad.
- The share of teaching staff exchange, including both departed and arrived, is at least 2% of all teaching man years.
- The minimum number of foreign languages provided is 5.
- The student, teacher and research exchange enhances the improvement of quality of education

166 The term "youth education" (nuorisoasteen koulutus in Finnish) means education right after secondary education, meaning that students are mostly between 18 – 30 years. Thus, engineering education provided as adult education was not the primary focus, when developing the criteria for a Good Campus.
167 The maximum distance of premises should be 50 kilometers.

and research as well as supports strategic choices of the higher education institution.

Quality of education and graduation rate

- The graduation rate (enrolled/graduated) is improved on the level of 65% by 2012 and to 75% by 2020 without sacrificing learning outcomes.
- The quality assurance system, including, for example, feedback from students and employers is transparent and well documented.
- Students find teaching, counseling, IT, infrastructure for teamwork and library services to be sufficient and of good quality.
- Permanent teaching staff at universities has taken the minimum of 30 ECTS pedagogic studies. In polytechnics the minimum amount of studies corresponds to the enactment.

Employability

- The employment rate of graduates with the B.Eng degree and M.Sc.(Tech.) degree is at least 90% of the national average at the time of graduation as well as 2 years after graduation.
- At least 50% of those graduated from a polytechnic are employed in the region of the higher education institution.
- The average salary of recently graduated students is at least 80% of the national average.
- The employment of all graduated students is adequate: competence requirements correspond to the degree.
- The indicators describing the quality of employment need to be improved and supplemented later.

Criteria that need to be assessed depending on the profile of the higher education institution – average performance required to be good

Interaction of R&D and teaching

- Research publications / teaching man years (FTE)
- Participation of students in research
- Number of doctoral students in relation to B.Sc. and M.Sc. students (only universities)
- Number of M.Eng students in relation to B.Eng students (only polytechnics)
- Share of external funding from enterprises
- Proximity of research organizations

Active co-operation with working life

- Extent of work experience of students
- Support of combining theoretical expertise with work-based learning
- Extent of co-operation projects with enterprises
- Man-years of external lecturers
- Extent of alumni activities

Interaction with society

- Share of external funding of total funding
- Share of entrepreneurs of all graduates
- Co-operation and strategic partnerships with other higher education institutions

- Shared services with other higher education institutions
- Sufficient number of population: at least million inhabitants within the reach of 250 km

Challenging of present strategies

- Pioneer: The strategy of higher education institution challenges national and regional strategies and is visible in education and research.

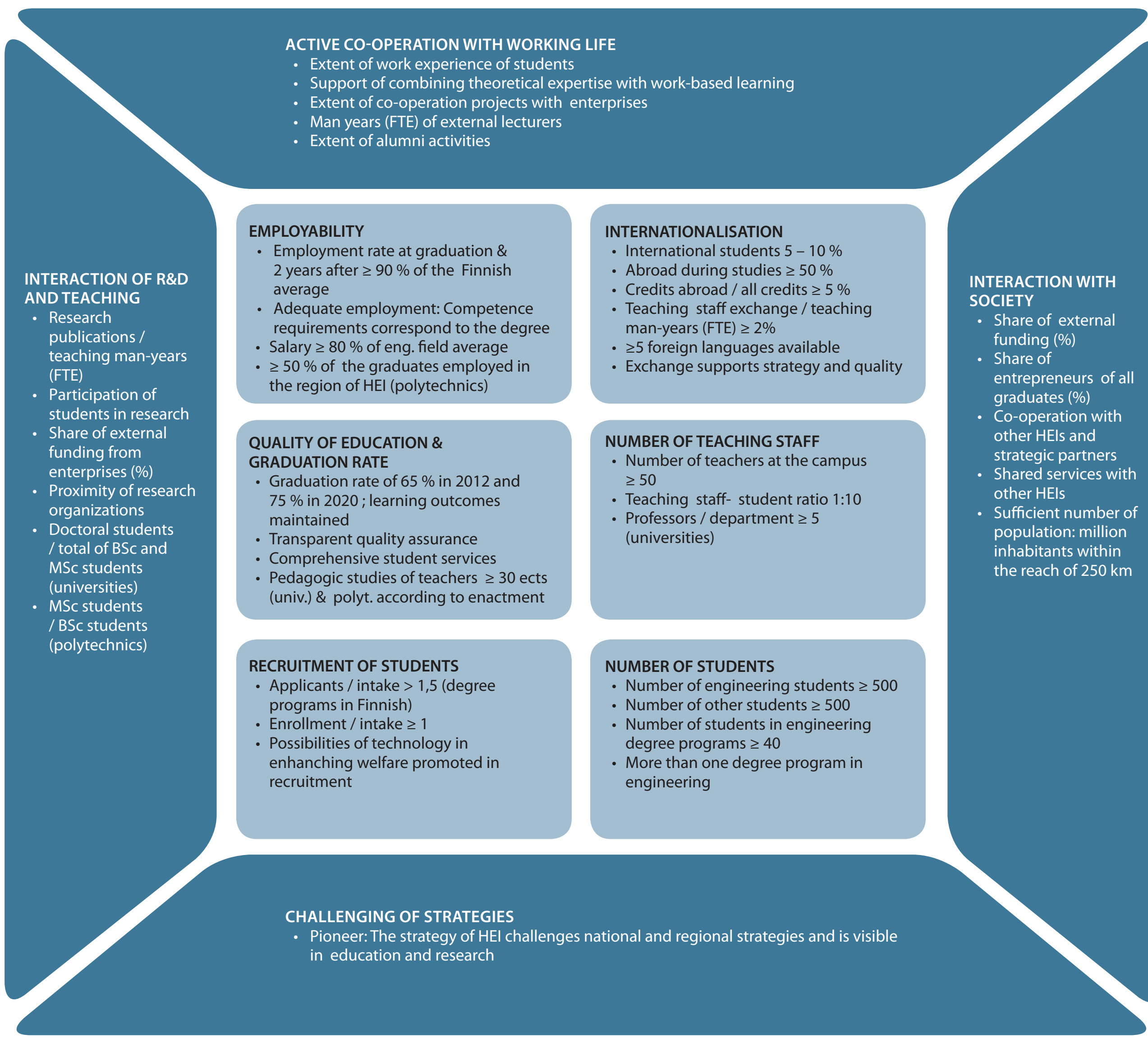

Figure 6.2 Criteria for a Good Campus providing engineering education as defined by the National Collaboration Group for the Finnish Engineering Education (Allt, Korhonen-Yrjänheikki & Savolainen 2009, 27).

CGW suggests that the number of polytechnics providing engineering education should in the future be 15 and of universities 5 – 7. Furthermore, engineering education needs to be concentrated onto one campus in every higher education institution[168].

The scenario "New parallel model" in AD, presented in Chapter 6.3.1, contains a new interpretation of the dual model concerning organizational structures, namely enabling also mergers between universities and polytechnics, while ensuring that two different streams of engineering education, practically- and theoretically-oriented, remain content-wise. This is suggested also by OFS and CGW as the needed new interpretation of the dual model in the future.

Despite the need for university specialization, the participants of AD find probable , although undesirable, that because of strong pressure from regional politics, a few new degree rights will be granted by 2015[169].

The majority of the participants of AD find likely and desirable that by 2015 there will be a few private universities providing engineering[170] in Finland. The supporting argumentation presented by representatives of higher education is that this would provide a new standard for the quality of education, that private university is more likely to meet the labor market demand, and that globalized Finnish enterprises need private universities.

6.4.2 Co-operation with Stakeholders

AD, OFS and CGW argue that several reasons drive up the importance of stakeholder co-operation of higher education in the future. Among these are the nature of the present society that requires networking and development of anticipation, follow-up and feedback systems as well as practical pressure to gather funding from several sources. A customer-oriented approach becomes more common. The bargaining power of students is likely to increase because of increased competition of talented students (AD, OFS, CGW).

Results from AD, OFS, CGW and TLW suggest further investment in developing the special strength of Finnish engineering education – the close relationship with industry. There is still development work to do in identifying needs of the labor market and integrating them to the engineering curriculum (CGW, TLW). Co-operation with industry in education needs to be intertwined with pedagogic management (TLW). Co-operation needs to support reaching learning objectives. Work-based learning could be used more efficiently as part of the curriculum including setting of the learning objectives for the practical training periods (CGW, TLW).

In the future there is also a need to improve the documentation of industrial co-operation in order to increase systematic organizational learning and to be able to prove the close co-operation also in international quality assessments (OFS, CGW).

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168 Concerns education aimed primarily at the youth, thus excluding adult education.

169 This took place already in 2004, when University of Vaasa and University of Turku got the right to grant M.Sc.(Tech.) degrees.

170 The Universities Act enabled foundation-based universities in 2009. Thereafter, Helsinki University of Technology TKK merged with Helsinki School of Economics and Helsinki University of Art and Design forming a foundation-based Aalto University. Also Tampere University of Technology transformed into a foundation-based university.

6.4.3 Professional Management of Higher Education Institutions

Almost two thirds of the AD participants find it desirable that the President of a university providing engineering education would in the future become a professional manager that is often recruited outside university. Views on the probability differ. A narrow majority finds it improbable. According to the proposed argumentation, increased importance of stakeholder co-operation, need for strong financial skills, professional management of human resources, and a need for considerable restructuring may be behind the need for a professional manager from outside the university.

OFS and CGW suggest changing the collegial leadership model at universities and emphasize a need to increase university autonomy[171]. Also the results of OFS and CGW suggest that the university President needs to be a professional manager. However, OFS argues that also in the future the President needs to be a scientist as well. CGW suggests that also Deans need to be professional managers.

CGW suggests that that there is a need to increase the number of university-external stakeholders in the board, although staff and students need also to be represented. The heterogeneous make-up of the board is found to enable better strategic planning in the present society. Moreover, CGW argues that there is a need to increase the knowledge and skills related to professional working in a university board. It is desirable that some of the participants of a university board have board experience from a foreign university (CGW).

CGW also suggests that there is a need to develop ownership steering of polytechnics in the future. However, no concrete suggestions are made of a new model for steering of polytechnics.

CGW and TLW suggest developing pedagogic management in higher education institutions on all levels of organization including structures, policies as well as knowledge and skills enabling professional pedagogic management.

6.4.4 Funding System

AD claims that it is probable and desirable that the importance of quality indicators in budgetary funding will increase considerably in the future. Representatives of higher education are most suspicious on the probability of the development. Both OFS and CGW are of the opinion that there is a need to increase the quality criteria in budgetary funding of universities and polytechnics. CGW sets a concrete aim that in the future 40% of the budgetary funding should be based on quality criteria.

CGW proposes doubling the funding per engineering student in the future using several means: increasing of budgetary funding, widening of funding sources including enabling the introduction of tuition fees, diminishing student intake, and requiring higher education institutions to specialize and increase co-operation with partners in the innovation system. The introduction of tuition fees is proposed by CGW especially what comes to enabling extensive export of the Finnish engineering education and Master's programs as part of continuing education. However, tuition fees for other degree-oriented education are not ruled out as long as the strength of the Finnish education is ensured: the opportunity to receive higher education is dependent on talent and not on income.

OFS also suggests enabling collection of tuition fees. The discussion on enabling tuition fees contained also disagreeing opinions, especially stated by student representatives, which was the case also in

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171 The new Universities Act, accepted in July 2009, increased autonomy of universities and implied changes to the collegial leadership model. The Act regulates that the minimum share of external stakeholders (not staff of students) in a public university is 40%. Also professors, other teaching and research staff, and other personnel, as well as students need to be represented in the board (Act 558/2009).

CGW. In AD a clear majority finds tuition fees desirable. However, views concerning the probability of the development differ. All political decision makers find introduction of tuition fees improbable.

CGW suggests that there is a need to increase knowledge and skills in higher education institutions among management in order to be able to efficiently sell engineering education to international students.

AD, OFS and CGW argue that the ability to increase quality criteria to the budgetary funding of higher education institutions is intertwined with the development of systematic follow-up and feedback systems of education.

6.4.5 Anticipation and Quality Assurance

Participants of AD find it probable and desirable that universities and polytechnics providing engineering education will systematically invest in improving anticipation, follow-up and feedback systems for education. Centralized anticipation carried out as an example by the Finnish Ministry of Education is deemed necessary, but alone completely insufficient. A comprehensive feedback system is found to be a prerequisite for the continuous quality improvement of education.

Also OFS and CGW argue for increasing the importance of quality assessment as well as for a need to develop anticipation, follow-up and feedback systems of education. The stress in the development of anticipation systems needs to be shifted from volume to skills needs (CGW). Anticipation of skill needs to be carried out in close co-operation with industry both nationally and regionally (CGW). CGW suggests also pressure to develop quality assurance in continuing education.

OFS and CGW propose that higher education institutions need to be required to monitor employment rate and adequacy of employment of recently graduated students. OFS suggests monitoring it 6 months and 5 years after graduation, while CGW proposes it as a minimum requirement right after graduation and two years after graduation. OFS and CGW suggest developing national quality assessment and feedback systems for the engineering discipline. A narrow majority of AD find it desirable but improbable that associations of professional engineers, TEK and UIL, would play an important role in developing national follow-up and feedback systems for engineering. OFS also proposes that TEK could have a co-ordinating role in developing and implementing the feedback system[172].

TLW claims that in the future there is a need to develop assessment together with engineering pedagogy, namely assessment needs to enhance reaching the learning objectives.

Neither OFS nor CGW propose a pan-European accreditation system for the Finnish engineering education. Also the majority of AD is of that opinion. However, it is noteworthy that one third of the AD participants, especially those representing industry, find a pan-European accreditation for the Finnish engineering education probable and desirable.

6.4.6 Recruitment and Role of Technology in Society

Participants of AD, OFS and CGW believe that in the future there will be increased competition on talented students. This may be a positive factor in enhancing pressure to develop the quality of the Finnish engineering education, but it is also a risk for Finnish higher education institutions if a great share of talented students go abroad.

172 A national follow-up a feedback system - enabling also follow-up of the adequacy of employment - for recently graduated M.Sc.(Tech.) students at universities providing engineering education is in piloting phase in spring 2011. The system is co-ordinated by TEK.

The need to increase the number of women in engineering in the future is suggested by AD, OFS and CGW. Participants of AD are skeptical whether the share of women studying engineering could increase considerably in the near future. They find it improbable that the share of women studying engineering would be 35 – 40% by 2015.

OFS and CGW emphasize increasing the number of international students as an important means to widen the recruitment base of engineering in the future. Participants of CGW and SDR suggest that the increased heterogeneity is important in order for the learning environment to support diversity.

Increased interdisciplinarity in engineering and understanding of the role of technology in increasing welfare is found by AD, OFS and CGW among key measures to increase interest towards engineering in general, as well as the number of women students. CGW argues for a need to communicate better the key role engineering education plays in ensuring the national emergency supply and facing of global challenges like climate change, sufficiency of natural resources, aging of population and urbanization. This is supported by the findings of SDR. Also role models and increased knowledge of the wide variety of engineering careers are found to be potential means for increasing interest towards engineering (OFS, CGW). Furthermore, there is a need to have an impact on the attitudes of primary and secondary school teachers towards technology in general as well as to encourage women more actively to study engineering (OFS, CGW). Mathematics, natural sciences and technology need to be considered as an integral part of all-round education (CGW).

AD believes that in the future departments of universities are grouped into lager units for the intake of engineering students and the actual choosing of the degree program takes place 1 – 2 years after beginning of studies. This is proposed to increase student motivation, because after some studies they know better what they are interested in. Also, this is suggested to improve meeting of the labor market demand because of shortening time-to-market.

CGW proposes that a suitable volume for M.Sc.(Tech.) education through a centralized recruitment system would be an intake of 3 500 students yearly. AD does not propose a figure separately for the centralized system, but suggests that including all entrance tracks, approximately 4 400 students may be an appropriate level. However, this is not an unanimous view. The most hesitant stakeholder group in terms of increasing the intake are representatives of higher education. Some of them argue for lower intake, and none of them proposes to increase the intake above 4 400. The participants of AD find it probable and desirable that Master's programs in engineering to graduates with some other degree than B.Sc.(Tech.) will increase considerably. For the B.Eng education aimed for the youth, CGW finds that the appropriate intake would be 7 000.

The majority of AD participants find it desirable that the selection of students to higher education institutions providing engineering would be primarily based on matriculation examination. Views on the probability differ. The supporting argumentation for the suggestion is that this could shorten the time between high school and higher education. One of those panelists that finds the development undesirable comments that students are more motivated to study after spending one year working in-between.

6.4.7 Degree System

AD, CGW and TLW are of the opinion that the B.Sc.(Tech.) degree is an intermediate degree towards the M.Sc.(Tech.) degree. It provides a solid foundation of engineering fundamentals in a more theoretically-oriented way than the B.Eng degree and its primary aim is not to qualify for the labor market. This is the key difference between the B.Sc.(Tech.) and B.Eng degrees in the scenario "New Parallel Model" of AD (see also Claims 3.4 and 8.2 in Appendix 2) as well as in the results of CGW and TLW. More thorough methodological knowledge and skills of B.Sc.(Tech.) are emphasized by OFS and TLW.

The profile of M.Eng degree is defined by OFS to be comparable to a broad continuing education program that is taken during the career. Thus, it should be oriented towards professional development needs stressing, for example, project work and business management skills.

Participants of OFS and CGW are of the opinion that also in the future doctoral education needs to be provided only by universities, because the foundation of the degree is a theoretically-oriented scientific degree which needs to be provided by research-oriented universities. Also participants of AD find improbable and undesirable the scenario that all higher education institutions would become universities, and as a result, also polytechnics would provide doctoral education.

The majority of AD regard it as probable and desirable that the degree structure in the European Union is largely uniform, implying that the Lic.Sc.(Tech.) degree will be abolished from the degree system. The key reason for this is that the degree is not recognized internationally. One third of AD are not willing to abolish the Lic.Sc.(Tech.) degree. Two representatives of higher education argue that it is a sensible intermediate degree towards PhD, especially since doctoral studies in engineering are often carried out beside work. One of the representatives of policymakers that finds it undesirable is afraid that if the degree is abolished, there is a risk that the title will be assigned to a completely different degree.

AD considers it probable and desirable that the value of expertise will increase at the expense of degrees. Fast-changing skills needs is found to be among key reasons for the development. One of the participants of AD summarizes it by claiming that appreciation crystallizes through competence. Some get it through completing a degree, while others may receive it through work-based learning. Another participant of AD that stresses the importance of completing a degree argues that completing a degree is a proof that one is able to complete a project in a limited time-frame, which is important when project-oriented work increases. Therefore, degrees are valued in parallel with competences.

Recognition of prior work-based learning as part of undergraduate engineering degree aroused conflicting views in TLW. The majority sees that in theoretically-oriented engineering education provided by universities, the recognition of prior learning needs to be limited or very limited. Participants find it important to define the maximum amount of recognized prior learning in order to ensure a sufficient share of theoretically-oriented studies. Attitudes towards recognition of prior learning in polytechnics are clearly more positive.

AD views it as probable that in the future the appreciation of an engineering degree varies greatly depending on the institution that granted it. Furthermore, the department, degree program, or research group also has an impact on the value of the degree. Panelist views on the desirability of the development differ. Among the reasons for increasing differences in valuing the degree are the increased volume of engineering education, specialization of higher education institutions, as well as increased differences in quality of education in a scattered network of higher education institutions.

6.4.8 Curriculum, Teaching and Learning

Contents of the curriculum

Results from CGW, SDR and TLW suggest that engineering students would need to understand better than at present the societal context of technology and the role that engineering plays in society. Increasing interdisciplinarity is important both in relation to other disciplines (AD, OFS, CGW, TLW) as well as within technology (AD, TLW). To a large extent, the suggestions related to the development of the curriculum are intertwined with the development of the context of learning in OFS, CGW, TLW and SDR. The researcher would synthesize the results from SDR and TLW regarding the development of engineering problem solving as follows: there is a need to shift the focus in engineering curriculum from solving technical problems to searching, defining and analyzing complex transdisciplinary problems in interdisciplinary teams. Development needs of the learning environment are discussed below.

AD argues that environmental values, ethics and entrepreneurship will become more prominent in engineering curriculum in the future. With regard to increase in ethics, several panelists are hesitant whether its role will be increased as desired. A need for developing the context of learning in order to bridge the skills gap in knowledge and skills related to sustainable development and ethics is brought up also in TLW and SDR. A need for developing entrepreneurial skills is suggested also by TLW as part of a wider context of business skills.

OFS suggests a need to develop the learning environment and culture of higher education institutions to enhance dissemination of knowledge, co-operation and collaborative learning - both physically as well as virtually. Also the results of TLW suggest development of the curriculum and context of learning in order to improve teamwork and collaborative learning capabilities of engineering graduates. TLW proposes deeper analysis of the learning objectives related to teamwork skills in order to be able to enhance the systematic development of teamwork skills during studies.

There is a need to increase understanding of systemic and life-cycle thinking among engineering graduates to face the skills needs related to enhancing sustainable development (SDR). This provides also a foundation for continuing professional development. Results from SDR suggest that in the future engineering graduates need to be better equipped with knowledge and skills related to materials and energy efficiency. Additionally there are engineering field-specific skill needs related to sustainable development that would need to be analyzed and met separately in different fields of engineering (SDR). OFS brings up the need to develop the curriculum to better enhance skills and qualities needed for improving productivity of services, which is of growing importance.

Figure 6.3 provides a summary of the competence and skills needs in engineering education related to sustainable development suggested by SDR. Figure 6.4 is a synthesis of competencies and skill needs expected from engineering graduates as a whole as defined by TLW.

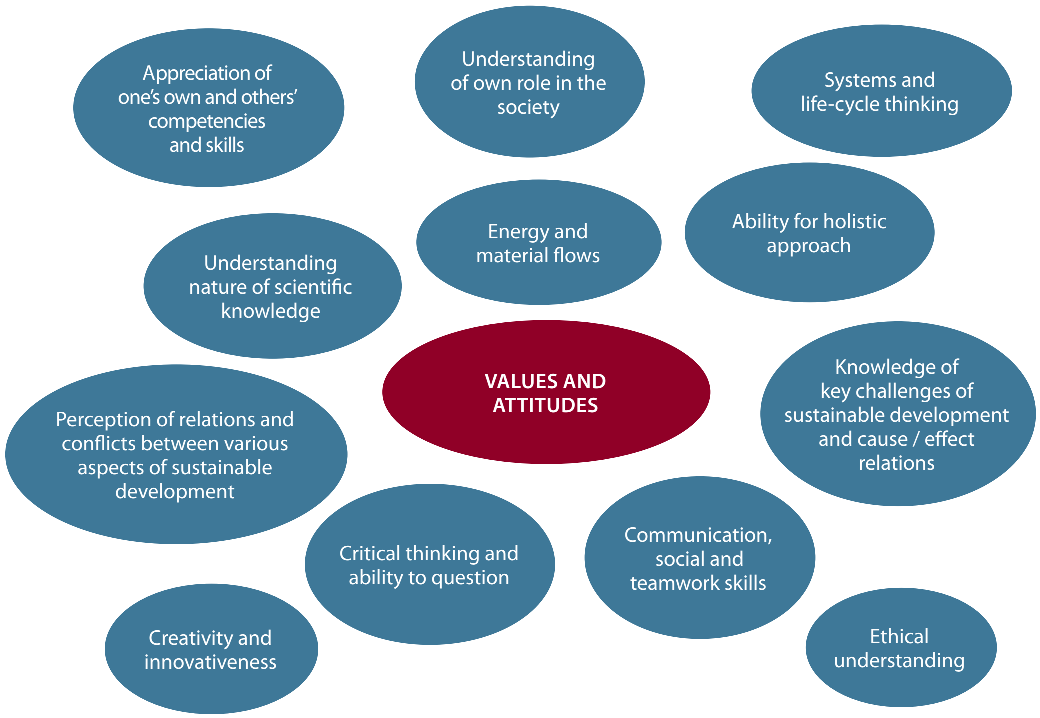

Figure 6.3 Competence and skill needs in engineering education related to sustainable development (Takala 2009, 99).

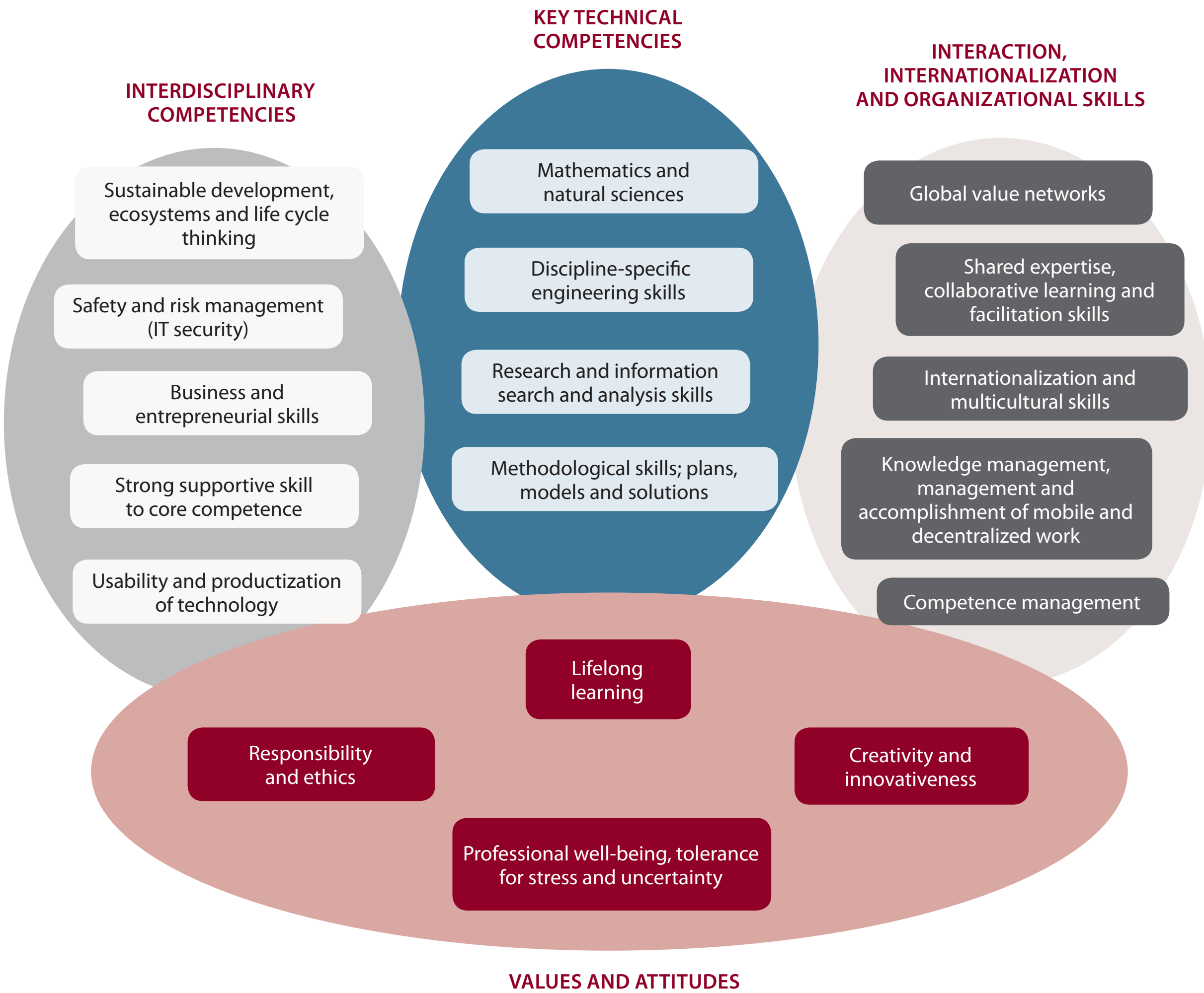

Figure 6.4 Competencies and skills expected from engineering graduates (Mielityinen 2009a, 35).

AD argues that the continuously expanding degree requirements of undergraduate engineering education will be limited and part of studies transferred to postgraduate and continuing education. Also OFS and TLW emphasize the importance of analyzing the core content that engineering students need to learn during their undergraduate education. TLW formulates this as prioritizing the learning objectives in order to find a solution for dealing with the overloaded curriculum. TLW suggests that, in addition to defining more clearly the core content, students need to commit better to studies and spend more time on studying than at present.

Learning Environment, Engineering Pedagogy and Pedagogic Management

Results from OFS, CGW, TLW and SDR suggest that the context of learning in engineering education has to be developed. TLW claims that it is more important and urgent than developing curriculum contents. The learning environment needs to enhance openness and dissemination of knowledge better than at present (OFS). The learning environment needs to be characterized by trust that encourages open discussion and willingness to take risks, without fear of mistakes, or failure (SDR). Results of SDR indicate a need to increase diversity of students in terms of ethnical background, gender and discipline, as a means to enhance systemic understanding and holistic thinking, as an example of sustainable development.

AD, OFS, CGW and TLW argue that gathering practical work experience needs to remain also in the future an integral part of engineering education. TLW proposes setting learning objectives for practical training periods. Also CGW suggests, in the desirable scenario of Finnish engineering education in 2020, to utilize practical training more efficiently in reaching learning objectives.

SDR and TLW claim that a prerequisite for holistic understanding of the degree is that students perceive their curriculum as a whole and not a variety of courses. Therefore, TLW argues that also better pedagogic management is needed.

OFS, CGW and TLW argue that there is a need for considerable development of engineering pedagogy. AD, OFS, CGW and TLW suggest introducing incentives to increase the appreciation of teaching. Results of TLW indicate that also pedagogic management and assessment methods enhancing reaching of the learning objectives need to be developed. OFS states that development of the context of learning would enhance several skills that are essential for continuing professional development.

OFS, CGW and TLW suggest of improving the student/teacher –ratio as one measure to enable better pedagogy and quality of education. CGW and TLW propose of setting a minimum requirement of at least 30 ECTS pedagogical studies for the teaching staff at universities. According to TLW, the actual aim needs to be 60 ECTS. The Ministry of Education needs to follow up investments of higher education institutions in the development of education, and the budgetary funding system has to encourage the development of the quality of education (TLW). Criteria for measuring success in pedagogic management need to be developed. Furthermore, development of engineering pedagogy needs to be assigned resources and included in the job descriptions of the teaching staff (TLW).

OFS and TLW draw attention to considerably developing the pedagogy of the engineering fundamentals. Today's mass lectures may not be optimal (OFS, TLW). TLW suggests research in order to find better pedagogical solutions.

Two thirds of the participants of AD believe that virtual learning will increase considerably. Moreover, in continuing education the role of e-learning is anticipated to be even more important than in undergraduate education. Also OFS and TLW bring up a need to invest in developing virtual learning environments. TLW claims that on average the ability of the next generation for virtual communication will be a giant leap ahead of the teaching staff.

Participants of AD believe in strong internationalization of the Finnish engineering education in the future, translating into considerably more studies provided in English and more joint degrees with foreign universities. Results from OFS, CGW, TLW and SDR contain proposals for action for increasing the number of international students and staff as well as mobility of Finnish engineering students and staff. Internationalization is included as part of "Criteria for a Good Campus" defined by CGW. Participants of OFS and TLW suggest that curriculum needs to enhance multicultural teamwork. The aim set by CGW is that by 2020 at least 50% of engineering students either study or work abroad during their studies. The aim set by OFS is even more demanding: by 2015 and all engineering students.

OFS and TLW suggest creating incentives and also obligations (OFS) for increased interaction between research and teaching functions at universities in order to better disseminate the latest research results. OFS proposes the development of degree programs of excellence in joint co-operation with higher education institutions – each providing a module focused on their core competence area. Extra public and private funding – as an example in the form of a foundation – would be needed for designing and implementing a program aimed for students with extraordinary talent. OFS suggests utilizing talented students more often as teaching assistants.

According to OFS, CGW and TLW, the high drop-out rate of students is a problem due to several reasons, such as the lack of teaching resources compared to the number of students and poor pedagogy intertwined with learning difficulties and motivation problems. Students may have been originally not interested in engineering, but applied because of easy entry (OFS). Thus, the improvement of engineering pedagogy and student/teacher –ratio by increasing teaching staff and lowering the volume of education may be among measures for decreasing drop-outs. CGW sets as an objective the improvement of the pass rate to 65% by 2012 and up to 75% by 2020 without lowering the quality requirements.

Two thirds of the AD participants believe that the study counseling system will improve considerably. Application of ICT, more systematic utilization of peer support and career counseling are mentioned as means of improving the counseling system.

6.4.9 Post-graduate and Continuing Education

The need to increase the supply of continuing education for engineering professionals is suggested by AD, OFS and CGW. Participants of AD are of the opinion that degree orientation of continuing education increases in the future, but the primary focus is on promoting documentation of professional development. A representative of higher education in AD argues that a new form of adult education emerges that is in-between open university and continuing education. Also CGW participants anticipate the development of new forms of continuing education. As an example, development of facilitated work-based learning is found to be important. Also, there is a need to develop the quality assurance of continuing education (CGW).

AD suggests that the growing needs of continuing education in the future are mainly funded by enterprises. Individual people finance continuing education to a certain extent, but the state with only a relatively small share. This is because growing state subventions would distort the competition. Furthermore, the needed budgetary funding for Bachelor's and Master's education increases so much that continuing education must be mainly self-financing. CGW suggests making continuing professional development widely tax-deductible.

CGW claims that there is a need for better productization of continuing education in the future. Moreover, higher education institutions need to focus on continuing education supported by their profile in undergraduate education and research.

Participants of AD find it probable and desirable that doctoral studies in engineering will increase considerably, and 15 – 20% of M.Sc.(Tech.) graduates complete also the Ph.D. degree, and in some universities almost 30%. It is noteworthy that three out of those four AD participants that find the increase in PhD volume undesirable represent industry. Thus, does the labor market actually need more doctorates?

AD proposes that more interdisciplinarity is needed not only for undergraduate engineering education, but also for postgraduate education. Moreover, AD argues that a profile of a more generalist type of PhDs are needed that have in-depth knowledge about how to conduct scientific research and are able to apply their knowledge and skills in several fields.

7. CONCLUSIONS AND DISCUSSION

This dissertation has sought to shed light on how to develop the Finnish engineering education to face the anticipated challenges of the future primarily on the basis of the views of the key stakeholders in the three group communication processes of the study. This chapter provides conclusions and discussion on the research questions of the study.

Chapter 7.1 discusses future prospects of the Finnish engineering education and proposals for action (Research Question 2). Chapter 7.2 deals with the definition of stakeholders and selection of participants for a group communication process aiming at capturing future prospects and enhancing the development of engineering education nationally (Research Question 1). Chapter 7.3 focuses on discussing stakeholder processes in the study from the viewpoint of knowledge creation with group communication methodologies in futures research.

Chapters 7.1 – 7.3 contain also suggestions for further research. Limitations of the study are examined in Chapter 7.4. When referring to the stakeholder processes of the study, the same abbreviations[173] are used as in previous chapters of the study.

7.1 FUTURE PROSPECTS OF THE FINNISH ENGINEERING EDUCATION

This chapter discusses Research Question 2 underlying the overall research problem:

What are the future prospects and development proposals for the Finnish engineering education based on the views of the key stakeholders on the past, present and future, as well as literature and statistics describing the long-term development and present?

The engineering discipline is impacted by the immediate business environment more than most professions (Stokes 1997, Clark 1998, Allenby et al. 2009), because of the practical nature of the discipline (Niiniluoto 1984, Hendrichs et al. 2000, Heikkerö 2009), although it is worth noting that engineering fields are not identical regarding their relationship between theory and practice (Naukkarinen 2006, Jørgensen 2007). Therefore, the researcher claims that analyzing and anticipating driving forces in the business environment is important when aiming at capturing future prospects of engineering education.

Based on the analysis of AD, OFS and CGW on the development of the business environment (Chapter 6.1) and literature on the nature of engineering discipline and the changing society (Chapters 4.1 – 4.2) , the researcher argues that the driving forces in the business environment impacting the Finnish engineering education are open innovation environment with abundant knowledge that is a result of the change of society from industrial to knowledge-based service economy, globalization and fast development and converging of NBRIC-technologies[174], growing pressure for enhancing sustainable development and possible value changes. The combination of sustainable development and deepening globalization may result in emphasizing immaterialism and global welfare, but contradictory changes in

173 The Argument Delphi panel (AD), the Open Futures Search event (OFS), the workshops of the Collaboration Group (CGW), the workshops on teaching and learning in engineering education as part of the work of the Collaboration Group (TLW) and the research on sustainable development in engineering education as part of the work of the Collaboration Group (SDR).

174 The term NBRIC (nano- and biotechnology, robotics, information- and communication technologies and cognitive science), was not brought up in stakeholder processes, although the importance of the listed technologies and technologies in general was recognized. For example Allenby et al. (2009) proposes that the convergence of NBRIC-technologies is a major driving force in the present business environment impacting engineering discipline.

values emphasizing materialism and individualism are also possible.

In the knowledge economy there is a growing need for speeding up and improving knowledge creation and application processes. At the same time, increased interdependencies call for the whole-system approach and open stakeholder dialogue, disruptive patterns of innovation and change emphasize the need for capturing weak signals, and different interests of actors increase social complexity in society. And consequently, increased complexity may be regarded as an overall megatrend characterizing societal change from industrial to knowledge-based as proposed, for example, by Boisot (1998) and Scharmer (2009).

The researcher suggests that there are two social learning cycles that operate in different ontological levels: individual-driven, for example I-space of Boisot (1998), and collective-driven, proposed, for example, by Nonaka & Takeuchi (1995) in their theory of knowledge spiral. The researcher maintains that Scharmer (2009) in his U-theory on knowledge creation enabling grasping of emerging knowledge has managed to combine individual- and collective-driven social learning cycles. The combination of individual and collaborative learning enhances reducing and absorbing the increased complexity, and therefore, the researcher argues that it is a key finding impacting engineering education as a system as well as the needs for developing curriculum and the learning context.

The researcher would summarize the impact of the changing business environment on the Finnish engineering education system as follows:

The open innovation environment characterized by increased interdependencies (dynamic complexity), disruptive patterns of innovation and change (emerging complexity), and heterogeneity (social complexity) imply a need to further develop the collaborative stakeholder dialogue of HEIs as well as the curriculum and learning context of engineering education. There is a need to develop collaborative learning processes aiming at capturing emerging knowledge, and in general, to absorb and reduce complexity through enhancing individual- and collective-driven social learning cycles.

Figure 7.1 presents the driving forces in the business environment and their overall impact on Finnish engineering education.

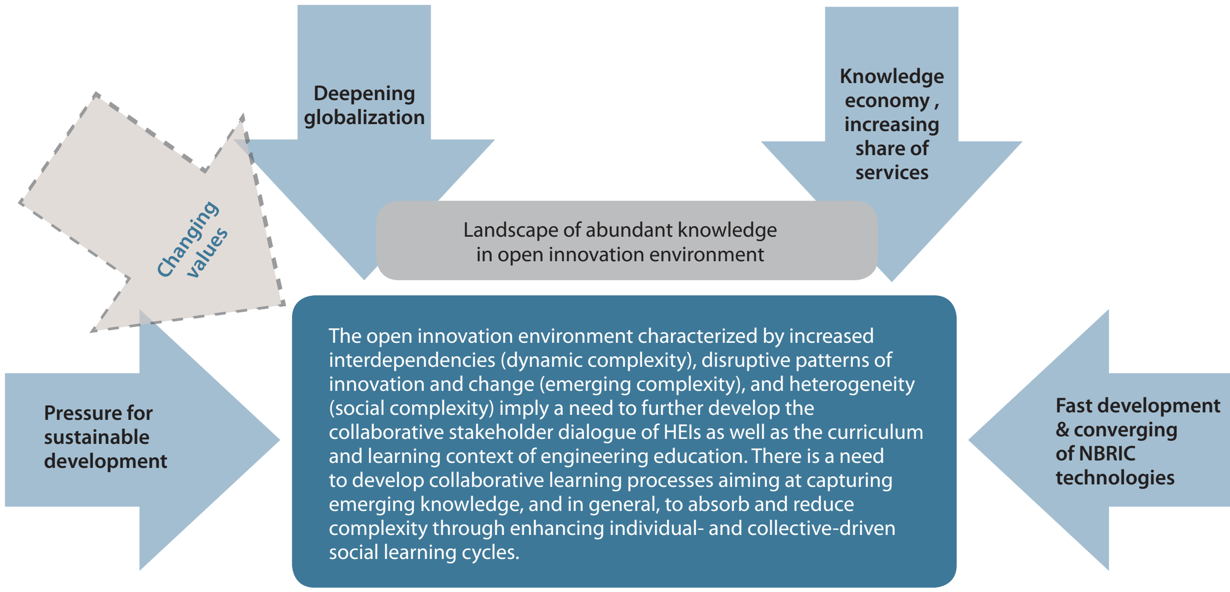

Figure 7.1 Driving forces in the present business environment and their overall impact on Finnish engineering education.

The key findings of this study regarding the future prospects of the Finnish engineering education as well as key proposals for action (Research Question 2) are summarized in eight statements below. Thereafter, each of these eight key findings including argumentation is discussed.

1) Engineering graduates need to be developed from technical problem-solvers to collaborative creators capable of defining and creating solutions collaboratively to complex transdisciplinary problems. The most critical skills shortages are in graduates' abilities and skills related to collaborative learning.
2) Active student-centered learning methods are in key position in facing the challenges of the changing society. The development of physical and virtual learning environments need to enhance collaborative learning. The Finnish engineering education needs to utilize the advantage of strong student community and non-hierarchical culture in developing the education.
3) The identity of engineers becomes more multi-fold. Need to introduce M.Sc.(Systems) and M.Syst.Eng degrees. System sciences may lead into splitting engineering into two disciplines because of differences in engineering fields with relation to systems science revolution.
4) Need to build on existing strengths and to further develop co-operation with labor market intertwining the learning environments and aiming at systematic stakeholder dialogue and enhancing of organizational learning in labor market co-operation.
5) Need for a more multicultural learning environment, internationally recognized degrees and quality assurance – requiring the removal of Lic.Sc.(Tech.) from the degree system and introducing accreditation - and enabling selling of degree-oriented higher education.
6) Need to develop continuing professional development of engineers to become a core activity of HEIs, especially new ways of formalizing and enhancing work-based learning. Expansion of

continuing education requires development of quality assurance.

7) Difficulties in renewing social capital hinder reforming the HEI network. HEIs have to focus and learn collaborative competition. Need to increase incentives for improving the quality of education and to use it also as a means to trim the HEI network. The number of HEIs providing engineering education needs to be decreased.
8) Need to develop the dual system: allow mergers, clearer positioning of degrees and research activities. Impact of systems science revolution on the dual system is open.

1. Engineering graduates need to be developed from technical problem-solvers to collaborative creators capable of defining and creating solutions collaboratively to complex transdisciplinary problems. The most critical skills shortages are in graduates' abilities and skills related to collaborative learning.

Literature (see Chapter 4.2) and results from the stakeholder processes (see Chapters 5.5, 5.6.6 and 6.4.8) suggest that, although technical expertise is important also for future engineers, it does not suffice alone. Development of value-related[175], behavioral, social and business competencies need to be acknowledged as part of the core of the engineering curriculum. In order to enhance welfare of people and environment, defined by the key stakeholders as the mission of the Finnish engineering education, engineers need to understand the broader social context of their work. Engineers have to be able to handle non-standardized social and technical processes in collaborative teamwork. In the open innovation environment, engineers have to be able to interact with various stakeholders and understand value creation and business, increasingly also in services, and especially KIBS, emphasizing also entrepreneurial skills.

The researcher argues that the most severe skills shortages of engineering graduates compared to future needs are the abilities and skills related to collaborative learning. This is because of six reasons emphasizing the need for developing abilities for collaborative learning:

- competitiveness of a nation is increasingly dependent on its ability to renew through social innovations that are a result of collaborative learning processes (Hämäläinen & Heiskala 2007)
- opening innovation environment increases interaction with various stakeholders (Chesbrough 2003 a,b)
- increasing emergent complexity of the society that would require grasping of self-transcending knowledge through collective flow that may be regarded as a result of an optimum collaborative learning process (Scharmer 2009)
- complex transdisciplinary problems like climate change emphasizing importance of collaborative learning (TLW, SDR)
- an increased need for continuing professional development during the engineering career (Korhonen 1997, Allt & Suutari 2002, Keski-Heikkilä 2002, Savolainen & Taukojärvi 2004, Martin et al. 2005, Korhonen-Yrjänheikki 2009, Keltikangas & Allt 2009, Savolainen 2010) and the socio-cultural aspect of becoming an expert and developing expertise require collaborative learning skills (Helle et al. 2006).
- engineers increasingly work in expert positions requiring teamwork

The researcher defines collaborative learning skills as "a set of values, attitudes and abilities needed for collaborative knowledge creation". The researcher has developed a conceptual model on how to enhance collaborative learning skills. The underlying theories of the presented model are the following knowl-

175 For a discussion on value-related capabilities and skills as part of engineering competence, see Korhonen-Yrjänheikki et al. (2011).

edge creation theories: Knowledge Spiral (Nonaka & Takeuchi 1995, Nonaka et al. 2000) and Theory U (Scharmer 2009).

Commitment and willingness to listen, reflect and share knowledge and skills openly form the values and attitudes layer of the conceptual model. Values embrace trust, commitment, love, openness, courage, the belief that an individual's benefit cannot be separated from the benefit of others, appreciation of deep listening and acceptance of uncertainty. Furthermore, a needed attitude is being passionate about whatever you do. The needed field structures of attention are I-in-you and I-in-now. Knowledge grows through reflection with others, and only through the shared context "Ba" and presencing is it possible to grasp the emerging knowledge.

The second layer of the conceptual model consists of the ability to listen, reflect and share one's knowledge and skills, which requires knowing oneself, ability to listen, ability to communicate in diverse contexts, and systems understanding. Engineering graduates need to be able to identify and define their own competencies, skills and personal qualities, including limitations. They have to understand the wider societal context and role of engineers in society, as well as how value is created with technology. Ability to listen without prejudice combined with ability to communicate across disciplinary borders, also in multicultural teams and virtual contexts is part of this dimension.

The third layer of the conceptual model consists of factors required from the learning process and context needed for collaborative knowledge creation. It is closely related to the values layer, since similar values that are required from individuals need to characterize the learning environment. The values of trust, commitment and love form the core. Other important factors in the learning process and environment are:

- clear intention = clarified learning objectives, prioritized learning content, systematic pedagogic management and developed assessment methods
- enough requisite variety and redundancy = multidisciplinary and -cultural learning context but balance between diversity and similarity to ensure the shared context
- creative chaos / autonomy = participative active learning methods (project-based, problem-oriented, use of drama and art)
- enhance deep listening = contemplative practices
- conversational field structures = dialogue and presencing
- prototyping = learning context that is a combination of theory and practice

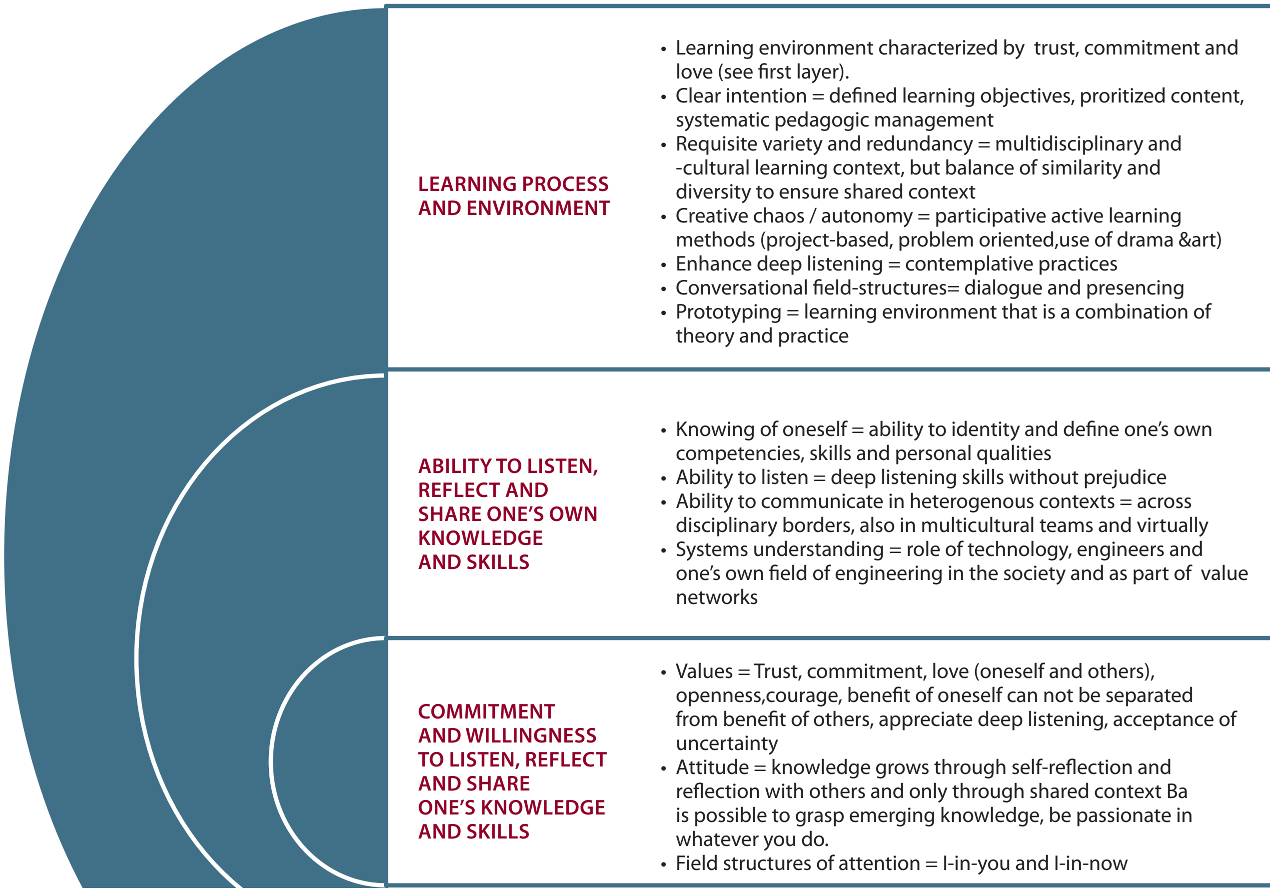

Figure 7.2 A conceptual model for developing collaborative learning skills of engineering graduates.

2. Active student-centered learning methods are in key position in facing the challenges of the changing society. The development of physical and virtual learning environments need to enhance collaborative learning. The Finnish engineering education needs to utilize the advantage of strong student community and non-hierarchical culture in developing the education.

The researcher argues that because of four reasons, active student-centered learning methods are among key issues for developing the Finnish engineering education:

- It is not always possible to add new subjects to the curriculum, and in many cases the curriculum is already overloaded compared to the allotted credits.
- Several of the key skill needs, for example the ability for systems understanding, lifelong learning, abilities and skills related to enhancing sustainable development and collaborative learning skills, cannot even be met by adding new subjects to the curriculum.
- There is room for substantial improvement in achieved learning results since the present learning environment in the Finnish engineering education does not favor deep-approached studying

orientation[176]. Deep-approached studying orientation is intertwined with aiming to understand the learned issue and how it interrelates to the curriculum and learning as a whole. Thus, it is at the core of educating engineers that are collaborative system thinkers.

- We cannot know for sure what are the exact skill needs of the labor market in the future, when the students entering engineering studies graduate, and therefore, the learning environment is more important than curricular details.

The results from AD and TLW suggest a need to develop pedagogy of virtual learning. Those hesitating in AD are worried that the social aspect of learning will suffer. TLW seems to point to the same issue by stating that there is a need to improve opportunities for collaborative virtual learning. With consideration to the fast development and convergence of NBRIC-technologies, the researcher argues that the development of virtual learning environments that would enhance collaborative learning in engineering education is highly important.

The researcher suggests that the Finnish engineering education should utilize the benefit of strong student participation in administration and development of education at HEIs. Non-hierarchical organization cultures, Universities Act (558/2009) and Act on Polytechnics (351/2003) ensuring participation of students in administration, and strong traditions particularly in universities, allow students to assume an important role in participating in educational development. Active student-centered learning methods require intertwining of students in developing education.

The researcher finds it a relevant threat scenario that unless the learning context as a whole - teaching methods, assessment, pedagogic management and physical space - are not developed to favor deep-approached learning, the Finnish engineering education is not able to fulfill its mission and vision for 2020 set by the key stakeholders in this study. This would result in an increasing share of strategic executors (see Erkkilä 2009) that have surface orientation, to whom learning is repetition and remembering resulting in a degree, rather than learning skills and interrelations of different issues. These engineers are not capable of collaborative knowledge creation, of understanding the role of engineering in society, systems and value creation, and their ability for enhancing sustainable development of society is very limited.

3. The identity of engineers becomes more multi-fold. Need to introduce M.Sc.(Systems) and M.Syst.Eng degrees. System sciences may lead into splitting engineering into two disciplines because of differences in engineering fields with relation to systems science revolution.

Engineering fields are not similar in relation to the systems science revolution, stressing of different fields of natural science, and practical orientation praxis. The researcher argues that the new systems science may well provide a solid foundation for the epistemology of engineering education, and finally provide a conclusion to the debate on whether the engineering discipline is applied natural science, or a discipline with its own epistemology, ontology and methodology. It seems also possible that engineering is about to split into two disciplines, one that has its roots strongly in traditional natural sciences, and another vein of systems science that is by its very nature multidisciplinary. Further studies are needed in epistemology on engineering education in the era of converging technologies and the systems science approach.

However, as an immediate practical consequence of the increasing importance of systems approach, the researcher suggests adding a new degree as part of the engineering discipline, namely Master of Sci-

176 Based on a study by Erkkilä (2009), which is limited to learning environment in universities providing engineering education. However, the researcher argues based on her knowledge and experiences obtained during this study that there is no reason to believe that the situation would be different in Finnish polytechnics.

ence in Systems Sciences (universities) and Master of Systems Engineering (polytechnics) provided by some of the HEIs that at present offer engineering education. In addition to B.Sc.(Tech.) or B.Eng, a wide variety of Bachelor's degrees, for example in economics, law, social sciences and arts, may provide the necessary knowledge and skills for the Master's program. And in fact, the researcher finds it necessary that in these Master's programs of systems sciences, students would represent a wide variety of educational backgrounds for enriching the learning context to enable the whole-system approach. At the same time the researcher maintains that it is important to make sure that the labor market can count on that those graduates taking the M.Sc.(Tech.) degree are skilled in traditional engineering fundamentals and have a solid theoretical background in natural sciences. Therefore, access to those Master's programs should primarily be restricted to B.Sc.(Tech.) graduates and B.Eng graduates supplementing their theoretical knowledge in natural sciences with additional studies in universities.

4. Need to build on existing strengths and to further develop co-operation with labor market further intertwining the learning environments and aiming at systematic stakeholder dialogue and enhancing of organizational learning in labor market co-operation.

When discussing increasing needs for co-operation with stakeholders external to the university, the researcher finds it crucial to note that universities are not only driven but also need to drive the social change. The researcher suggests that driving social change in the knowledge society is not possible without acting as a partner in an open innovation system and opening up towards stakeholders external to the university.

The researcher claims that behind the argumentation that as result of increasing involvement of external stakeholders, universities are at risk of forgetting the kernel of their work (Kantanen 2007) and limiting the academic freedom (Amaral & Magalhaes 2002), is the conception of external stakeholders as a coercive intervening force, whereas they should rather be seen as potential collaborators.

The researcher argues that the nature of the needed intensified external stakeholder co-operation is rather dialogue and intertwining of the learning and research environments than developing education based directly on feedback received from the labor market or limiting academic freedom carrying out basic research. An example of the needed systematic dialogue between the stakeholders of higher education is provided in this study in the context of the Finnish engineering education.

Results of the stakeholder processes (Chapters 5.5, 5.6 and 6), literature and statistics (Chapters 5.1 – 5.4) indicate that the Finnish engineering education has an exceptionally close relationship with industry, especially from the viewpoint of practical training of students and R&D co-operation between universities and industry. The researcher argues that "the stakeholder approach" is built into the culture of the Finnish engineering education, primarily regarding co-operation with industry, but also research organizations and labor market associations representing employers and the alumni. A practical manifestation of this is the work process of Collaboration Group in this study. The researcher recommends building further on that strength since development of the business environment favors systematic networking and stakeholder dialogue.

The researcher maintains that the remarkable amount of gathered studies-related work experience of Finnish engineering graduates[177] is a major strength and opportunity for the future because of several reasons: working-life projects provide, from the cognitive constructivist perspective, possibilities to integrate theory and practice (Helle et al. 2006), from the socio-cultural perspective, opportunities for

177 B.Eng typically 1 – 1.5 years and M.Sc.(Tech.) 1.5 – 2 years.

professional socialization (Keltikangas & Martinsuo 2009) and interacting with different kind of professionals (Helle et al. 2006), and from pragmatist perspective, a vast amount of experiential learning – both knowledge acquisition and creation of new knowledge (Helle et al. 2006).

The researcher claims that there is plenty of room for improvement in how efficiently practical training can be used to enhance reaching learning objectives as brought up in the stakeholder processes of the study (CGW, TLW) as well as in literature (for example Helle et al. 2006). Learning objectives need to be set for practical training periods, gathered learning need to be reflected through portfolios and learning diaries, and proper supervision and feedback is needed. Moreover, mutual understanding is needed on the roles and expectations of all parties.

The overall challenge identified during the stakeholder processes of the study (OFS, CGW) is to develop the co-operation with working life more strategic. Although several teachers of engineering have close co-operation with working life, others have barely none (TLW). The researcher suggests studying further alternatives on how to ensure active interaction of the teaching staff as a whole with the labor market, and how to follow up on teachers' continuing professional development. The researcher argues that systemizing the co-operation would improve organizational learning and ability to deal with the possible risks related to external stakeholder co-operation, such as dialogue turning into direct steering (for an example, see Michelsen 1999 in Chapter 5.1).

5. Need for a more multicultural learning environment, internationally recognized degrees and quality assurance – requiring the removal of Lic.Sc.(Tech.) from the degree system and introducing accreditation - and enabling selling of degree-oriented higher education.

Based on the results of the stakeholders processes (AD, OFS, CGW, TLW) and analysis of the statistics presented in Chapter 5.4.4, the researcher claims that poor internationalization is among the core deficiencies of the Finnish engineering education compared to the development of the business environment with the deepening globalization emphasizing the need for engineering graduates to be able to cope in a multicultural business environment. A good-quality learning environment is international, and internationalization is an important part of a proper learning experience, as suggested by CGW in the "Criteria for a Good Campus" (see Chapter 6.4.1).

Consistent with the results of the stakeholder processes (AD, OFS, CGW), the researcher is of the opinion that in a higher education system like Finland, where degree rights and degree targets are regulated on a national level by the authorities, a quality assurance system based on auditation organized by Finnish Higher Education Evaluation Council would be enough to ensure the minimum quality. However, the researcher argues that if the aim of Finland is to attract a significant number of international students, we have no choice but to introduce an accreditation system, at least in all programs that are in English and are specifically aimed to attract international students. It is noteworthy that although the majority of AD is of the opinion that accreditation will not be introduced by 2015 in Finland, and there will be no pan-European accreditation system, one third of AD disagrees. Three out of seven panelists that find the accreditation system probable and desirable represent industry.

The researcher maintains that one of the challenges with the present EUR-ACE initiative aiming to become the framework for accreditation of engineering education in Europe (EUR-ACE 2005) is that it is not developed for a dual system of education. However, if regarding the EUR-ACE criteria as a minimum requirement, it may be an alternative to consider. Finland could also co-operate with Germany and the Netherlands, for instance, in developing further criteria better applicable to a dual system. However, for enabling wider global recognition of Finnish engineering degrees, joining the EUR-ACE initiative may be not enough. We may need to seek direct recognition of the Finnish engineering degrees in the US, Asia and other parts of the world. This is because the researcher argues, based on her experiences in international engineering education community[178], that as an example, recognition of the EUR-ACE by the Washington Accord, enabling recognition in the US, is highly unsure.

AD and CGW suggest that problems exist in the international recognition of the Lic.Sc.(Tech.) degree. Also statistics[179] reveal constant decrease in the number of Lic.Sc.(Tech.) degrees since 1997, while at the same time the number of completed D.Sc.(Tech.) degrees has steadily risen. The researcher agrees with the majority of AD participants that find it probable and desirable that the Lic.Sc.(Tech.) degree is abolished from the degree system, mainly because of the lack of international comparability. The researcher is of the opinion that at the same time the requirement of a completed postgraduate degree in the requirements for principal teachers in polytechnics (Statutes 352/2003; 23§) should be supplemented with an alternative of a Master's degree and 10 years of relevant work experience[180]. This is because the researcher claims that in a HEI providing practical-oriented education, the competence acquired through work-based learning needs to be appreciated and acknowledged as a relevant option for acquiring the needed competence.

The stakeholder processes of the study suggest a growing potential to sell higher education internationally, including engineering education, and propose to enable gathering of tuition fees in degree-oriented higher education (AD, OFS, CGW). However, stakeholders are not unanimous. Especially students disagree on the desirability. Nearly all participants of the stakeholder processes (AD, OFS and CGW) are of the opinion that if tuition fees are introduced, it is extremely important to ensure that also in the future the possibility to enter higher education is dependent on skills and not economical status. The researcher also suggests that this is a core strength of the Finnish society. Designing a proposal for the system of introducing studying fees, keeping in mind the need to ensure access to higher education, would a topic of another study. However, the researcher argues that in one form or other, we need to enable HEIs to grasp the potential of the growing service market, and to enable tuition fees.

6. Need to develop continuing professional development of engineers to become a core activity of HEIs, especially new ways of formalizing and enhancing work-based learning. Expansion of continuing education requires development of quality assurance.

The stakeholder processes of the study (AD, OFS, CGW), statistics and literature (see Chapter 5.4.6.) suggest that the continuing education system of engineers is undeveloped compared to the increasing needs for continuing professional development. By combining the fast-growing need of continuing professional development, increasing importance of active experiential learning, and decreasing appreciation of degrees (AD), the researcher suggests that enhancing continuing professional development of engineers needs to be moved from the fringes to become one of the core functions of HEIs. With reference to the results of CGW, the researcher claims that when expanding the continuing education function there is also a need to develop the quality assurance of continuing education.

The presence of the demanding customer in the home market – bearing in mind that one degree in

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178 Since 2004 the researcher has been Member of the Board in the European Society of Engineering Education SEFI, and during years 2007 – 10 a Vice President.

179 KOTA-database: In 1997 the number of completed Lic.Sc.(Tech.) degrees was 202 and D.Sc.(Tech.) degrees 150, while in 2009 the corresponding number of degrees was 64 and 332.

180 The enactment (352/2003; 23 §) in its present form includes as an option not to require post-graduate degree because of special reasons. However, the researcher argues that there is a need to formalize the option to obtain the competence through work-based learning, and not to treat is as a special case.

five in higher education in Finland is taken in engineering (Statistics Finland 2010) -, and favorable advanced factor conditions in the form of close labor market co-operation (see Porter 1990 for the diamond model on competitive advantage) and Finnish engineers favoring work-based learning as a form of continuing education (Keski-Heikkilä 2002, Allt 2006, Savolainen 2010), are factors that would speak for the opportunity to create a competitive edge by developing pioneering continuing education of engineers in Finland.

The researcher suggests that there is a need to develop new innovative ways of education by combining the learning environments in university and industry, as well as degree-oriented and continuing education. Facilitated work-based learning is an example of a learning method in-between formal and in-formal learning. The researcher finds the on-going work for developing recognized professional qualifications for M.Sc.(Tech.) graduates (Ihalainen 2009) a promising example. The researcher suggests as principles for planning the recognized professional qualifications[181]:

- Developed in collaboration with all key stakeholders: HEIs, alumni, industry and policymakers.
- Continuous development of the concepts is required. Therefore, continuous research on skills shortages and anticipation of skill needs is needed.
- HEIs need to specialize also with regard to continuing education. The qualifications provided must be in synergy with the existing core competencies of the HEI.
- The extent of a special professional qualification is 30 – 60 ECTS.
- Individualization in implementation: prior learning needs to be recognized.
- Intertwine learning environments at work and in HEI.
- Ensure proper learning conditions: set learning objectives, clarify roles for each actor, ensure facilitation of the learning process as well as feedback and reflection.
- Ensure that contents and implementation fit the open, multicultural and transdisciplinary innovation environment. Developed qualifications must meet existing long-term skill needs of the labor market.

The results of AD suggest that doctoral studies in engineering will increase remarkably in future, and on average 15 – 20% of M.Sc.(Tech.) graduates, and in some universities almost 30% would take the PhD degree. It is noteworthy that three out of four of those four participants in AD that find the increase in PhD volume undesirable represent industry. The researcher maintains that often the need for continuing professional development is mixed with post-graduate studies. The labor market does not necessarily need considerably more doctorates, like the results of AD may indicate, but there is a need for new ways of continuing professional development, as suggested by AD and CGW. The researcher argues that recognized professional qualifications may be one way to meet the growing demand.

7. Difficulties in renewing social capital hinder reforming the HEI network. HEIs have to focus and learn collaborative competition. Need to increase incentives for improving the quality of education and to use it also as a means to trim the HEI network. The number of HEIs providing engineering education needs to be decreased.

Social capital not only fosters knowledge creation (Nonaka et al. 2000) but may also increase collective blindness[182] (Nahapiet & Ghoshal 1998). This is a relevant risk in the present society requiring renewal of the social capital in the changing business environment (Hämäläinen & Heiskala 2007). Stakeholder

181 First version of the suggested principles by the researcher published in Korhonen-Yrjänheikki (2009).
182 For discussion on groupthink see Chapter 7.3 and Appendix 15.

processes of the study suggest that incentives for developing the quality of education are much too low in the Finnish system of higher education (OFS, CGW). The researcher regards as a minimum requirement the objective set by CWW that at least 40% of the budgetary funding criteria needs to be tied to the quality of education.

This is because of two reasons. First, the researcher argues that the present funding criteria of universities and polytechnics increases the risk of a moral hazard phenomenon[183]: Because funding is primarily based on the volume of education – number of students and degrees - HEIs[184] do not have to worry about the share of unemployed graduates, adequacy of the employment, or meeting of the labor market skill needs. In other words, HEIs have an incentive to increase the volume of education without taking responsibility for the societal consequences.

Second, results from the stakeholder processes (AD, OFS and CGW) suggest that the network of the Finnish HEIs providing engineering education is not competitive in its present form. Resources are too scattered, which neither enhances quality nor efficiency. The researcher claims that unless the funding system does not force HEIs to focus and rationalize their operations resulting in a decreasing number of HEIs and campuses providing engineering, as proposed by CGW, the quality differences between achieved learning will increase.

Statistics reveal considerable differences in the employment of B.Eng graduates between different polytechnics (see Chapter 5.4.5). Literature suggests problems in adequacy of employment of B.Eng graduates (for example Vuorinen & Valkonen 2007 and Koivumäki 2008) and variation between skills of graduates in engineering fundamentals (Mäkitalo-Keinonen 2006). Variation in the quality of education in polytechnics providing engineering may be an explaining factor. CGW suggests decreasing the number of polytechnics providing engineering from 21 to approximately 15. The researcher argues that in addition to trimming the network of polytechnics providing engineering, there is also a need to decrease the volume of B.Eng education in order to ensure adequate employment.

The clearly weakened enrolled/accepted –ratio between 1997 – 2009 and not enough prospective students with advanced mathematics in matriculation examination (see Chapter 5.4.1) suggest severe problems in recruitment of universities providing engineering education. The weakest enrolled/accepted –ratio of all universities[185] providing engineering is in University of Vaasa (UV): 50%. The rate of external funding in UV is 24%, which is considerably less than in other universities providing engineering[186]. The volume of engineering education in UV is very low, 2009 below 1% of all M.Sc.(Tech.) degrees (KOTA-database). The researcher suggests[187] to consider discontinuing engineering education in UV. The most important reasons for this are insufficient recruitment base and not enough volume[188] for providing sufficient interdisciplinarity within engineering that would be important for a good quality engineering education in the present business environment (AD, CGW, TLW). In 2009 the degree program of ICT provided by UV was offered also by six other universities and four other universities also provided

183 For moral hazard phenomenon see, for example Tuomala (2009).

184 Note that the funding systems of universities and polytechnics differ from each other considerably. However, the same problem concerning lack of incentives for improving quality of education concerns both sectors. The problem is even more evident in polytechnics, where 70 % of the core funding is based on number of students and 30 % on completed degrees.

185 In other 6 universities the enrolled/accepted –ratio varies between 55 – 71% (KOTA-database 2009).

186 In other 6 universities the share of external funding varies between 40 – 57% (KOTA-database 2009).

187 CGW suggests 5 – 7 HEIs as a suitable number of universities providing engineering education. As discussed in Chapter 3.3.4, problems in face-to-face group communication had an impact on the proposal since a clear majority was anonymously in favor of 5.

188 Because of severe problems in recruitment base suggested by the statistics and enough qualified engineers available in the labor market (IMD 2009), increasing the total volume of education does not seem viable.

the degree program of electronic and electrical engineering (Allt, Korhonen-Yrjänheikki & Savolainen 2009). Also the amount of research publications in engineering in UV is low (KOTA-database 2009: 42; research publications / teaching man years 2.3), which is worrying bearing in mind the intertwined nature of research and education in a university, as stated in the Universities Act (558/2009; 2§): "to provide higher education based on research".

The researcher argues that also the extremely low volume of engineering education in University of Turku (KOTA-database 2009: 7 M.Sc.(Tech.) degrees) is problematic in terms of providing interdisciplinarity within technology. However, referring to KOTA-statistics from 2009, the enrolled/accepted –ratio, share of external funding, and amount of research publications in engineering are considerably better than in UV. The researcher suggests further studies on whether UTU could co-operate more closely with Åbo Akademi, as was done before year 2004, when UTU acquired the right to grant engineering degrees.

It is worth noting that the results from OFS suggest as a weak signal that the monopoly of HEIs to grant degrees vanishes in future. Opening up of the higher education market would be the ultimate way to increase incentives for focusing and improving quality[189].

8. Need to develop the dual system: allow mergers, clearer positioning of degrees and research activities. Impact of systems science revolution on the dual system is open.

Based on the results from OFS and CGW, the researcher argues for a need to redefine the dual model to allow different kind of organizational structures, including also mergers between universities and polytechnics. The researcher claims that the core of the dual model are different learning objectives between theoretically- and practically-oriented education, not the organizational structures. The researcher suggests that allowing different kind of organizational structures would enhance specialization of HEIs[190] that is seen as a priority issue in all stakeholder processes of this study.

The impact of the systems science revolution on the dual system was not discussed in any of the stakeholder processes of the study. Further studies in epistemology of engineering education are needed before drawing any conclusions. Anyway, in the foreseeable future, up to 2020, the researcher argues that the dual model is justified in the Finnish engineering education, as suggested in the stakeholder processes of the study (AD, OFS, CGW).

The researcher proposes, based on the results from OFS and TLW, that the main difference in the overall learning objectives not dependent on engineering-field, between B.Eng and B.Sc.(Tech.), is in using theoretical knowledge of mathematics and natural sciences for searching and defining problems and creating new solutions. The researcher claims that while B.Eng graduates should be appliers and professionals of the engineering practice, B.Sc.(Tech.) education must provide strong theoretical and methodological skills in order to allow graduates to become professionals of combining theory and practice after the Master's program. And consequently, B.Sc.(Tech.) is an intermediate degree, while B.Eng is a degree with strong labor-market relevance. With regard to the results of Naukkarinen (2006) and Jørgensen (2007) on the engineering-field-specific differences between the role of theory and practice, the researcher argues that further engineering-field-specific studies on learning objectives would still be needed for clarifying the role differences.

In order to emphasize the difference between the M.Eng and M.Sc.(Tech.) degrees, the researcher

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189 Note that this is not a suggestion for a way forward, but a relevant future option that HEIs need to be prepared for.
190 Specialization of HEIs is strongly manifested as an important aim in the Finnish higher education policy at present (see for example Prime Minister's Office 2007, Finnish Ministry of Education 2008b).

finds crucial the requirement of three years' work experience after completing B.Eng degree before one is able to continue studies towards M.Eng degree (Act 351/2003; 20 §). This underlines the role of the M.Eng degree as part of continuing professional development, unlike M.Sc.(Tech.) that is clearly part of undergraduate education, and the first undergraduate degree from university with full labor-market relevance since the nature of B.Sc.(Tech.) is that of an intermediate degree.

The researcher argues that also in the future, doctoral education should be provided only by universities, as suggested by AD, OFS and CGW, and the criteria for selecting students needs to be decided on by universities themselves (CGW). In practice, the researcher finds important that access of M.Eng students to doctoral studies is not categorically denied, although the allowed students need to be treated more as special cases than as mainstream, because of the lacking theoretical orientation of studies that may require a considerable amount of supplementary studies. If access of M.Eng students to doctoral studies is categorically denied, the researcher views it as a probable threat scenario that the dual system is blurred, and the Act on Polytechnics is changed to allow polytechnics to provide doctoral education.

The focus of this study is in engineering education, but when making conclusions on the development of the dual model, the researcher finds it necessary to make a conclusion also on the role of HEIs in research. This is because research is an essential factor differentiating universities and polytechnics (See Acts 558/2009 and 351/2003). The researcher suggests, as presented in Figure 7.3, that the role differences of universities and polytechnics in research could be defined by applying Pasteur's quadrant describing scientific research with two dimensions: quest for fundamental understanding and considerations of use (Stokes 1997, 73).

The focus of universities should mainly be on pure basic research that needs to be publicly funded, and use-inspired basic research that is funded by public sources as well as industry[191], and only to a minor extent on pure applied research funded by industry. Exploring particular phenomena without having in mind either general explanatory theory or considerations for use is also a minor activity. However, sometimes this may be a precursor of pure basic research or occur when aiming primarily at research skills development (Stokes 1997).

On the other hand, research activities of polytechnics would need to be focused on applied research funded by industry, and to a very minor extent on exploring without objectives when aiming to develop faculty research skills. Some public funding may be justified for pure applied research in polytechnics to enhance co-operation with industry that directly benefits development of education and supports regional development.

191 Chesbrough (2003 b) argues that in the open innovation system that does not favor internal R&D, the interest of industry to fund basic research will increase.

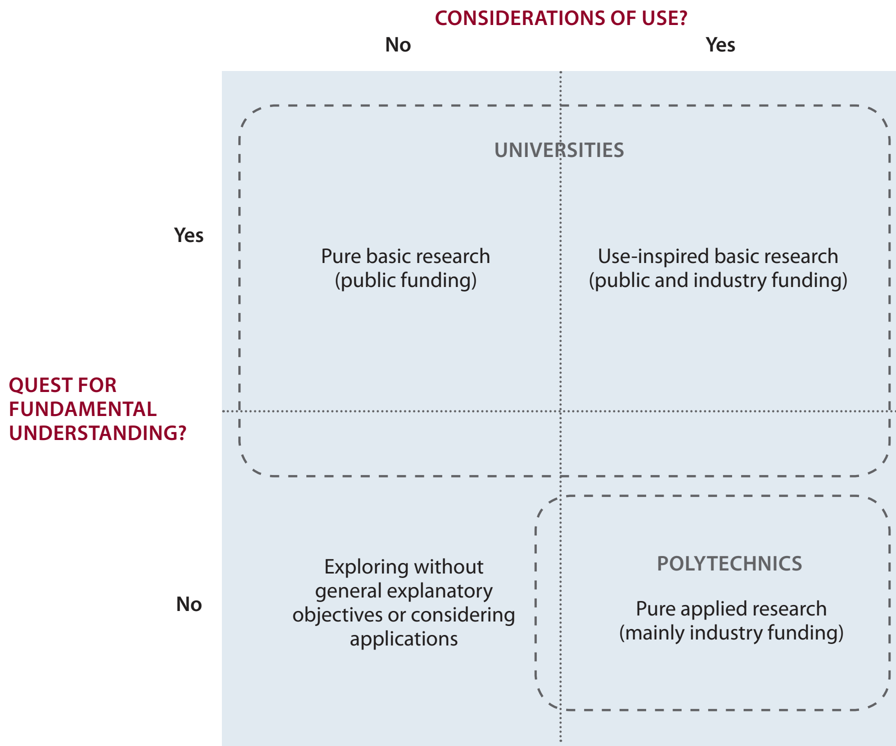

Figure 7.3 The researcher's suggestion on the role differences of universities and polytechnics in research, and funding sources of research in the framework of Pasteur's quadrant (Stokes 1997, 73).

7.2 DEFINITION OF STAKEHOLDERS AND SELECTION OF PARTICIPANTS

This chapter discusses Research Question 1 underlying the overall research problem:

What kind of a framework can be developed for selecting participants for a group communication process of key stakeholders when aiming at capturing future prospects and enhancing development of engineering education nationally, in this case in the context of Finland?

The task of capturing future prospects and enhancing the development of engineering education system nationally in the context of knowledge society can be regarded as relative complex with a wide variety of needed knowledge, skills, networks and decision-making power. The complexity of the task (Bowers et al. 2000, Stangor 2004), the societal environment of the knowledge economy (Scharmer 2009), the ontological level (Pouloudi & Whitley 1997, Boonstra & Vries 2008), and the higher education context (Clark 1998, Amaral & Magâlhaes 2002 and Bjørquist 2008) suggest for a fairly broad definition of stakeholders. However, the researcher argues that a broad definition of stakeholders leading to a wide variety of selected participants does not automatically lead to superior results in anticipating future prospects and framing proposals for action for the desired future of engineering education nationally.

Based on the theoretical framework and empirical observations during the three stakeholder processes of the study, the researchers suggests that this is because of two reasons:

First, **commitment and trust underlie human knowledge creation.** The stakeholder processes of the study, especially the work process of the Collaboration Group that lasted roughly two years, provide empirical evidence on how commitment affects knowledge creation in the long run. No matter how relevant the position of the representative of a stakeholder group is in theory, it has no use if the person does not commit to the work, for example, focus on the work at hand while present in a workshop, or does not even bother to participate. And on the other hand, if an individual is motivated and willing to participate, learn and create collaboratively, it is possible to push the whole group towards what the researcher would call "collective flow": shifting the field structure of attention through dialogue to I-in-you, and finally to I-in-now through presencing and reaching the emergent self-transcending knowledge (Scharmer 2009). This is of extremely high interest in anticipating and creating the future of any issue, including engineering education.

Second, both similarity and diversity of participants have their pros and cons regarding collaborative knowledge creation. **Enough requisite variety and weak ties, in other words, diversity of participants, are of key importance to knowledge creation but they cannot be utilized unless the shared context for knowledge creation "Ba" exists, moderated by trust and commitment, because a shared context is a prerequisite for knowledge creation.** Diversity contains at least aspects of personal charasteristics, knowledge, skills, gender and age group, and in a more multicultural society than Finland, also the ethnical background.

Perceived commitment and trust are intertwined with the group process but they also obtain a dimension of initial commitment and trust perceived before the group process. Because commitment and trust play a key role in knowledge creation, the researcher suggests that **initial commitment to collaborative knowledge creation should be considered a necessary pre-condition for the relevant stakeholder definition**.

In addition to the initial commitment, the researcher suggests that the relevant attributes to consider are knowledge and decision-making power. Relevant stakeholders are committed and obtain either one or both of these attributes. Consequently, relevant stakeholders are **those that have knowledge and/or decision-making power in engineering education in NN, and that are committed to collaborative knowledge creation and action for enhancing development of engineering education in NN.**

The proposed framework for participant selection, presented in Figure 7.4, consists of five phases:

1. Definition of objective of the group communication process
2. Definition of relevant stakeholders
3. Selection of organizations representing stakeholders
4. Decision on the number of participants
5. Selection of participants

HEIs form the core of the engineering education system. Using the definition presented above, the key stakeholders internally in a HEI are the management, teaching and research staff, staff responsible for development and administration of teaching and learning, as well as students. External to the core of the system, the key actors are policymakers, representatives of employers, representatives of the alumni and representatives of research and funding organizations of technology.

The focus of development is an inter-organizational system. The researcher maintains that when selecting organizations representing stakeholders, it is important to pay attention to the representativeness of different stakeholder groups. First, with regard to HEIs, the researcher suggests that an important aspect is representativeness of research-oriented and teaching-oriented institutions. If the educational system is that of a dual model, like in Finland, Germany or the Netherlands, this refers, in practice, to ensuring the representativeness of universities and polytechnics. Second, it is necessary to make sure that both multidisciplinary and engineering-focused HEIs are represented. Third, it is worth considering the regional representativeness of HEIs. And fourth, the researcher suggests paying attention to representativeness of different fields of engineering.

Regarding employers, the researcher suggests ensuring the representativeness of the most important employers of engineers in the country. Different aspects to consider are sectors – private, public and associations -, industrial clusters, and size of companies. The number of representatives invited from enterprises is dependent on the number of participants in the entire group. As a minimum requirement the researcher proposes to involve representatives of the key labor-market organizations of employers of engineers.

Representativeness of the alumni can be ensured by inviting representatives from the most important professional and labor-market organizations of engineers. When considering relevant actors regarding policymakers, the researcher proposes paying attention to inviting representatives from those Ministries dealing with education, science, innovation and employment. It would also be beneficial to involve the Ministry of Finance. The researcher argues that it is also useful to invite representatives of the Parliament. If several Parliamentarians are invited, the researcher recommends paying attention to the representativeness of different parties.

The suitable number of participants invited to a face-to-face group communication event is dependent on the applied group communication methodology (see discussion in Chapter 2.3.1). Moreover, it is also dependent on whether one is planning to organize one event or a work process of a group with plenty of workshops that can be regarded as a collaborative learning process. If one is planning to set up a Collaboration Group aiming at a collaborative learning process including several events, the researcher suggests to keep the group as small as possible bearing in mind the representativeness of the system, and the needed diversity in knowledge, decision-making power, personal charasteristics, gender, age group and ethnical background. This is likely to enhance forming the shared context "Ba", which is of key importance for knowledge creation as discussed above.

The core Collaboration Group of the study consists of 28 participants. When aiming to benchmark the operational model of it to another country, the researcher claims that the optimal number of participants[192] in the core group is between 25 – 30. This allows enough diversity, but is not too large for slowing down shared context creation[193].

The following questions are helpful when defining the stakeholders and ensuring enough diversity in terms of knowledge, skills, personal charasteristics, gender, age group and ethnical background:

- Is the person committed to collaborative knowledge creation and action for enhancing development of NN engineering education? (commitment)

192 The researcher suggests that substitutes should not be allowed to participate in group-internal workshops. This way the group formation process (Stangor 2004) does not start all over again in every workshop. Furthermore, the researcher maintains that one factor increasing trust, thus promoting creation of knowledge, in the Collaboration Group was that no substitutes were tolerated to participate in the workshops of the Group.

193 However, in order to seek group-external knowledge on a specific theme like teaching and learning in engineering and also to decrease the risk of groupthink, the researcher suggests that it is beneficial to organize also workshops with specific themes like, in this case, on teaching and learning. Approximately 50 participants attended the teaching and learning workshops and workshop on structural development as part of the Collaboration Group work process. If applying large group communication methods, like Open Space, the number of invited participants may be considerably larger.

- What kind of knowledge and expertise does the candidate have in engineering education in NN or its business environment? (knowledge and skills)
- What is the candidate's ability to influence on engineering education in NN? (decision-making power)
- Are different types of personalities included – also critics? (personal charasteristics)
- Are both females and males represented? Is it possible to improve gender balance without sacrificing other aspects of diversity? (gender)
- Are different age groups represented? (age group)
- Does the panel represent the ethnical variety of society? (ethnical background)

In the Open Futures Search event and the Argument Delphi panel, the researcher identified organizations representing different stakeholder groups and selected also participants from these organizations. It is also possible to define the invited organizations and to let the top management to appoint the organizational representatives, which was the case regarding the Collaboration Group in this study. The researcher argues that this may increase the commitment of organizations in addition to participating individuals, which is also important in the case of an inter-organizational system, such as national engineering education system. The most important aspect, however, as the researcher suggested in the relevant stakeholder definition, is the commitment of the individual that participates in the group communication process. Therefore, the researcher argues that it is important to stress the required commitment also when asking the defined organizations to nominate their representatives.

It is important to remember that the stakeholder map is dynamic and the relevant stakeholders may change over time (Savage et al. 1991, Mitchell et al. 1997, Cummings & Doh 2000, Antonacopoulou & Meric 2005). Therefore, if one is planning to facilitate a group communication process, even with aims similar to this study, the researcher accentuates that it is important to carry out the analysis of relevant stakeholders again.

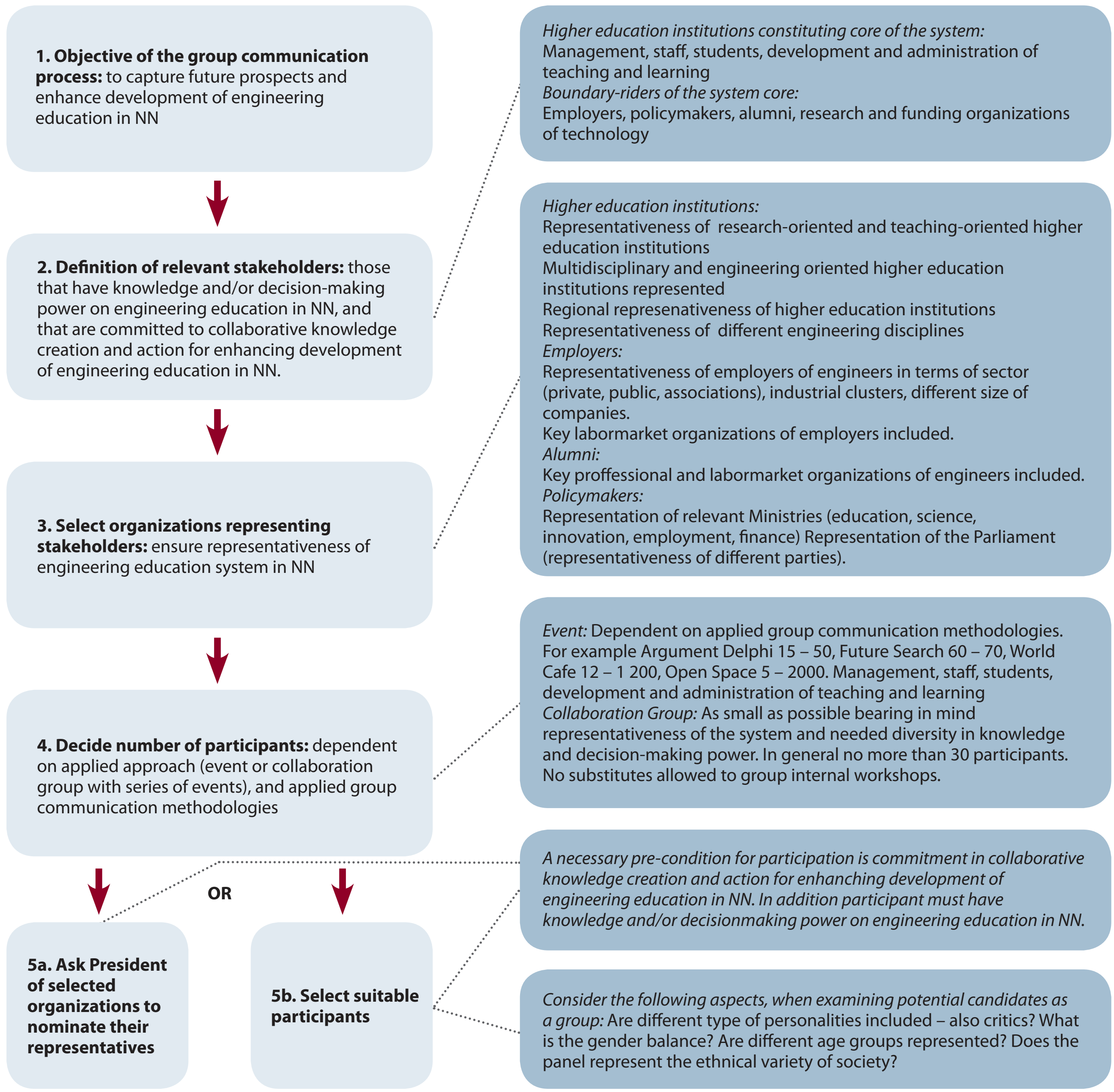

Figure 7.4 A framework for selecting participants for a group communication process when aiming at capturing future prospects and enhancing development of engineering education nationally.

7.3 KNOWLEDGE CREATION WITH GROUP COMMUNICATION IN FUTURES RESEARCH

This chapter discusses the key findings of the study regarding knowledge creation in anonymous and face-to-face group communication processes in futures research. The chapter includes also suggestions for further research.

The conversational mode of the Argument Delphi panel during the first-round thematic interviews was dialogue between interviewee and the facilitator (researcher). The conversational mode in the second round was a debate. The Open Futures Search event combining Futures Search and Open Space methodologies employed primarily the mode of dialogue. This was the case also during the work process of Collaboration Group, where the most widely applied participative working methods were variations of World Café.

None of the applied methodologies fully employed the mode of presencing as described by Scharmer (2009). However, the researcher argues that during the work process of the Collaboration Group there were moments when the field structure of attention shifted to I-in-now that the researcher would call collective flow. Those moments were characterized by a shared feeling of trust and losing track of time and space, meaning that the group operated as one organ. However, the researcher maintains that the ability to reach the era of emerging self-transcending knowledge was only very limited.

The researcher suggests that in defining the concept of 21st century systems theory including self-transcending not yet embodied knowledge, Scharmer (2009) actually defines the epistemological and ontological foundation of futures studies, although not explicitly stating that. Keeping in mind the arguments of Nonaka et al. (2000) on the role of shared knowledge creation context "Ba", Scharmer (2009) on the key importance of primary mode of cognition affecting on how the future unfolds, and Boisot (1998, 10) stating that "complex processes may not allow much in the way of detailed prediction, but they may not be impossible to manage"[194], it seems important for futures studies to develop face-to-face group communication methodologies, including participant selection frameworks that promote energizing of the "Ba" and the presencing mode of cognition. The researcher also suggests that in futures research it would be important to develop further participative group communication methodologies that combine face-to-face dialogue with learning-by-doing in order to mobilize experiential learning (see Nonaka et al. 2000 "building an archetype" or Scharmer 2009 "co-evolving").

This study suggests that face-to-face group communication has potential for providing several benefits over anonymous group communication in futures studies. One weakness of anonymous group communication is that it is weak in creating and ensuring commitment (see Kuusi 1999). This is a severe drawback if the aim of the study is not only to study future options, but to enhance realizing the future through action research. However, the researcher claims that the most important benefit of face-to-face group communication over anonymous is the possibility to mobilize both individual- and collective-driven social learning cycles. Anonymous group communication does not enable acquisition of tacit knowledge through shared experience and knowledge conversion between tacit and explicit knowledge through dialogue due to the non-existent face-to-face interaction, and therefore, it does not enable collaborative learning. Because it does not enable the collective-driven social learning cycle, then it is not possible to reach the optimum state of collaborative learning, the collective flow, that allows to grasp the emerging self-transcending knowledge.

194 Boisot (1998, 11) explains this through laws of thermodynamics: The entropy level of an open system can be reduced only by increasing the entropy level of the environment. Management of the energy conversion means either reversing the course of energy conversion or minimizing the rate of conversion.

Despite this major weakness of anonymous group communication, the researcher suggests that this does not automatically imply superiority of face-to-face group communication over anonymous if the main aim of the futures research is related to defining all relevant options for the future (option reasonability, Kuusi 1999) including capturing of weak signals. This is because pressure for unanimity may be a key hindrance to open communication in a conflicting face-to-face situation resulting in groupthink, as suggested in literature (see, for example, Janis 1972, Turoff 1975, Nahapiet & Ghoshal 1998, Kuusi 1999, Baron & Kerr 2003, Stangor 2004, Schein 2006, Collins & O'Rourke 2009) and supported also by empirical evidence in this study (see Chapter 3.4.4.).

Because of the problem of groupthink, anonymous group communication may be sometimes better in initiating a need for change, although theoretically the collective flow in the conversional mode of presencing should provide better results. Because of the increasing emergent complexity of society, the ability to identify a weak signal that may lead to a major change is highly important. In this study, AD brought up in 2001 an indication of considerable changes in pulp and paper industry that began to materialize in the latter part of the decade impacting also engineering education. Minority of AD found probable the scenario that pulp- and paper production plants mainly move away from Finland. Although face-to-face OFS was carried out five years later, in 2006, this threat scenario of considerable restructuring was not visible in a way similar to AD. However, discussions of OFS brought up another weak signal, vanishing monopoly of HEIs in granting degrees.

The researcher argues that both anonymous group communication process of the study (AD) as well as face-to-face group communication processes in OFS and Collaboration Group contain seeds of a possible, more fundamental change in the engineering discipline implied by the 21st century systems science leading engineering to split into two disciplines. However, explicitly this was not introduced in any of the stakeholder processes. This is an example of an emerging future issue that the researcher claims may be a weak signal of a major restructuring in engineering education. The researcher argues that both anonymous and face-to-face group communication methodologies may be used in identifying weak signals, and ideally both of them should be used in order to find out whether similar issues are brought up.

The researcher agrees with Eric Trist (In: Holman & Devane 1999,43) that paradigm shifts may be achieved only if developing tools for a large number of people of experiencing them for creating the needed commitment. This study also suggests that participative face-to-face group communication methodologies are useful in creating commitment for realizing the desirable future. Moreover, they are important because they enable individual- and collective-driven social learning cycles. And furthermore, in an ideal state of collective flow, they enable grasping of emerging knowledge. However, the researcher claims that anonymous group communication methodologies are a useful additional tool in initiating change and bringing up to discussion potentially conflicting and delicate issues, and thereby improving the identification of different options for the future.

Literature contains a wide variety of suggestions[195] for minimizing the risk to groupthink in face-to-

195 Suggestions in the literature for overcoming the problem of groupthink include fostering of a culture of trust (Bunker & Alban 1997, Nahapiet & Ghoshal 1998, Forsyth 2010), truthfulness, courage (Heikkerö 2008) and openness (Nahapiet & Ghoshal 1998, Stangor 2004, Forsyth 2010), reserving plenty of time for discussion (Stangor 2004) including an analysis of pros and cons of all proposals (Forsyth 2010), more small group assignments (Nahapiet & Ghoshal 1998, Baron & Kerr 2003, Stangor 2004, Forsyth 2010), advising leaders not to advocate any one plan early in the discussion (Baron & Kerr 2003, Forsyth 2010), making members of group more openly accountable for their role in discussion (Baron & Kerr 2003, Forsyth 2010), openness to group-external knowledge (Baron & Kerr 2003, Stangor 2004, Forsyth 2010) and appreciating diversity and criticism (Nahapiet & Ghoshal 1998, Baron & Kerr 2003, Stangor 2004, Forsyth 2010) or even resorting to devil's advocate – an individual who is given a task to be critical and to express conflicting opinions in the group (Stangor 2004, Collins & O'Rourke 2009, Forsyth 2010). For more discussion on the problem of groupthink see Appendix 15.

face group communication. A suggestion for a conceptual model for developing collaborative learning skills developed by the researcher is presented in Chapter 7.1. The model is developed for the purpose of developing the collaborative learning skills of engineering graduates, but the researcher argues that it can be further developed to be applied also in other contexts for enhancing collaborative learning and also overcoming the problem of groupthink in face-to-face group communication in futures studies.

7.4 LIMITATIONS OF THE STUDY

This chapter deals with the limitations of the study.

A challenge for the study, regarding the development of the general framework for participant selection for a group communication process aiming at capturing future prospects and developing engineering education nationally, was that most of the work on the identification of stakeholders is accomplished on the ontological level of an organization, and more accurately privately-owned corporations (see, for example, Savage et al 1991; Mitchell et al. 1997; Cummings & Doh 2000), whereas the ontology of the study is an inter-organizational system in a context of mainly publicly-owned organizations. The application of stakeholder concept in the context of higher education is relatively new (Neave 2000a, Kantanen 2007, Bjørquist 2008), although the researcher argues that in engineering education the stakeholder approach is built into the nature of the discipline.

The researcher is of the opinion that the growing importance of the systems-approach in engineering education, as argued in Chapter 7.1, may lead to a need for further broadening the definition of relevant key stakeholders. Based on the analysis of the key factors in the societal environment, carried out in the stakeholder processes of the study, the researcher suggests that one concrete example of growing importance may be the public actors, enterprises and associations operating in the cluster of healthcare and welfare. This group was probably not enough represented in the stakeholder processes of this study.

If the planning of the work of the Collaboration Group would start now, the researcher would involve some phases, as an example, a few workshops where representatives of HEIs in Finland not providing engineering education, representatives of HEIs outside Finland providing engineering education, representatives of high school students, and the media would be invited. They do not belong to the group of key stakeholders as defined in Chapter 7.2, but they could bring relevant knowledge of the business environment and educational system as a whole. The researcher suggests that this could further improve facing of the challenges of increasing social, dynamic and emergent complexity of society (Scharmer 2009).

If planning to apply the suggested framework of participant selection for framing future prospects and developing of engineering education system outside Finland, the researcher reminds that cultural differences impacting the engineering discipline, and the nature of stakeholder co-operation exist that need to be taken into consideration.

The role of the researcher was not similar in all the three stakeholder processes of the study. In AD as well as in OFS the researcher was the facilitator. In the Collaboration Group the researcher was the initiator and manager of the process and participated in the group work as a representative of the alumni, while members of the researcher's team at TEK facilitated the workshops. The changing role may have had an impact on the analysis of the results of stakeholder processes.

AD was carried out in 2001 – 2002, OFS in 2006, and the work process of the Collaboration Group 2007 – 2009. There was a relative long time period between the analysis of the future prospects of the Finnish engineering education in AD compared to the Collaboration Group. This provided certain benefits for the identification of the key trends over a longer-term. As an example, the presented scenarios for the Finnish engineering education as framed by AD in 2001 still seem valid and bring up relevant topics for discussion. However, the time difference between the stakeholder processes is also a challenge for the comparison of the results from the different stakeholder processes.

As discussed in Chapter 7.3, the conversational field structure of the group communication processes of the study was mainly dialogue, and to some extent debate, and only in few cases during the work of the Collaboration Group, presencing. If the planning of the work of the Collaboration Group started now, the researcher would involve contemplative practices in the work process in order to facilitate reaching the state of presencing as suggested by Scharmer (2009), when applying the social presencing theatre as a tool in U-process. Moreover, the researcher would use drama and art at the workshops. The researcher would also incorporate more learning-by-doing into the work methodologies with the aim of enhancing internalization on the individual level (Nonaka & Takeuchi 1995) and co-evolving in the collective level (Scharmer 2009).

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APPENDIX 1: QUESTIONNAIRE IN THE SECOND ROUND OF THE ARGUMENT DELPHI: "FINLAND 2015"

TOP DECISION MAKERS DELPHI PANEL, ROUND 2: FINLAND IN 2015

Respondent's name:

Respondent's organization:

1. Finland in 2015 broad scenarios

Scenario 1: Slowing down the development of the information society

Scenario 2: A global information society of materialistic values

Scenario 3: A learning society and global welfare

Scenario 4: Chaos, terrorism, and environmental catastrophes

Please read the whole scenario first, then answer the questions at the end of the scenario.

Scenario 1: Slowing down the development of the information society

Core items: traditional Finnish way of life, intolerance, opposition to globalization, slowing down of the development of information technology, slowing down of the growth of the national economy.

Population, culture, and values

(1) "Finland for the Finns" is the predominant way of thinking. Multiculturalism has hardly increased compared with 2002 – the Finnish way of life is clearly the dominant culture. There are prejudices against foreigners and problems related to racism occur from time to time. The mobility of Finns to foreign countries is not increasing.

(2) Immigrants are not particularly interested in moving to Finland, and, on the other hand, the Finns want to protect the Finnish language and culture and feel that it is best achieved by keeping the number of immigrants as low as possible. Other cultures form small isolated pockets in Finland. Approximately 1 to 3 percent of the population is of foreign origin.

Settlement in Finland

(3) Because the national economy has not grown as expected, it has been necessary to seek savings in making public services more efficient and, thus, the regional coverage of services has deteriorated. Telecommuting has not caught on and the number of jobs in rural areas has continually decreased. Thus, rural areas are becoming depopulated. Regional centers are still relatively dynamic as the willingness of Finns to move far from their childhood neighborhoods after jobs and better economic prosperity has not increased.

Public services and welfare

(4) The weakened dependency ratio and the ageing population is a central problem for maintaining the welfare society. There have been attempts to maintain the welfare society by raising the tax rate, but the majority of Finns no longer accept the endlessly rising taxes as a solution. The growth of the national economy has slowed down and the big question is what to cut when it is no longer possible to maintain comprehensive public social, health, and educational services.

Education

(5) The idea that welfare in an information society is based on the highest possible general educational attainment has been abandoned. The number of university places on offer has been drastically cut compared with 2002. A place in higher education is on offer to 40 to 50 percent of an age group. One of the most important factors of this development has been the constant reduction in resources available for higher education. As the Finnish national economy has declined, both public budget funding and private funding have decreased.

(6) Intolerance and lack of pluralism in Finland is manifest as constant clashes between the technological and humanistic cultures. Interdisciplinary and multidisciplinary studies are not considered worth pursuing in higher education. In-depth knowledge of one's own field is the only deciding factor. Studies in the field of technology are quite separate from other university studies.

Economic development and business life in general

(7) Labor shortage and high taxation have driven some Finnish companies to transfer some of their operations abroad. For several years running, the Finnish national economy has clearly failed to reach the targeted level and the forecast for the national economy for the next few years shows the growth will cease altogether.

Technology and R&D

(8) Narrowness is also the predominant perspective in developing technology. Technology is clearly separate from the humanistic culture. The opportunities provided by social innovations utilizing technology have not been grasped. The slowing down of the technological

development has also considerably slackened the growth of the Finnish national economy. This has contributed to increasingly critical attitudes to technology. The share of research and development in the gross national product is 2 to 3 percent.

(9) The limited capacity of people to communicate electronically without personal face-to-face contact has slowed down the development of information and communications technology applications. The export of information and communications technology products is decreasing in Finland. It is hoped that the traditional forest and metal industries will save the national economy from a steep downward trend.

The environment

(10) No significant changes have taken place in Finland in values connected to the environment and nature compared with 2002. The significance of the environment as a factor in business has not increased.

The EU and other international developments

(11) The eastward expansion of the EU has added to Finnish prejudices towards the EU. There are fears of the disappearance of the Finnish culture and the diminishing of Finland's influence in the EU. Many Finnish citizens feel that the EU is nothing but a bureaucratic money grabber of little use to Finland.

(12) Opposition to globalization has attracted a significant number of Finnish opinion leaders. Nationalism as an ideology is on the increase and a large number of Finns are in favor of breaking away from the EU altogether.

Please rate the probability and desirability of Scenario 1.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 1 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Does the core item list of Scenario 1 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Which paragraph do you feel is the most central to Scenario 1?

Paragraph number:

Do you think Scenario 1 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 1?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 1, I would like to change it as follows:

Scenario 2: A global information society of materialistic values

Core items: materialistic values, global and local aspects compete, individuality and seeking one's own identity emphasized, information networks highly important to social interaction, heavy urbanization.

Population, culture, and values

(1) The set of values of the new economy have partly replaced the traditional Christian set of values. The sense of community as a value has become less significant and people mainly look after their own and their nuclear family's welfare. Individuality and seeking one's own identity are strongly emphasized. Birth and nationality are of secondary importance.

(2) Individual social networks are significantly less bound to the immediate physical environment, which is partly replaced by virtual networks. Because a very large part of communication occurs via networks, the significance of interaction and communication skills has clearly increased.

(3) The global virtual culture competes strongly with Finnish culture. The older generation is still interested in preserving the Finnish culture, but it seems that the significance of Finnish culture is gradually diminishing and being replaced by global virtual culture.

(4) Immigration to Finland has increased somewhat compared with 2002. A significant portion of the immigrants originate in Russia and the Baltic countries. Immigrants in Finland mainly work in unskilled jobs.

(5) The mobility of Finns to foreign countries has continuously increased. Taxation that is higher than in other EU countries is a contributing factor to the fact that emigration of Finns with a higher education in particular is on the increase.

Settlement in Finland

(6) The lifestyle is strongly urbanized. Settlement concentrates in the Helsinki metropolitan area and a few regional centers. Some people want to live slightly farther away from city centers in a rural environment, but rural areas are becoming depopulated of permanent residents and will survive through the holiday home culture. Only a small portion even of retired people want to return to the country to their childhood neighborhoods. Some, particularly young people, are not satisfied with the bustle of the Helsinki metropolitan area, but seek big cities worldwide.

Public services and welfare

(7) The weakened dependency ratio and the aging population are central problems. Society is clearly divided into winners and losers. Those with money are able to choose the most pleasant alternatives in health and educational services. The model of the welfare state is being dismantled and the Finnish set of values has become tougher, approaching a society in which people rely on themselves for welfare.

(8) Networks are utilized in producing many services. Network services have replaced many personal service encounters. E-learning has increased significantly on all levels of education. On the other hand, there has been reluctance to transfer certain functions to network environments. For instance, opportunities for telecommuting have increased slowly, which has contributed to the depopulation of rural areas.

Education

(9) Expertise is perceived as the most central factor of production. However, the appreciation of teaching and budget funding for higher education has not increased significantly compared with 2002. Instead, educational needs have continuously increased due to increased undergraduate, postgraduate, and continuing education in higher education institutions. A place in higher education is on offer to approximately 70 percent of an age group.

(10) The resources of higher education institutions per student for teaching are meager. Research commissioned by companies is used as a way of raising funds in an attempt to patch up shortages in funding undergraduate teaching. Furthermore, higher education has partly become subject to a charge.

(11) Virtual teaching is also used in an attempt to spare staff resources so that it would be possible to invest at least to some extent in personal supervision and some courses with personal teaching. Teaching is mainly developed on the terms of cost-efficiency, not in search of the best pedagogical solutions.

Economic development and business life in general

(12) The sensitivity of the global network economy to economic fluctuations has increased. Economic cycles are faster and more intense. The Western world has mainly begun to use electronic money. World trade has three main currencies: the dollar, euro, and yen.

(13) The significance of e-business has steadily increased. Making business processes electronic has played a key role in the increased significance of e-business. Electronic commerce is highly significant, especially in b-to-b trade.

(14) Considerable resources have been invested in information technology performance and security. Despite that, the infrastructure is more vulnerable than ever as dependency on information technology has continuously increased.

(15) Labor shortage is a serious problem in both unskilled tasks and jobs requiring higher education. The number of immigrants in Finland has increased slowly while the willingness of highly educated Finns to move abroad has increased.

(16) Finding skilled people for research and development tasks is difficult since, although the number of people with higher education is sufficient in relation to labor demand, the average standard of higher education in technology has decreased. Insufficient resources are available for education, because the funding of higher education has not increased along with the number of students.

Technology and R&D

(17) The appreciation of technology in Finland has remained the same compared with 2002. The share of research and development in the gross national product is 3 to 4 percent. Developing technology is seen as important for Finland's success. However, there has been little willingness to choose clear areas of focus. Rather, technology policies can best be described as policies of compromises.

(18) Technology is developed quite separate from the humanistic culture. Indeed, the utilizing of social innovations benefiting from technology has remained rather low.

The environment

(19) Environmental aspects are considered from the economic point of view. Environmental values are secondary to materialistic values. The well-being of waterways and forests in Finland is looked after mainly due to economic reasons.

The EU and other international developments

(20) Europe has steadily progressed towards closer co-operation and federation. Decision-making has increasingly moved away from the national level. Decisions concerning, for instance, educational policies are, to a significant extent, made at the EU level. Different blocks have formed within the EU.

(21) The internal development of Russia has been somewhat unsteady, due to great imbalance in wealth distribution and, thus, the low standard of living of a large part of the population. The significance of Russia in world economy has, however, increased.

(22) North America is still a central engine of world trade, but the significance of Asia in world trade has increased considerably compared with 2002. China, in particular, has emerged as a major world economic power. In addition, other Asian countries with strongly growing economies include India, Indonesia, and the Philippines.

(23) With the exception of South Africa and the very northernmost parts of the continent, Africa still lags markedly behind the development of the rest of the world. Some more resources are beginning to be invested in the poorest countries out of necessity, as there are fears of the explosion of diseases, such as HIV, and their spread to Western countries with a flood of refugees.

Please rate the probability and desirability of Scenario 2.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 2 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Which paragraph do you feel is the most central to Scenario 2?

Paragraph number:

Does the core item list of Scenario 2 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Do you think Scenario 2 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 2?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 2, I would like to change it as follows:

Scenario 3: A learning society and global welfare

Core items: balancing individuality and community, emergence of spiritual values alongside material things, plurality, global welfare, social innovations utilizing technology

Population, culture and values

(1) Multiculturalism and tolerance have survived difficulties to become part of everyday life. Finnish culture has been influenced by many other cultures. The share of foreigners in the Finnish population has increased quite rapidly in 2002-2015.

(2) Mobility in Europe has increased rapidly. The mobility of Finns has also significantly increased. Substantial numbers of immigrants have moved to Finland, both to highly skilled expert positions and relatively low-wage jobs in the service sector.

(3) Individuality and community go hand in hand. Individuality and finding internal peace are emphasized in the global world. On the other hand, people take responsibility for the welfare of family and local communities. Network democracy has increased the opportunities and willingness to influence society.

(4) Social networks tied to the immediate environment are complemented by virtual networks to form the core of the social reality of individuals. The significance of interaction and communication skills has increased. The expansion of social reality from the immediate physical environment and Finland to the rest of the world has increased interest in global welfare.

(5) Global virtual culture is a challenge to national cultures. Many countries, such as Finland, however, also desire familiar culture close to people, not just electronic culture. Finnish culture – literature, music, sculpture, etc. – has remained strong. Finnish culture also has export opportunities, because, in addition to global electronic networks, there is a demand for different cultural offerings.

Settlement in Finland

(6) Migration to Southern Finland and regional centers has continued but is clearly slowing down. Telecommuting has become significantly more common as technological development has enabled people to interact in an increasingly natural way. Telecommunications infrastructure throughout Finland is among the best in the world.

(7) Thanks to increased telecommuting and the growing significance of environmental values, rural areas have partly been able to retain permanent settlement. Increased interest in nature tourism has also revived rural areas.

Public services and welfare

(8) Finns have wanted to preserve the model of the welfare state in which everybody has equal opportunities for a good education and good social and health services. In addition to the Finnish welfare information society, the global well-being of people and the environment is a central topic in discussions and target of actions. Considerable economic resources are invested in increasing the welfare of people in developing countries and global environmental protection. Increasing educational attainment globally is a central objective.

(9) Information networks are utilized extensively in all human activity. Information networks have provided many new opportunities, in particular to learning and telecommuting. Finland ranks among the best in the world in developing technological solutions to care services.

Education

(10) Expertise is the most central factor of production. Appreciation of teaching has clearly risen. Maintaining the competitiveness of education is seen as a national project and clearly more budget funding is invested in eduaction than in 2002. In addition to budget funding, companies are increasingly funding higher education. The supply of highly skilled employees is a key factor of production for companies, so companies feel that investment in higher education is profitable in the long run.

(11) The highest possible general national level of expertise is perceived as a central objective. Attaining an education is not dependent on the financial situation of the individual. There is both free and paid higher education.

(12) Appreciation of manual skills, and with it vocational education, has risen. Good education does not necessarily refer to a university degree. On the other hand, it is felt that there is no such thing as being over-educated, and, indeed, the majority of people who choose vocational careers have a university degree.

(13) E-learning is widely utilized on all educational levels. However, on-campus learning still plays an important role in many fields, such as technology.

Economic development and business life in general

(14) The globalization and networking of economy has promoted world peace and abated conflicts. Mutually agreed checks and balances have been found for the global economy, which have helped to decrease cyclic fluctuation.

(15) Finland's national economy has grown steadily. There is a strong belief in Finland that considerable investment in education and research and development can keep the national economy on a good growing track.

(16) The significance of e-business has continuously increased. Making business processes electronic has played a key role in the increased significance of e-business. Electronic commerce is highly significant, especially in b-to-b trade.

(17) Multiculturalism has increased innovation in industrial activities in Finland. The significance of soft values, human skills, and multidisciplinary approaches has clearly increased. Thanks to immigrants, the dependency ratio of Finland has also improved.

Technology and R&D

(18) Compared with 2002, the appreciation of technology has risen and its image improved as technology, instead of traditional smokestack industries, is generally associated with welfare and security.

(19) Thanks to high-standard technological development, Finland is one of the most competitive countries in the world. Plurality has meant bridging the gap between the humanistic and technological cultures. Technological and social innovations have been united. Technological development is perceived to be closely connected with ethical issues and, on the other hand, it is deemed important to promote the development of technology to serve humankind.

(20) Interdisciplinary studies are common in higher education. The share of women in the field of technology has increased to approximately 35 to 40 percent of the students. Increased multiculturalism in Finland has also created prerequisites for innovation.

(21) Investing in research and development is considered very important and its share of the gross national product is 5 to 6 percent. Both undergraduate and postgraduate students commonly work in university research projects. A substantial number of research-based companies are born in universities. The amount of capital investments and know-how in capital investments have rapidly increased in Finland. More money than ever before is used for funding potential innovations of small companies with growth potential.

(22) Co-operation between companies and higher education institutions is close. Networking is perceived as the only alternative for doing top-level international research. Expensive equipment necessary to research and development has also served to bring together different actors. Co-operation between different actors is one of the national competitive advantages of Finland. Networking also internationally has enabled Finland to retain R&D activities within its borders although research groups are often small in international comparison.

(23) Thanks to close co-operation between companies and higher education institutions, movement of staff between universities and companies is common. A model in which a person works part-time at a higher education institution and part-time in the corporate world has also become more common.

The environment

(24) A clean environment without financial gain is a value in itself. The importance of environmental values has significantly increased compared with 2002 and the environment is considered a factor in all human activities. Finnish technologies associated with recycling, waste management, and combating climate change are among the best in the world and an important export item. In addition, environmental technology combined with other technologies plays an important role.

The EU and other international developments

(25) Keeping decision-making as close to those whom it concerns as possible has been a central principle in developing the EU. Furthermore, the expansion of the EU has contributed to the fact that the development towards a federation envisaged in the early 2000s has turned towards a more loosely connected union of states. In addition to economic co-operation, centralized co-operation is carried out in the fields of technology development, security, environmental protection, and combating crime, for instance. Decisions on educational policies are almost completely made at the national level.

(26) China and Russia are new important economic powers in the world. In addition, economic growth in Asian countries, particularly India, has been rapid. Europe has caught up with North America as an economic engine.

(27) How to increase welfare in the Third World has become an important issue. Africa still clearly lags behind the economy of the rest of the world, but turning the development trend in Africa upward has succeeded.

Please rate the probability and desirability of Scenario 3.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 3 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Which paragraph do you feel is the most central to Scenario 3?

Paragraph number:

Does the core item list of Scenario 3 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Do you think Scenario 3 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 3?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 3, I would like to change it as follows:

Scenario 4: Chaos, terrorism, and environmental catastrophes

Core items: atmosphere of fear, terrorism, local and global environmental catastrophes, depression of world economy, states withdraw from the world

Population, culture, and values

(1) Mobility in Europe has decreased dramatically as the fear of terrorism has spread. The EU national states are withdrawing from the world. Prejudices and intolerance towards foreigners are also on the increase in Finland. Concern for the safety of oneself and one's close relatives has brought an atmosphere of fear to everyday life. So far, Finns, however, try to lead their everyday life as before because terrorist attacks have mainly taken place outside Finland.

Settlement in Finland

(2) Although Finland is still felt to be a relatively safe country, the threat of terrorism has affected the attitudes of some people so that willingness to move away from large concentrations of people – mainly the Helsinki metropolitan area – has increased.

Public services and welfare

(3) Because the growth of the national economy has stood still for many years due to global disorder, it has been necessary to cut public social, health, and educational services drastically.

Education

(4) Due to the prolonged weak situation of the national economy, it has been necessary to drastically cut funding to education. This has led to a lowering standard of publicly funded education. Private, fee-charging educational services are also available, from pre-school all the way to continuing education. Tuition fees are a considerable expense for families. The kind of education attainable depends heavily on the prosperity of the family.

(5) Increasing virtual teaching in publicly funded higher education institutions, which are free of charge to the students, is seen most of all as a way of producing degrees at a lower cost. In some fields it is possible to take a higher education degree completely by e-learning.

Economic development and business life in general

(6) Terrorism is markedly common and huge concentrations of people in global centers are felt to be a risk. Due to global disorder, the world economy is very unstable and growth has stopped. As a consequence of the global trend, Finland's national economy is also depressed. Although Finland is still seen as a relatively safe country compared to many other countries, foreign investments in Finland have not grown significantly owing to the general weak state of world economy.

Technology and R&D

(7) Budget funding available for research and development has been drastically cut along with other cuts in the national economy. What remains of public funding is mainly targeted at technology that can help enhance Finland's national security, such as combating bioterrorism and information security technology. In addition, there is considerable demand in the world market for different applications of environmental technology.

The environment

(8) Russia has difficult environmental problems that also affect Finland. In addition, some environmental catastrophes with global impact have occurred in the world, and they have fundamentally changed the way people think. For instance, considerable adverse side effects of climate change have already been observed.

(9) The motive for changing the way of thinking has first and foremost been fear for one's own financial prosperity. There are fears that the world economy will collapse if climate change gets out of hand. In the EU, Finland is a wilderness reserve which still has clean nature.

The EU and other international developments

(10) Terrorism is a serious global problem. The confrontation between different ethnic and religious groups has escalated. Terrorism has many forms. Terrorists have used bioterrorism attacks to cause serious destruction locally. There is continual fear of attacks causing ever more widespread destruction.

(11) Another central form of terrorism that has caused considerable damage to world economy and spread fear among people is the rapid spread of computer viruses and information security break-ins. Developing information security technology has been unable to prevent

the above development.

(12) A united front of the EU and North America attempts to combat terrorism and all kinds of disorder. The idea is that global co-operation is the only chance to succeed in the battle. However, in practice, the withdrawal of countries in the atmosphere of fear causes problems.

Please rate the probability and desirability of Scenario 4.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 4 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Which paragraph do you feel is the most central to Scenario 4?

Paragraph number:

Does the core item list of Scenario 4 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Do you think Scenario 4 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 4?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 4, I would like to change it as follows:

Probability:	Desirability:
1 = highly probable	**1 = highly desirable**
2 = probable	**2 = desirable**
3 = improbable	**3 = undesirable**
4 = highly improbable	**4 = highly undesirable**

2. Finland in 2015 mini-scenarios: Number of people in higher education, expertise as a value in society, and funding of education

Please rate the probability and desirability of the scenarios.

2.1 The number of people in higher education

Scenario 1: A place in higher education is on offer to approximately 40 to 50 percent of an age group.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 2: A place in higher education is on offer to approximately 60 to 70 percent of an age group.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 3: A place in higher education is on offer to approximately 80 to 90 percent of an age group.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

2.2 Expertise as a value in society and funding of education

Scenario 1: Higher education is seen as a subjective right in the welfare information society = universal free higher education for everyone. Higher education institutions only offer free undergraduate studies.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 2: The aim is the highest possible general level of expertise. There is both free and paid higher education. Higher education is seen as a prerequisite of a healthy information society, but is simultaneously a business. There are both privately and publicly funded higher education institutions in Finland.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 3: Expertise is a central value in society, but individuals are always expected to pay part of their higher education. There is partly paid higher education in publicly funded higher education institutions and completely paid higher education in privately funded higher education istitutions.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 4: Higher education is seen first and foremost as a business and, thus, a service to be sold. There are a considerable number of private higher education institutions in Finland. Studies are subject to a charge in both private and mainly publicly funded higher education institutions.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

3. Finland in 2015 mini-scenarios: Investment in research and development

Please rate the probability and desirability of the scenarios.

3.1 R&D funding

Scenario 1: Investment of private funding in R&D increases. Government money goes mainly to education and funding basic research. Investment of private funding in all R&D has increased.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 2: Investment of private and public funding in R&D increase at the same rate. Private and public funding in research and development increase at the same rate and the ratio is at approximately the same level as in 2002, 70/30. By dividing the risk with the public sector, companies are more active in investing in more long-term research projects, which do not directly benefit business in the near future.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 3: The share of public funding in R&D increases. The share of public funding in research and development has increased. Increasing the share of public funding is seen as the only way of preserving sufficient long-term R&D.

The probability of the Scenario 1 2 3 4

The desirability of the Scenario 1 2 3 4

Scenario 4: Investment in R&D does not increase. Investment in research and development has not increased as compared with 2002 on the private or public sector.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

3.2 The share of R&D in the gross national product

Scenario 1: The share of R&D in the GNP is 2 to 3 percent.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The share of R&D in the GNP is 3 to 4 percent.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 3: The share of R&D in the GNP is 5 to 6 percent.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

4. Finland in 2015 mini-scenarios: Appreciation of technology and its image in society

Please rate the probability and desirability of the scenarios.

Scenario 1: Compared with 2002, the appreciation of technology has risen and its image improved as technology, instead of traditional smokestack industries, is generally associated with welfare and security. Plurality has meant bridging the gap between the humanistic and technological cultures. Technological and social innovation have been united.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The appreciation of technology in Finland has remained the same as in 2002. Developing technology is seen as important for Finland's success. However, technology is clearly separate from the humanistic culture and the opportunities provided by social innovations utilizing technology have not been grasped.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 3: Attitudes towards the development of technology are more critical than in 2002. This is because the development of technology is often associated with development of society only serving economic growth. In addition, there are fears of terrorist attacks made possible by technological development.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5. Finland in 2015: mini-scenarios by technology

Please rate the probability and desirability of the scenarios.

5.1 Energy technology

Scenario 1: Development of energy technology provides substantial potential and considerable resources have been invested in developing renewable energy sources in particular. Developing the energy technology of traffic is seen as an important sector in developing energy technology.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: Finland has not deemed energy technology to provide substantial development potential, so there is little willingness to invest in it.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.2 Information and communications technology

Scenario 1: Using and utilizing information and communications technology, the "Internet era" was just beginning in 2002. There has been a tidal wave of development, revolutionizing many activities of society.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The development of information and communications technology has continued in 2002-2015, but at a considerably more even pace than in the 1990s, that is, the speed of development has decreased somewhat compared to the 1990s.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 3: The development of technology was surpassing the human capacity to communicate already in 2002. The limited capacity of people to communicate electronically without personal face-to-face contact has significantly slowed down the development of information and communications technology applications in 2002-2015.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.3 Environmental technology

Scenario 1: The importance of environmental technology has significantly increased compared with 2002. Finnish technologies associated with recycling, waste management, and combating climate change, for instance, are among the best in the world and an important export item. In addition, environmental technology combined with other technologies plays an important role.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: Developing environmental technology provides no substantial potential. Environmental technology has some significance as part of other technologies.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.4 Well-being and health technology

Scenario 1: New potential applications have been discovered in the field of well-being technology, combined with, for instance, information technology, materials technology, and environmental technology. Health technology has helped to develop new services and speed up diagnoses. In international comparisons, Finland is in the forefront of development in developing technological solutions for care services.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: Some new applications have been discovered in the field of well-being technology combined with other technologies. The field of well-being technology does not, however, have considerable potential. The well-being cluster is still only being talked about in 2015.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.5. Biotechnology

Scenario 1: Understanding of bioprocesses has exploded. Biotechnology has grown into a new basis for the national economy. Combining biotechnology and information technology is discovered to have significant new application potential.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The development of biotechnology has been considerably slower than many expected in 2002. Although there is awareness of the fact that biotechnology might provide possibilities, for instance, for preventing and curing many diseases, the images of horror about developing biotechnology have predominated. Indeed, development has been considerably slowed down by fears of what widespread genetic modification might cause, for instance.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.6 Technology related to the forest cluster

Scenario 1: Developing technology related to the forest cluster is seen as a central sector and it has been developed in a versatile way. Thanks to high expertise capital and continuous technological development, the forest cluster is still central to Finland's national economy. In addition to expertise capital, production has also remained in Finland. Well-functioning co-operation with Russia has contributed to the acquisition of raw material.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The significance of the forest cluster to Finland's national economy has clearly decreased compared with 2002. However, Finland still has high-level expertise in the forest industry and it has been possible to keep some production facilities in Finland. Labor-intensive basic industrial production has, however, mainly moved away from Finland after cheaper labor costs.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.7 Technology related to the basic metal cluster

Scenario 1: The significance of the basic metal cluster as an employer and part of the GNP has remained nearly unchanged since 2002. Widespread utilization of information technology and investment in continuous technological development has enabled the volume of the basic industry to grow steadily with the GNP.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The significance of the basic metal cluster as an employer and part of the GNP has diminished since 2002. From the point of view of education, mechanical and metals engineering is not a central sector. The basic metal cluster does not stem from a strong Finnish background as there is no raw material nor strong "workers' culture". The strong focus on high expertise in the Finnish strategy has led to decreased attraction of the branch in the eyes of young people. Basic metal industry production has moved away from Finland in the hope of lower labor costs.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

5.8 Food technology

Scenario 1: Food production has moved away from mass production to emphasize locally produced and organic food. Functional foods are produced on a large scale. People are ready to pay relatively more than in 2002 for high-quality food produced locally. This has opened up new opportunities for Finnish food production.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Scenario 2: The food industry has become increasingly dependent on the international food supply chain. Efficiency in the food supply chain has continued to increase and small units are not able to be competitive. The development of food technology is not seen as important and in general, the food industry is not doing well in Finland.

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

6. Finland in 2015: Claims about the future by technology

Please rate the probability and desirability of the realization of the claims on the following scale:

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.1: Technology related to the building cluster

The building cluster is a so-called maintenance cluster. Although its volume has steadily increased in 2001-2015, its relative proportion of the GNP has diminished.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.2: Technology related to the building cluster

Information and well-being technologies have played a central role in the development of the building cluster. The home has become a user interface to the rest of the world.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.3: Technology related to the building cluster

The building cluster is focused on the domestic market. Some new markets have, nevertheless, opened up in the Baltic region as the Baltic Rim is perceived as a domestic market by the building cluster.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.4: Technology related to the transportation cluster

Transportation is not perceived as a separate cluster in Finland. Instead, transportation is connected to the operations of other clusters as logistics.The production of ships, cars, or rail cars does not play a financially important role in Finland.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.5: Nanotechnology

Nanotechnology has proved a potential technology sector.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.6: Materials technology

Materials technology has proved a highly potential technology sector. The development of materials technology has had a cross-disciplinary impact on other sectors. It has been discovered that the more the development of materials technology utilizes information technology and biotechnology, the more opportunities materials technology offers.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.7: Learning technology

The learning industry is a significant line of business in 2015. Because expertise is the most central factor of production, the efficiency, speed, and price of learning are central factors, influencing which is attempted by developing learning technology.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.8: Energy technology

Energy technology has, to a great extent, moved from large units to decentralized energy solutions. For instance, there are houses that produce their own electricity.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.9: Information and communications technology

Information and communications technology is a tool that integrates to all other sectors. Information and communications technology is widely applied in traditional industries. Information and communications technology plays a central role in developing services in the public sector.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.10: Information and communications technology

As the information and communications technology has developed, the significance of contents and services has significantly increased. Many new models of earning money have been created in business. Customer management is a central issue in business processes.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.11: Information and communications technology

The networking of companies and people made possible by information and communications technology has continued to increase. The end customer side in the information network is closely associated with mobility made possible by technology, providing considerable spatial freedom.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.12: Information and communications technology

Due to information and communications technology, the vulnerability of infrastructure has increased as compared with 2002. Indeed, technology related to information security is an important business branch.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.13: Information and communications technology

Utilizing information and communications technology as an extension of human senses is an important application area.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.14: Information and communications technology

A substantial amount of development resources are invested in the usability of applications utilizing information and communications technology. The significance of social innovations utilizing information and communications technology has clearly increased since 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.15: Biotechnology

Ethical and moral issues have emerged as important factors that are considered when developing biotechnology. The continuous assessment of risks posed by technology is deemed essential.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.16: Biotechnology

The engineering sciences have played an important role in developing biotechnology. Combining, for instance, electronics, theoretical physics, materials technology, and information technology has resulted in developing central biotechnological applications.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.17: Biotechnology

The development of biotechnology has enhanced the quality of living, especially in the Western countries, as anticipating diseases and highly specific medication and therapy have developed. Medication has been discovered for, for instance, impotence, obesity, allergies, and removing various addictions. There are tests, for instance, for determining the risk of contracting diabetes later in life, new ways of diagnosng cancer have been discovered, and softer treatments with fewer side-effects have been developed.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.18: Technology related to the forest cluster

The use of wood as a biological fuel and ecological building material has increased compared with 2002. It has been possible to influence the properties of wood fiber through means provided by biotechnology.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.19: Expertise-intensive services

Expertise-intensive services have proved a central business branch. Expertise-intensive services can be divided into three branches.

- traditional services (e.g. banking, designing, and data processing)

- products that combine an integrated service whole (e.g. elevators)

- new services enabled by telecommunications (e.g. entertainment and health services)

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 6.20: Adventure industry

Much demand has been created in the field of the adventure industry. People are willing to pay for different leisure time experiences related to culture or wilderness adventures, for instance. Opportunities provided by multimedia are widely utilized in the adventure industry.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

7. Claims about Finland in 2015

Please rate the probability and desirability of the realization of the claims on the following scale:

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.1: The importance of non-technological innovations has become significantly more obvious compared with 2002. Innovations related to, for instance, the structure of industry, business ideas, interdisciplinary approaches, and organizatorial matters become more obvious.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.2: The significance of e-business has steadily increased since 2002. Making business processes electronic has played a key role in the increased significance of e-business. Electronic commerce is highly significant, especially in b-to-b trade. Electronic b-to-c trade, for instance, in convenience goods, has progressed more slowly.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.3: Co-operation between clusters has proved highly important for the creation of new innovations. Many new lines of business have been created at cluster interfaces.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.4: It is common in business that nearly all operations outside the core operations have been outsourced.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.5: The significant development of information networks has brought on a wave of small businesses. Inventiveness about how to do business plays a key role. Creating jobs and entrepreneurship have become significantly more common than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.6: In addition to efficiency, impact is becoming increasingly emphasized in developing technologies.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.7: It is essential in business to consider the fact that ethical satisfaction has become an increasingly important value.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.8: The financial importance of adventures and unique experiences has increased significantly since 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.9: Bandwidth per capita is a more important measure than GNP per capita.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.10: The global network economy has become more sensitive to economic fluctuations. Economic cycles are faster and more intense.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.11: Network economy has brought on many new services and courses of action. Operating under big brands has become more common.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.12: Environmental hygiene and recycling are considered central factors in the planning and development of all industrial processes. Environmental aspects are considered in all activities.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.13: Considerable resources have been invested in information technology performance and security. Despite that, infrastructure is more vulnerable than ever as dependency on information technology has continuously increased.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.14: Transnational global decision-making systems have emerged in commercial policy, managing the movement of capital, and environmental protection.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.15: Cultural needs and demand have increased since 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.16: The increasing importance of science and technology in society is inevitable.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.17: Highest possible general level of expertise and free or nearly free higher education are seen as cornerstones of a democratic society. Developing the welfare state and information society side by side is seen as the strength of Finland.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.18: Finland's success is based on a high level of expertise and the development of the appreciation of teaching is a crucial factor for Finland's competitiveness. Appreciation of teaching has clearly risen as compared with 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.19: Higher education has in practice become compulsory education as nearly the entire age group is offered a place in higher education.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Claim 7.20: Due to the higher number of people with higher education degrees, there is greater variation in how demanding the work of college graduates is than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

8. Finland in 2015: Wild cards

Please read the list of possible wild cards below. Pick one or two particularly important wild cards for which you can show an issue or phenomenon already realized, which suggests that the wild card may become a fact. Please note that a wild card can be very important even if its realization is highly improbable if the impact of the wild card would be tremendous.

1. An Islamic revolution starting in the Middle East.
2. Terrorists are able to disrupt the Internet and the world economy collapses.
3. A natural catastrophe in one of the key nations of world trade, which leads to the collapse of world trade.
4. Global environmental catastrophe.
5. A wave of strong opposition to globalization, which results in the rise of nationalism.
6. Explosive spread of HIV in the Western countries.
7. A new, fast-spreading fatal disease that cannot be controlled.
8. Means provided by biotechnology are used for engineering a change in the human genotype with unexpected side effects.
9. Global population explosion.
10. Rapid thinning of the ozone layer.
11. Large-scale war with biological warfare.

Wild card A that I pick is number:

The issue or phenomenon related to wild card A that has already been realized:

Wild card B that I pick is number:

The issue or phenomenon related to wild card B that has already been realized:

APPENDIX 2: QUESTIONNAIRE IN THE SECOND ROUND OF THE ARGUMENT DELPHI: "FINNISH ENGINEERING EDUCATION YEAR 2015"

TOP DECISION MAKERS DELPHI PANEL, ROUND 2: HIGHER EDUCATION IN TECHNOLOGY IN FINLAND IN 2015

Respondent's name:

Respondent's organization:

1. Higher education in technology in Finland in 2015

Broad scenarios: Structure of the education and degree system and the duties of higher education institutions

Scenario 1: New parallel model

Scenario 2: Parallel in theory – overlapping in practice

Scenario 3: Return to the old parallel model

Scenario 4: All higher education institutions become universities

Please read the whole scenario first, then answer the questions at the end of the scenario.

Scenario 1: New parallel model

Core items: administrative merger, clearly different job descriptions and degree profiles, teaching highly appreciated, research results create new companies, universities of technology actively participate in civic debate

The structure of the higher education system

(1) Content-wise, the higher education system is based on a parallel model: universities and polytechnics have different duties in teaching and research. Administratively, the majority of universities (and faculties) and polytechnics providing engineering education have merged.

(2) Enlarging the size of units has proven to be beneficial for organizing research, teaching, and administration. This way, it is believed, the institutions can better survive in the tightening competition of the global educational market. The profiles of the degrees Bachelor of Engineering (polytechnic) and Master of Science in Technology (university) have become quite distinct, as it is quite natural that an administratively merged higher education institution does not provide degree programs with overlapping contents.

The duties of higher education institutions

(3) The aim of universities is to produce new knowledge and expertise in co-operation with business life and society. The aim of polytechnics is to apply the knowledge created at universities and make it available to society at large. Thanks to clear, different aims of universities and polytechnics, co-operation runs smoothly. The administrative merger of higher education institutions has also promoted co-operation in which the operations of the parties complement each other in research, as well as teaching, and unnecessary overlap has been cut.

(4) Teaching has emerged alongside research as a valued activity in universities and faculties of technology. Universities and polytechnics providing engineering education invest significantly more resources in teaching and continuous development of teaching than in 2002.

(5) Compared with 2002, entrepreneurship has a significantly more important role in higher education institutions. Thinking about how new research results can create new business and companies is a central issue. Universities providing engineering education have assumed an increasingly active role in civic debate.

The degree system

(6) The administratively merged polytechnics and universities providing engineering education offer a practically-oriented Bachelor's program (Bachelor of Engineering) and a theoretically-oriented Bachelor's program (Bachelor of Science in Technology). Both degree programs enable the student to apply for Master's –studies at universities (Master of Science in Technology). Some polytechnics that for some reason or other have not merged with a university providing engineering education, offer Master's programs for persons graduated at a polytechnic with the Bachelor of Engineering degree.

(7) Internationally, the Bachelor of Engineering degree compares with the Bachelor of Science in Technology. However, students who have chosen the practically-oriented Bachelor's program (Bachelor of Engineering) must take 20 credits of supplementary studies if they wish to apply for Master's studies at universities (Master of Science in Technology).

(8) Those with a Master's level degree (Master of Science in Technology) can apply for doctoral studies. In addition, many universities have a separate researcher training program leading directly to a Doctor's degree. Applying for these programs is possible directly after taking the Bachelor of Science in Technology degree. The degree between Master and Ph.D., Licentiate degree, still in the degree system of 2002, has been abolished.

Please rate the probability and desirability of Scenario 1.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 1 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Which paragraph do you feel is the most central to Scenario 1?

Paragraph number:

Does the core item list of Scenario 1 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Do you think Scenario 1 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 1?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 1, I would like to change it as follows:

Scenario 2: Parallel in theory – overlapping in practice

Core items: co-operation between higher education institutions necessary though difficult, no clear division of tasks, degree profiles close to one another, degrees partly directly comparable, universities of technology value research more than teaching

The structure of the higher education system

(1) Polytechnics and universities providing engineering education operate as partly parallel, partly overlapping systems. Polytechnics have attempted to gain status by making their degrees directly comparable to university degrees.

(2) Increasing co-operation between higher education institutions has been deemed necessary because competition in the global educational market has become fiercer. However, similar profiles of polytechnics and universities providing engineering education hamper co-operation.

The duties of higher education institutions

(3) In theory, universities and polytechnics have different aims and duties. However, in practice, the role division has become blurred. Basic research is the duty of universities, but, in practice, some polytechnics endeavor to engage in basic research in addition to applied research. The situation is made even more confusing by the fact that applied research is anticipated to offer so much business potential that some universities focus clearly more on applied research than basic research.

(4) The practical nature of polytechnic studies has decreased compared with 2002. As the theoretical emphasis of the content of undergraduate studies at universities and faculties of technology has not increased, the content of a Bachelor of Engineering degree is beginning to resemble that of a Bachelor of Science in Technology -degree.

(5) Teaching is not as highly appreciated an activity at universities as research. This has contributed to the slow development of teaching in universities.

The degree system

(6) Polytechnics offer Bachelor's degrees (Bachelor of Engineering) and Master's degrees. The Bachelor of Engineering -degree is comparable to a Bachelor of Science in Technology -degree. If students who have taken a Master's degree at a polytechnic wish to obtain the degree of Master of Science in Technology, they have to supplement their studies with 20 credits at a university and write a Master's thesis.

(7) Bachelor of Science in Technology is the typical first degree in universities. The majority of students, however, continue their studies to become Masters of Science in Technology. Postgraduate students aim at a Doctor's degree as the Licentiate degree no longer exists in the degree system.

Please rate the probability and desirability of Scenario 2.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 2 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Which paragraph do you feel is the most central to Scenario 2?

Paragraph number:

Does the core item list of Scenario 2 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Do you think Scenario 2 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 2?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 2, I would like to change it as follows:

Scenario 3: Return to the old parallel model

Core items: polytechnics heavily practically oriented, from polytechnics with several fields of study to polytechnics of technology, degrees are not comparable, in universities of technology teaching valued secondary to research, engineers a quiet profession in society

The structure of the higher education system

(1) Polytechnics and universities providing engineering education operate as parallel systems. The structure of higher education has taken a step backwards. Polytechnics providing engineering education are mostly separated from multidisciplinary polytechnics. Their operations markedly resemble the engineering colleges that existed before the polytechnic reform.

The duties of higher education institutions

(2) Universities and polytechnics have different fields of duties. Teaching in polytechnics has a heavy practical orientation. The service function is central in that polytechnics engage in applied research in close co-operation with enterprises.

(3) The operations of universities emphasize research. Basic research and applied research are carried out side by side. Teaching is secondary to research. This is clearly obvious in, for instance, recruitment criteria, investments in undergraduate teaching and the development

of teaching.

(4) On the societal level, engineers are a silent profession. Representatives of universities providing engineering education do not actively participate in civic debate.

Degree system

(5) Polytechnics concentrate on providing practically-oriented studies aiming at the Bachelor of Engineering degree. Bachelor of Engineering studies offer the opportunity to take the intermediate degree of a technician. In addition, polytechnics provide continuing education.

(6) Those with the Bachelor of Engineering degree who wish to continue their studies in the field of technology mostly apply to universities. Universities compensate approximately 70 to 90 credits for the Bachelor of Engineering degree, depending on the case, if a student wishes to study for the Master of Science in Technology degree. Degrees taken in polytechnics in the field of technology are not comparable to university degrees.

(7) The majority of engineering students in universities take Master of Science in Technology as their first degree. There is also the Bachelor of Science in Technology degree, but only few students want to take it as an intermediate degree. Postgraduate degrees provided by universities are the licentiate and doctorate.

Please rate the probability and desirability of Scenario 3.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 3 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Which paragraph do you feel is the most central to Scenario 3?

Paragraph number:

Does the core item list of Scenario 3 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Do you think Scenario 3 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 3?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 3, I would like to change it as follows:

Scenario 4: All higher education institutions become universities

Core items: all higher education institutions become universities, no division of duties between polytechnics and universities, decentralization of resources, first degrees and postgraduate degrees available in all universities, degrees directly comparable

The structure of the higher education system

(1) Polytechnics and universities providing engineering education operate as an overlapping system. All higher education institutions have become universities. It is possible to take Bachelor's and Master's degrees in the field of technology in approximately 30 higher

education institutions in Finland.

The duties of higher education institutions

(2) There is no division of duties between universities and polytechnics in the field of technology. The lack of division of duties has made co-operation more difficult, as everybody competes for the same resources. Furthermore, the decentralization of resources has weakened the international competitiveness of the Finnish engineering education.

(3) Both universities and polytechnics are engaged in basic research in technology. Both also engage in applied research. Differences in engaging in basic or applied research are more dependent on the individual higher education institution than general differences between polytechnics and universities. It is impossible to define on a general level the difference in duties of universities and polytechnics in research and teaching.

Degree system

(4) Polytechnic students commonly take Bachelor's and Master's degrees, which are directly comparable to degrees taken at universities (Bachelor of Science in Technology = Bachelor of Engineering and Master of Science in Technology = Master of Engineering). It is also possible to take a Doctor's degree in some polytechnics.

(5) Bachelor of Science in Technology and Master of Science in Technology are the first degrees in universities.The licentiate and doctorate are the postgraduate degrees.

Please rate the probability and desirability of Scenario 4.

Probability:

1 = highly probable

2 = probable

3 = improbable

4 = highly improbable

Desirability:

1 = highly desirable

2 = desirable

3 = undesirable

4 = highly undesirable

The probability of the Scenario	1	2	3	4
The desirability of the Scenario	1	2	3	4

Would you like to add an item to the list of core items for Scenario 4 given in the beginning of the Scenario? If yes, which item or word would you like to add?

1 No.

2 Yes, I would like to add:

Does the core item list of Scenario 4 include an item that you feel is not among the central items of the Scenario and that you would like to remove from the list? If yes, which item would you like to remove?

1 No.

2 Yes, I would like to remove:

Which paragraph do you feel is the most central to Scenario 4?

Paragraph number:

Do you think Scenario 4 contains an irrelevant or otherwise inappropriate paragraph that you would like to remove? If yes, how do you think the paragraph should be changed to make it relevant to Scenario 4?

1 No.

2 Yes, I would like to remove paragraph number:

In order to make the paragraph relevant to Scenario 4, I would like to change it as follows:

The following sections, 2 to 12, present **claims related to higher education in technology in 2015** from different sectors. Please first read the claim and the related points and reasons which possibly emerged in the interviews. Then give your **assessment of the probability and desirability of the claim** on the following scale:

I feel the realization of the claim is	1 probable	2 improbable
I feel the realization of the claim is	1 desirable	2 undesirable

If you so wish, you can **add reasons** for your opinion to the end of the "Reasons" section.

2. Higher education in technology in 2015: Educational system

Claim 2.1: Universities and faculties of technology concentrate significantly more than in 2002 on generic technologies and developing new technologies. Polytechnics mainly concentrate on teaching existing technologies.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- The different roles of universities and polytechnics in the educational system have led to clearly different profiles in research and teaching.

Claim 2.2: The universities and faculties of technology are expected to assume a significantly more active role in civic debate than in 2002.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Knowledge and expertise are the most important factors of production in society.

- Technology plays a key role in, for instance, solving environmental protection issues. Technology can promote sustainable development.

Claim 2.3: There are some private universities in Finland with technology as one field of study.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Finland's strong image as a high-tech country has increased the willingness of foreign universities to establish a unit in Finland.

- Finland's educational market cannot be a separate island in the global educational market, which also offers undergraduate studies subject to a charge.

Claim 2.4: Some of the polytechnics and universities offering higher education in technology offer many fields of study while others concentrate on teaching and research in the field of technology.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

3. Higher education in technology in 2015: Degree system and student selection

Claim 3.1: The Licentiate degree has been abolished from the degree system.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- A Licentiate degree has no place in international comparisons.

Claim 3.2: Internationally, the polytechnic engineer degree is comparable to a Bachelor of Science in Technology degree from a university or faculty of technology.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 3.3: Internationally, the polytechnic engineer degree combined with a postgraduate degree from a polytechnic is comparable to a Master of Science in Technology degree from a university.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 3.4: Bachelor of Science in Technology is primarily an intermediate degree in studies aiming at a Master of Science in Technology degree. Its primary aim is not qualifying for the labor market, although some students do not immediately continue their studies to a Master of Science in Technology degree.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 3.5: The student intake of universities and faculties of technology is for the Bachelor of Science in Technology degree. There is a separate selection process for the Master of Science in Technology programs.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 3.6: There are no separate entrance examinations for the Bachelor's degree in the field of technology. Student selection is mainly based on high school grades. In addition, students are admitted by special selection processes.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Abolishing entrance examinations has been proven to shorten the interval between high school and college studies. This way, students graduate younger than before.

Claim 3.7: Student selection to first-degree studies in universities and faculties of technology is not by department as in 2002. Departments are grouped into larger units for the student intake. ICT, process engineering, or design, for instance, can be such alternatives. Departments and degree programs are chosen one to two years after studies begin.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 3.8: The Bachelor's and Master's degrees are significantly more often from different fields of study than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 3.9: Double degrees, or taking two Master's degrees in different EU countries, have become significantly more common than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 3.10: Compared with 2002, how highly a degree is valued depends much more on the university that granted it.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 3.11: How much a university degree in technology is valued varies greatly depending on the university that granted it. The department, degree program, or research group also affect the value of a degree.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- The rapid increase in the number of degrees has affected the value of university degrees.

- The fact that universities have increasingly high profiles in their own areas of expertise is apt to promote the significance of the university that grants the degree.

- If there will be more units than in 2002 that have the right to confer Master of Science in Technology degrees, it will be increasingly significant where the degree was granted.

- I'm afraid that the variety of degrees will increase so much that in the future it will be the identity of the school that guarantees quality.

Claim 3.12: The value of expertise has increased at the expense of the value of degrees. Degrees are still valued, but the appreciation has diminished compared with 2002. It is necessary for everyone to document their expertise and how it has been continuously upgraded.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- The significance of continuously developing one's skills and expertise will become increasingly important. Having a first degree does not guarantee that people have continuously updated their skills and expertise. Appreciation is crystallized in expertise – some have a degree, some do not.

- Degrees will still be valued alongside expertise, because a degree proves that the person is capable of achieving something in a set time. This is important as there will be more and more project work.

Claim 3.13: Taking a degree in as short a time as possible is not considered a value as such in the field of technology. Short studying times are appreciated but, on the other hand, gaining work experience during studies is considered equally important.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

4. Higher education in technology in 2015: Regional offering and profile building

Claim 4.1: University level higher education in technology is threatened by fragmentation. Several universities have applied for the right to confer Master of Science in Technology degrees and some rights have already been granted.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- The general opinion is that research in the field of technology requires a sufficiently large mass, provision of teaching must be extensive enough for students – also for interdisciplinary studies between different fields of technology – and small units find it hard to succeed in the increasingly stiff international competition. Regional policies, however, create pressures to grant more rights to confer degrees.

Claim 4.2: Tougher competition in the education market, together with increasingly popular e-learning, has forced higher education institutions to network and considerably increase their co-operation with other Finnish and foreign higher education institutions.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 4.3: The universities and faculties of technology have more significant differences in emphasizing research or teaching than in 2002.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 4.4: Tougher competition in the education market has forced higher education institutions in the field of technology to specialize.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- It is especially important when there is much co-operation that educational establishments have clear profiles of their own. Otherwise there are fears that the schools are doing the same thing and competing with each other.

- Research requires a critical mass.

Claim 4.5: The specialization of higher education institutions applies more to universities and faculties of technology than polytechnics, because the central aim of polytechnics is to serve their region. This means that they must offer studies in nearly all of the commonest fields of technology.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

5. Higher education in technology in 2015: The EU and international competitiveness

Claim 5.1: As a rule, higher education institutions decide about the content of their studies independently. Preserving diversity is deemed important because it is believed to be the only way to succeed in the fiercely competitive international education market.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 5.2: Compared with 2002, education has become much more of a business. This development has contributed to tougher competition and the need for higher education institutions to profile themselves. Many Finnish polytechnics, universities, and faculties of technology have joined in large global higher education consortia. Some educational brands considered superior have emerged.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Education is one of the fastest growing industries. Competition is becoming tougher and global education consortia hold their own in the competition.

- Companies must be offered larger education packages and wholes than in 2002. The one stop shop: education providers must be able to provide a network in Finland, as well as internationally.

- Outsourcing education is easier for global companies if there are global educational consortia.

- It is important to keep up the international network. The problems and requirements of education have many global similarities.

- International consortia enhance the standard of teaching materials.

- Co-operation with internationally renowned universities aims at gaining status.

- Brands are very important, particularly in continuing education, but also in undergraduate and postgraduate studies.

Claim 5.3: In Finland, the content of studies is decided at the national level and in the educational establishments, while the structures of the educational system, including degree structure, are largely uniform in the EU.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- The EU Ministers of Education want to learn from each other and set shared goals in the Bologna Process. The decision-making powers in educational policies are not being transferred away from the national level.

- It has been noticed that harmonizing educational structures facilitates comparing degrees and, thus, mobility within the EU Member States. Whereas there has been little desire to harmonize the content of studies because it is deemed that different educational profiles allow the needs of the labor market to be better met and consequently help promote the competitiveness of the EU.

- Educational policy is so bound with local culture and the labor market that it has not been deemed sensible to make educational policy transnational as regards the contents of studies.

- Compared with 2002, differences within the EU in industrial structures and cultures have further increased when new Member States have joined the EU. Consequently, controlling educational policy at the EU level has become more difficult than ever.

Claim 5.4: Compared with 2002, many Finnish higher education institutions have to compete harder for students. For many Finnish students interested in the field of technology, pursuing studies at a foreign university is a realistic alternative.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

6. Higher education in technology in 2015: Planning and developing education

Claim 6.1: Follow-up and feedback systems have been improved considerably in higher education institutions in the field of technology. Special attention has been given to utilizing feedback more systematically and efficiently than before.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- A comprehensive feedback system is a prerequisite of continuously improving quality.

- As the criteria for performance-based management in higher education institutions become more extensive, the follow-up and feedback systems of education must also evolve.

- Educational establishments have wanted to improve monitoring the progress of studies to cut down dropout rates and shorten studying times.

- Co-operation with business life has been improved by taking feedback from business life better into account in developing education.

- Feedback from the alumni is utilized more extensively than before in the development of education.

- Information technology can be widely utilized in collecting and analyzing feedback.

Claim 6.2: The Finnish Association of Graduate Engineers TEK and the Union of Professional Engineers in Finland play a key role in developing follow-up and feedback systems for education in the field of technology.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 6.3: No pan-European accreditation system of higher education has been created. The accreditation of higher education in Finland means that the Ministry of Education grants the right to confer degrees.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- As long as the Ministry of Education grants the rights to confer degrees, there is no need for a separate accreditation system in Finland. A pan-European accreditation system would add bureaucracy in higher education institutions without bringing corresponding benefits to the development of education.

Claim 6.4: Quality assessment of education has increased considerably compared with 2002. National quality assessment systems are compared and partly harmonized, but no pan-European quality assessment criteria for higher education in technology have been created.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- The need for education quality assessment has increased with the commercialization of higher education. However, it has not been deemed necessary to create a pan-European set of quality criteria, for instance, because there are such national differences in cultures and the needs of the labor market. An important part of assessment is based on self-evaluation by the higher education institutions.

Claim 6.5: Higher education institutions in the field of technology have systematically invested in anticipating educational needs. Higher education institutions also take initiatives in developing the content of studies. The development is not solely based on feedback from the business life on what is considered important at a given time.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 6.6: Responsibility for anticipating educational needs in the field of technology has continued to shift to the higher education institutions. Centralized anticipation of educational needs carried out by the Ministry of Education is deemed necessary, but completely insufficient alone.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 6.7: Polytechnics in particular must be able to respond to the changing needs of business life faster than in 2002 as regards the content of studies and number of students.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

- Education provided by polytechnics must be practically oriented. Being able to make decisions quickly is an absolute prerequisite for successful operations. Continuing education, in particular, should be able to provide new training very fast. When the training has been "tested" in continuing education, it can be adopted in undergraduate studies if necessary.

7. Higher education in technology in 2015: Number of students and foundations

Claim 7.1: Student intake to universities and faculties of technology is approximately at the same level as in 2002.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 7.2: Although student intake to universities of technology directly from high school has not increased much, the number of Master's degrees in technology has grown 50 percent compared with 2002. The main increase in the number of degrees results from polytechnic engineers who have wanted to continue their studies in a university or faculty of technology.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 7.3: Upgrading studies and Master's programs to graduates with some other degree than Bachelor of Science in Technology have become considerably more common since 2002.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 7.4: Postgraduate studies in technology have become significantly more common than in 2002. Approximately 15 to 20 percent of Masters of Science in Technology go on to take a doctoral degree. In some universities and faculties of technology the share of Masters who go on to a doctorate approaches 30 percent.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- The more important production factor knowledge becomes, the more postgraduate students are needed.

- It has been considered important for the technological development of Finland to increase the number of students in doctoral studies in the field of technology.

- Because technology is becoming more complex, it is essential that in the future there will be more technology professionals interested in research than in 2002.

- Doctors increasingly find employment in other places besides universities.

- The heavy increase in the volume of Master of Science in Technology education has increased the desire to stand out from the mass with a postgraduate degree.

Claim 7.5: Women's share of technology students is approximately 35 to 40 percent.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Interdisciplinary studies have increased women's interest in careers in the field of technology.

- The image of technology has become wider to encompass not only machines but also uniting technology and social innovations. As a result, technology is no longer felt to be solely a male domain.

8. Higher education in technology in 2015: Content of studies

Claim 8.1: The professional content of the degrees of Master of Science in Technology and engineer has become wider and the content of the degrees is increasingly individual. As a result, the professional identity of Masters of Science in Technology and engineers has changed and become more varied.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 8.2: Preserving the professional identity of Masters of Science in Technology and engineers is more difficult than in 2002, but it is considered very important.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Preserving the professional identity of Masters of Science in Technology and engineers is a critical issue, because professionalism begins with being a member of a group. The engineer identity is a central issue, because it is the basis for morals and ethics. In fact, the entire profession will disappear without a shared identity.

Claim 8.3: Organizations and associations in the field play a key role in preserving the professional identity of Masters of Science in Technology and engineers.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

Claim 8.4: There is a greater need for individual solutions in the content of studies and ways of studying in higher technology education than in 2002.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Studying becomes more efficient when the content and methods of studies can be better tailored to suit individual needs.

- The diversity (background education, age, situation in life) of students is continuously increasing.

Claim 8.5: The provision of courses in English has increased considerably compared with 2002. It is possible to take undergraduate and postgraduate studies entirely in English in nearly all polytechnics, universities, and faculties of technology.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.6: Studies consist of modules. A degree in technology consists of studies taken in several different higher education institutions significantly more often than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- When the studies consist of modules, it is easier to compile a degree of studies in several different higher education institutions.

- Studies consisting of modules are able to faster respond to the changed needs of expertise.

Claim 8.7: Entrepreneurship has become more prominent in the content of studies in higher technology education compared with 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.8: Environmental values have become more prominent in the content of studies in higher technology education compared with 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.9: Ethics have become more prominent in the content of studies in higher technology education compared with 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.10: An interdisciplinary approach within the field of technology has become significantly more common than in 2002, in both higher education and research in technology.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.11: An interdisciplinary approach between the field of technology and other disciplines has become significantly more common than in 2002, in both higher education and research in technology.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- A significant number of new inventions are made along the borders of different sciences. Systemic thought and teamwork are essential.

- The concept of technological development will become more extensive to also encompass uniting technological and social innovations.

- If students only interact with students in the same field, problems will later emerge in co-operation in a work community.

Claim 8.12: Compared with 2002, undergraduate studies in universities and faculties of technology emphasize a solid foundation in mathematics, science, and information technology combined with a wide-ranging general education. The amount of in-depth specialist studies in technology has decreased in the undergraduate studies of most students.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- A solid, wide-ranging foundation in skills and expertise is the only way to guarantee an individual's capability and opportunities for continuous development of one's skills and expertise.

- Many fields of technology do not exist when a student is in college vs. *ten years later in his or her career. Thus, the essential thing is that the foundation is solid, enabling the person to learn new things.*

- The fact that anticipating educational needs is difficult emphasizes the importance of a solid foundation.

- Students must learn the basics that will not change soon even though the development of technology is fast.

- The need for real generalists will increase.

Claim 8.13: Although the majority of students choose a wide-ranging option in their undergraduate studies, the contents of studies, significantly more flexible than in 2002, enables the students to choose an in-depth specialist education in the field of technology if they so desire.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Top specialists are always in demand in the field of technology.

Claim 8.14: The content of studies for polytechnic engineer degrees has not been made more wide-ranging to the same extent as is the case for Bachelor of Science in Technology and Master of Science in Technology degrees. The education of polytechnic engineers has been made more wide-ranging primarily through teaching methods, such as project learning.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.15: The continuously expanding degree requirements in undergraduate studies in technology have been limited in order to avoid the lengthening of studying times. Specialist studies have been increasingly transferred to postgraduate and continuing education.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.16: The degree of a Doctor of Science in Technology can include parts that have been taken elsewhere as continuing education, such as an MBA degree.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.17: More "generalist doctors" will be needed in the field of technology than in 2002. They have in-depth knowledge of how to conduct scientific research and they can apply their knowledge in several fields.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 8.18: Research carried out for a doctoral thesis in technology is increasingly connected to a day job in the corporate world.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

9. Higher education in technology in 2015: Learning environment

Claim 9.1: Distance learning has increased radically in the entire educational chain from elementary school to continuing education.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.2: It is possible to complete 30 to 50 percent of higher education courses in technology by virtual learning without actually being on campus.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.3: As a result of strongly increased virtual learning, universities of technology have built a considerable number of premises suited to distance learning on their campuses. Students use these premises to study virtually, yet simultaneously have face-to-face contacts with each other.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- The social aspect is so central, especially to undergraduate studies, that the students do not want to study mainly alone in their dorms even though it would be possible technically.

- Interaction plays a central role in learning. Brainstorming and team work, for instance, are important ways of learning, which would not be possible if all studies took place as distance learning off campus.

Claims 9.4 (9.4.1-9.4.5): Virtual university – as a result of development in the field of technology…

Claim 9.4.1: Co-operation between higher education institutions has increased considerably.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.4.2: Higher education units have merged administratively to form larger wholes.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.4.3: The courses offered by all Finnish higher education institutions are available to all Finnish university students, as well as those of many foreign universities.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.4.4: The quality of teaching materials has improved.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.4.5: Higher education institutions have profiled themselves much more clearly in their own areas of strength than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.5: Teaching offered by Finnish virtual university and polytechnic is subject to a charge outside Finland.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.6: The study counseling system has developed considerably compared with 2002. Despite the relatively large student to teacher ratio, utilizing information and communications technology, for instance, in student supervision (e-supervision) has improved the supervision. Peer supervision is utilized more systematically than before. Study counseling also includes career counseling.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Information technology provides opportunities to personally supervise a larger number of students per teacher than just supervising face-to-face.

- The performance-based management system encourages making monitoring the progress of studies more efficient as attempts are made to make studies more efficient.

Claim 9.7: The improvement of the supervision system has produced positive results in the form of reduced dropout rate and shorter studying times. Motivation to study has improved.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.8: In polytechnics of technology, a company can be the learning environment of approximately 40 to 50 percent of studies. The corresponding share in universities and faculties of technology is approximately 25 to 30 percent.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Close co-operation with the business life is central to the development of education.

- Study times can be shortened by enabling flexible ways of studying.

- The need for learning in companies is continuously growing. Degree-oriented staff training is facilitated by the fact that the learning environment of higher education studies can be a company.

- Learning in companies has brought more interdisciplinary aspects to higher education without reducing the amount of advanced studies much.

Claim 9.9: Sandwiching studying and working is common in the field of technology. Higher education institutions have made the provision of courses and study methods more versatile so that from the third year onwards, in particular, it is possible to carry out studies in a very flexible way.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Gaining practical work experience is deemed so important in the field of technology that studies are designed so that they can be carried out alongside work.

Claim 9.10: Appreciation of teaching merits has significantly increased in higher education in technology compared with 2002. Good research merit alone is not enough to be appointed to posts including teaching duties.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.11: Teaching has emerged alongside research as an equally valued activity in universities and faculties of technology.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 9.12: Competition for students has not only increased competition between higher education institutions offering higher education in technology, but also within educational establishments. Competition between teachers has become stiffer because the quality of teaching is used as a means of competing for students.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons

10. Higher education in technology in 2015: Continuing education and lifelong learning

Claim 10.1: The share of e-learning is greater in continuing education in technology than in undergraduate studies.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- People studying in continuing education usually have already established their social networks and e-learning can be applied more easily.

Claim 10.2: Continuing education in technology is more degree oriented than in 2002, for instance, through increasingly common Personal Development studies. However, creating a formal degree structure for continuing education has not been deemed necessary. Instead, the primary focus has been on developing the documentation of skills and expertise.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Skills and expertise and developing them are valued more in the labor market than degrees.

- The continuing education needs are so individual that degree structures have not been deemed necessary. Accomplishing different modules oriented towards working life is deemed more meaningful and useful.

- Learning on the job is a central part of continuing education. Fitting that into some degree structure is not meaningful.

Claim 10.3: Quality assurance in continuing education in technology has increased.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 10.4: The continuing education market in technology has grown significantly since 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 10.5: Higher education institutions of technology have committed their alumni to a process of continuous learning through continuing education. This also provides systematic feedback from the business life to develop education.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Continuous development throughout one's career is essential to all professionals in the field of technology. Because continuing education provides an opportunity for profitable business, higher education institutions are willing to commit their alumni to acquiring continuing education through their own higher education institution.

- It is also hoped that the alumni will have an indirect positive influence in increasing funding from the corporate world.

Claim 10.6: Companies are outsourcing the majority of their training and continuing education has become an important means of raising funds for the higher education institution and, thus, partly fund undergraduate studies.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 10.7: Higher education institutions must be able to clearly tell what abilities their continuing education provides or promotes.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Companies will not outsource their training services if they cannot estimate clearly how buying the training services benefits their business.

Claim 10.8: Considerably more commitment and resources than in 2002 are required of companies to offer their staff opportunities for educating themselves.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- When knowledge and skills have become a crucial factor of production, companies are ready to pay for it the same way as for machinery and equipment, for instance. The education budget is seen as an investment.

Claim 10.9: Companies finance most continuing education. Individual people finance continuing education to a certain extent, but the state only a relatively small share. The financial responsibility of the state for higher education focuses on undergraduate studies. Continuing education mainly operates on the terms of the free market economy.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Subventions to continuing education distort competition.

- The necessary government investments in undergraduate education increase so much that continuing education must be mainly self-financing.

11. Higher education in technology in 2015: Administration, funding, and steering system

Claim 11.1: The performance-based management criteria of universities and polytechnics have become increasingly similar compared with 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 11.2: Criteria measuring the quality of education, such as employment after graduation, are significantly more important than in 2002 in performance-based management.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- If funding is mainly based on the number of degrees, universities cannot invest enough in the quality of education.

Claim 11.3: The financial autonomy of universities has increased. As a result, competition between universities has increased and universities and faculties of technology have clearly profiled themselves in their own fields.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 11.4: Compared with 2002, a significantly higher number of professors in universities and faculties of technology are fixed-term.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Fixed-term professorships allow flexibility in reallocating professorships between different fields.

- Thanks to fixed-term professorships, only those who do their job well stay in their posts.

Claim 11.5: Degree programs are the focal point of the organization of higher education institutions from the point of view of teaching. Interdisciplinary approaches in degree programs between both different branches of technology and other disciplines have become significantly more common compared with 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Interdisciplinary degree programs crossing departmental borders are much easier to implement when degree program administration is separate from the departments.

Claim 11.6: Strategic leadership in degree programs has been strengthened compared with 2002. The head of the degree program can replace a teacher if he or she continually receives bad course evaluations from the students.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 11.7: The rector is most of all a career executive It is not uncommon that a rector of a university of technology comes from outside the university.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- The duties of a rector lay heavy emphasis on wide stakeholder co-operation.

- The most important development areas of the university in the next few years, such as the need for expertise in financial matters, human resources, reform, or innovation are emphasized in the choice of a rector.

Claim 11.8: The Council of the university is a strategic body with wide-ranging visions. Approximately one third of the Council consists of stakeholders outside the university, such as the corporate world.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 11.9: Higher education institutions have the opportunity to charge tuition fees from all undergraduate, postgraduate, and continuing education students, if they so wish.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Private higher education institutions will be established and publicly funded higher education institutions feel it essential that they are able to compete with private institutions on the same terms.

- When charging fees by higher education institutions is possible, they can recruit even large numbers of foreign students if they so wish, because foreign students pay for their education.

- It will be easier to create European higher education programs with several universities or polytechnics participating when it is possible to charge students tuition fees.

- Including a fee paid by students in the funding of higher education is seen as providing an opportunity to shorten the time it takes to complete a degree.

Claim 11.10: Thanks to a wider financial autonomy and financial base, higher education institutions are able to pay better salaries for teaching in particular and are thus able to compete for highly skilled labor with industry better than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

12. Higher education in technology in 2015: Stakeholders

Claim 12.1: Stakeholder co-operation has increased considerably compared with 2002. There are more co-operation partners.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Closer stakeholder co-operation is important to a well-functioning planning, follow-up, and feedback system.

- Stakeholder co-operation is crucial for higher education institution funding, which must be gathered from several sources.

- The entire health care sector is a new, important stakeholder compared with 2002.

Claim 12.2: Co-operation between higher education institutions in the field of technology has increased considerably since 2002. Both teaching and research is networked. Polytechnics and universities in the field of technology also co-operate more closely.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Small units are not competitive alone. Operating in networks improves the quality of teaching and research.

- The demands and problems of education are largely the same, also globally.

Claim 12.3: Co-operation between higher education institutions in the field of technology and the corporate world has increased considerably since 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

- Co-operation in research has increased. Many of those with a doctor's degree work for the corporate world.

- Most students in higher education combine working and studying. It is possible to do approximately half of the polytechnic studies and a quarter of the university studies with a company as the learning environment.

- Higher education institutions receive an important part of their funding from the corporate world in 2015.

- The continuously increasing need for continuing education by companies has made co-operation with polytechnics and universities of technology closer.

Claim 12.4: Co-operation in teaching and mobility of staff between higher education institutions and the corporate world has increased. Compared with 2002, teaching in higher education institutions in the field of technology is increasingly given by senior corporate employees who are about to retire and who are interested in and capable of teaching.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 12.5: Companies not only finance applied research, but also basic research significantly more than in 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable 2 undesirable

Reasons:

Claim 12.6: A customer-oriented approach in the operations of higher education institutions in the field of technology has increased considerably since 2002.

I feel the realization of the claim is

1 probable 2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- The buyers of educational services, whether private students or companies, have improved their bargaining position as the competition in the education market has become tougher.

Claim 12.7: A substantial number of research-based companies are born in universities and faculties of technology.

I feel the realization of the claim is

1 probable   2 improbable

I feel the realization of the claim is

1 desirable   2 undesirable

Reasons:

- Thinking about how to benefit financially from the knowledge available at higher education institutions is a central issue.

APPENDIX 3: THE DELPHI METHOD

The Delphi method can "be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem."(Linstone & Turoff 1975, 3). It does this by identifying the underlying reasons for different opinions, rather than aiming at high statistical validity with a large respondent group. With the Delphi method, it is possible to convert expert opinion in a case where no one right answer exists.

The Delphi method is not a tool for decision making, but rather a procedure mapping different aspects and options for considerations before decision making (Turoff 1975, 80; Bell 1997, 272). Gordon (2009a, 4, 11 - 12) phrases the value of the Delphi method as follows: "The value of Delphi rests with the ideas it generates, both those that evoke consensus and those that do not. The arguments for the extreme positions also represent a useful product… Does the method produce an accurate view of the future? It is no more accurate, probably, than any expert, single or composite. But suppose we wanted to form a scenario based on expert views of what might be possible. Or suppose we needed a judgment about whether or not we could mount a manned Mars mission and if so, how. Or suppose we wanted to explore the range of future events that could affect population growth or weaponry or war. No better way exists to collect and synthesize option than Delphi."

Anonymity is one of the key features of the Delphi method (Linstone & Turoff 1975; Woudenberg 1991; Kuusi 1999, 2003). Kuusi (2003, 220) suggests that anonymity of participants concerns only the argumentation phase of the study. There is no obstacle for face-to-face discussion after presenting argumentation first in the anonymous process. And moreover, in order to motivate participants for the study, Kuusi (2003, 220) proposes informing the participants of the make-up of the panel before the study, although actual argumentation is anonymous.

When applying the computer-based Delphi study, Hiltz & Turoff (1993, 32) encourage the use of pennames instead of complete anonymity. They argue that the advantage of pennames over anonymity is that participants can address a reply to a penname, but you cannot send a message and discuss with "anonymous".

A Delphi study consists of four phases: exploring the subject under discussion, reaching an understanding of how group views the issue, bringing up underlying reasons for disagreements, and final evaluation (Linstone & Turoff 1975, 5 – 6). The research process, when applying Argument Delphi in this study is discussed in Chapter 3.2.2.

The Delphi method was first applied in the US defense community in RAND corporation in the early 1950s (Linstone & Turoff 1975). Gordon & Helmer (1964: In: Linstone & Turoff 1975) brought the Delphi method outside the defense community. The original applications of Delphi emphasized it as a method for finding consensus of experts and implemented it as a series of questionnaires. The name of the method was drawn humorously from the region of the Greek oracle at Delphi where "experts of the future" of that time, necromancers, foretold the future using hallusinogenic vapors and animal entrails (Kuusi 1999, Gordon 2009a).

The reasoning behind the development of the Delphi method is two-fold (Linstone & Turoff, Gordon 2009a). First, experts - particularly when they agree - are more likely to be correct about questions in their field than non-experts. Second, face-to-face communication makes challenges of group conformity pressures surface (Asch 1952), and therefore, there is a need for an anonymous group communication method converting expert opinion.

The critique of Sackman (1975) had a profound effect on the development of the Delphi method (Kuusi 1999, 2003). The general common features of the Delphi method are still anonymity, iteration and feedback (Woudenberg 1991), but most of the researchers applying the Delphi method no longer seek consensus between experts but different views of the future development supported by argumentation (Kuusi 2003, 210). For example, Turoff (1975, 80) points out that when applying Policy Delphi, due to the selection of the respondent group and structure of communication, it is unlikely that the respondents reach consensus, and it is not an objective either.

Another important change in the application of the method, resulting basically from the critique of Sackman (1975), is that the average estimate of participants of the Delphi panel is no longer presented as the best estimate of the future development (Kuusi 2003, 210). If panel selection is partial and biased, so is the average judgment. The critique of Sackman (1975) is discussed in more detail in Chapter 3.2.3, assessing the reliability and validity of the Argument Delphi panel.

The empirical research method, Argument Delphi that is applied in this study, is a variation of Policy Delphi (Kuusi 1999). Just like in Policy Delphi, rather than aiming at artificial consensus, the reasoning behind arguments is brought up and conflicting interests are discussed. The focus is on the analysis of reasoning behind argumentation, and therefore, the variation of the Delphi is called Argument Delphi.

In addition to conventional Delphi with paper and pencil, computer-based communications were introduced already in 1970s (Turoff 1972). Several studies since late 1990s have used on line questionnaires. In Finland eDelfoi (www.edelfoi.fi) developed by Hannu Linturi, Osmo Kuusi and Jari Kaivo-oja has been in extensive use. In 2006 a software Real Time Delphi was introduced and it has been used extensively, for example, in the Millenium Project of the United Nations developing futures research methods (Gordon 2009a). Gordon (2009a) argues that the strengths of Real-Time Delphi, compared to the conventional Delphi study with paper and pencil, are speed, flexibility, lower costs, and centralization of a data bank of questions and responses. A weakness is the difficulty to motivate participants to come back on-line once they have completed the questionnaire. Studies indicate that only 25 – 50% of the respondents revisit the questionnaire. This is a serious deficit since one of the key features of Delphi is iteration. Another observed difficulty is how to motivate participants for serious argumentation on line.

When applying eDelfoi in Finland, attempts have been made to overcome problems of motivation to participate through interviews before on-line participation increasing motivation, and through organizing "hot periods", in other words, periods of one or two hours when most of the experts are present on line judging and commenting the arguments (Gordon 2009a).

Kuusi (2003, 211) argues that it is important to be aware of how personal characteristics and attitudes of experts shape their expectations of future development. Therefore, Kuusi has sometimes - for example in a study concerning the future of materials (Kuusi 1994) - asked panelists from which approach they estimate future development, for example, do they regard themselves as followers of development or active contributors impacting future development.

The selection of participants for a Delphi panel is among the key challenges of all group communication processes (Linstone & Turoff 1975). Selection of participants to the Argument Delphi of the study is discussed in Chapter 3.2.1.

APPENDIX 4: PARTICIPANTS OF THE OPEN FUTURES SEARCH EVENT 29.-30.11.2006

Aho Marita	Confederation of Finnish Industries EK
Angervuo Jani	Tampere University of Applied Sciences (student)
Ekman Kalevi	Helsinki University of Technology
Forsman Kimmo	ABB Oy
Fält Martin	Åbo Akademi (student)
Haapsaari Janne	University of Vaasa (student)
Harsia Pirkko	Tampere University of Applied Sciences
Heiskanen Kari	Helsinki University of Technology
Hintikka-Varis Sari	Office of the National Coalition Party
Jokinen Jari	Finnish Ministry of External Affairs
Jokinen Siina	Tampere University of Technology
Juusti Jukka	Defence Command Finland
Kaplas Heikki	Satakunta University of Applied Sciences (student)
Karhu Markku	EVTEK University of Applied Sciences
Karikorpi Mervi	The Federation of Technology Industries in Finland
Kimari Risto	Oulu University of Applied Sciences
Kivikoski Markku	Tampere University of Technology
Koskinen Hanna	National Union of Finnish Students
Kostiainen Juha	YIT Oy
Kymäläinen Anni	South-Carelia University of Applied Sciences
Laajala Tiina	Oulu University of Applied Sciences
Lahtinen Markku	Tampere University of Applied Sciences
Lammasniemi Jorma	Technical Research Center of Finland VTT
Lampinen Kalle	Savonia University of Applied Sciences (student)
Lehmusvaara Antti	South-Carelia University of Applied Sciences
Lehtomäki Kari	Savonia University of Applied Sciences
Linko Susan	Academy of Finland
Lähdeniemi Matti	Satakunta University of Applied Sciences
Maanavilja Aimo	Elisa Oyj
Mattila Markku	Finnish Ministry of Education
Mäkelä Jukka	Finnish Association of Graduate Engineers TEK
Pursula Matti	Helsinki University of Technology
Pöllänen Esko	Savonia University of Applied Sciences
Rantala Pekka	Oulu University of Applied Sciences
Ruotsalainen Keijo	University of Oulu
Saari Reijo	University of Oulu
Saarikangas Hannu	Union of Professional Engineers in Finland UIL
Saarnivaara Veli-Pekka	Finnish Funding Agency for Technology and Innovations TEKES
Salmi Pekka	National Fund for Research and Development SITRA
Salonen Markku	Satakunta University of Applied Sciences
Savolainen Antti	Helsinki University of Technology (student)
Schrey-Niemenmaa Katriina	EVTEK University of Applied Sciences
Syrjänen Mikko	Gaia Group Oy
Terho Helena	Kone Oyj
Toivonen Hannu T.	Åbo Akademi
Torvela Mikko	Oulu University of Applied Sciences (student)
Toukola Mari	Lappeenranta University of Technology (student)
Törmälä Pertti	EVTEK University of Applied Sciences

Viherkari Jaska	Tampere University of Technology (student)
Virtanen Ilkka	University of Vaasa
Vuento Aimo	South-Carelia University of Applied Sciences
Vänsä Riitta	Nokia Oyj
Väänänen-Vainio-Mattila Kaisa	Tampere University of Technology

APPENDIX 5: FUTURE SEARCH AND SEARCH CONFERENCE METHODOLOGIES

The theoretical roots of Future Search are largely based on the Tavistock tradition and Search Conference, and therefore, Future Search and Search Conference contain a lot of similarities. The aim in both methods is to turn the participants into the "ideal-seeking mode" and to search collectively for the desired future. Moreover, equal and open participation, good dialogue and focus on common ground is emphasized in both of the methods. (Emery & Purser 1996, Bunker & Alban 1997, Weisbord & Janoff 2000).

Weisbord & Janoff (2000) state that Future Search applies the Asch's (1952) conditions for effective dialogue like Search Conference. Emery & Purser (1996, 219 - 221) are of the opinion that Search Conference mobilizes effective dialogue process better than Future Search. This is because in Search Conference the participants are selected to reflect the whole range of knowledge and interests in a system, but they attend as individuals. In contrast, in Future Search participants are specifically noted as stakeholders.

The same topics, environmental analysis, historical analysis, analysis of the current system, desired future and action planning, are covered in Search Conference and Future Search events. However, working methods, grouping of participants and order of the work phases are different. In Search Conference, most of the work is accomplished with the whole group, whereas in Future Search a great deal of the work is carried out in small groups. Bunker & Alban (1997) point out that in Future Search the working methods are more evocative than those of Search Conference. In Future Search focus is more on generating collaborative action towards the desired future, whereas in Search Conference focus is more on "democratizing the working place".

The agenda in Future Search is more often considered with a large systemic change than in Search Conference. Therefore, the number of attendees needed to participate in the event in order for all the necessary stakeholders to be represented is often larger in Future Search (Bunker & Alban 1997). According to Emery & Purser (1996, 10), the optimum number of participants when applying Search Conference is 20 – 35, and according to Bunker & Alban (1997, 59) 35 – 40. In a typical Future Search event, there are 60 – 80 participants, and 64 is regarded as an optimum number (Weisbord & Janoff 1999, 47).

APPENDIX 6: DETAILED DESCRIPTION OF THE WORK PROCESS OF THE OPEN FUTURES SEARCH EVENT ON THE FINNISH ENGINEERING EDUCATION 29.-30.11.2006

DAY 1:

1. Introduction (40 min)

- **musical performance (5 min)**
- **welcome speech by the sponsor (5 min)**
- **introduction to the event by the facilitator (15 min)**
- **opening activity, participative group process "Cocktail party"(Nummi 2007) (15 min)**

When the participants arrived at the Conference site, there was an orchestra of strings welcoming them. The event was opened by the chairman of the Board of TEK, Merja Strengell. Thereafter, the researcher presented the background of the conference, the project team that had organized the event, objectives of the event, and the stakeholder groups attending the conference. Furthermore, the researcher presented the ground rules for working:

- all ideas are valid
- record everything on flip charts in working groups
- listen to each other
- observe time frames
- seek common ground and action
- disagreements and problems are acknowledged, but they are not the focus

The ground rules were from Weisbord & Janoff (2000, 57), except that the researcher slightly modified the stand towards problems and conflicts. Weisbord & Janoff (2000, 57) say that "Seek common ground and action – not problems and conflicts". The researcher divided this rule into two separate rules. The attitude at the conference towards conflicts and problems was applied from Search Conference, where more time is spent on confronting and working out conflicts if needed (Bunker & Alban 1997, 58). Moreover, an additional note was made, asking the participants to appreciate the time investment everybody has made by spending two days at the conference and to keep mobile phones off during the assignments.

The researcher presented also the roles of participants and facilitator at the conference. Moreover, the researcher presented guidelines for the group work. The facilitator's introduction to the conference was also available in written form in the participant workbook that was in the conference folder.

Weisbord & Janoff (2000, 82 – 83) do not utilize any opening activity before historical analysis. However, Rees (2005) and Nummi (2007) point out that opening activities are important to group work, because they unite people towards a common purpose and even affect group productivity.

2. Historical analysis: society, Finnish engineering education, individual (120 min)

- **individual assignment (20 min)**
- **small group work, mixed stakeholder groups (30 min)**
- **small group presentations (30 min)**
- **plenary dialogue (40 min)**

The objective of the historical analysis was to create a shared context of the history of the Finnish engineering education. The first assignment of facing the history together is planned to satisfy two of Asch's (1952) criteria for effective dialogue: experiencing that we all live in the same planet (shared field) and are psychologically the same (psychological similarity). The participants were asked to think over the milestones of the history of the Finnish engineering education, whole society, as well as their personal history during 1960 – 2006. After making their own notes, the participants were asked to write down the milestones on the three timelines hanging on the walls.

In the second phase, the participants were divided into eight working groups. The groups were heterogeneous, in other words, stakeholder groups were mixed. The assignments of working groups were allotted. Working groups 4 and 8 were asked to tell a story of the societal timeline and to look for patterns and insights that are useful for the strategy work in engineering education. The Finnish engineering education timeline was analyzed by working groups 1 and 7. Working groups 2 and 3 examined the timeline of personal history. The assignment of working groups 5 and 6 was to make a synthesis of all three timelines, and look for similarities, differences and interdependencies.

In the third phase, the groups presented the results of their work in a 3-minute presentation. Thereafter the whole group discussed of lessons learned, and what the consequences are for the strategy work.

3. Focus on the present, part 1: Analysis of the business environment (85 min)

- **individual assignment (10 min)**
- **small group work, mixed stakeholder groups (20 min)**
- **plenary dialogue, visual tool mind-map (30 min)**
- **individual assignment, prioritization (10 min)**
- **plenary dialogue (15 min)**

The objective of the environmental analysis was to analyze collaboratively the business environment of the Finnish engineering education. This was accomplished by drawing a mind map of the business environment on the wall. The participants looked for the key trends and weak signals affecting the Finnish engineering education up to 2015. Weisbord & Janoff (2000) invite only trends in this phase, but the researcher found it important to ask also for emerging change factors (weak signals). Before the assignment, the facilitator explained the concept of a mind map.

First, participants drew their own understanding of the mind map on the paper, after which, the facilitator allotted the assignments for working groups. The groups 2 and 7 drew the mind map of the business environment on the wall. The other working groups (1, 3 , 4, 5, 6 and 8) discussed the key trends and weak signals they had drawn individually. Although this was not requested, groups 5, 6, 8 drew a shared mind map of the working group on a flip chart as well.

Thereafter, all participants gathered around the mind map that groups 2 and 7 had drawn on the wall. A representative of the working groups 2 and 7 presented the mind map to all participants. A plenary dialogue was opened, and the facilitator asked for the participants to add trends and weak signals, potentially still missing, to the mind map.

After everybody was pleased with the mind map, the facilitator asked the participants to prioritize the most important factors in the mind map. All participants had 7 small dot stickers for prioritizing. The stakeholder groups had different colors of stickers in order to be able to observe if stakeholder views were similar or not. It was up to the participant to choose how he or she wanted to share the stickers. It was possible to post all stickers on one factor, one on seven, two on three and one on one etc. The facilitator and the project team counted the results. Finally, the participants discussed the most important trends and weak signals.

4. Focus on the present, part 2: Analysis of the present in Finnish engineering education: current prouds and sorries (125 min)

- **small group work, divided by stakeholder group: 1) key issues for concern, what is currently being done and what should be done 2) strengths and weaknesses analysis (30 min)**
- **small group presentations (40 min)**
- **discussions in small groups on similarities and differences in group presentations, new ideas (15 min)**
- **plenary dialogue (40 min)**

The analysis of the present situation in the Finnish engineering education was the only phase in the event where stakeholders were not mixed in the working groups. This is because this way people learn at the same time what their peers think, and during presentations what other stakeholder groups think (Weisbord & Janoff 2000, 94 – 95). The purpose of this phase in the Future Search is to get people to take responsibility for what they are doing, and urge them to think what they could do.

In this phase, the researcher combined the reinterpretation of the mind map by stakeholder group and prouds / sorries analysis into one assignment. This was because of lack of time (the event shortened from the original to last two days), and the researcher did not want to shorten the time reserved for action planning.

The participants were asked to write down what the key issues of concern were to their stakeholder group, and to draw a mind map or a picture how these issues were related to each other. On the same flip charts the participants were asked to write down what they were currently doing about the situation they described, and what they were not doing, but would like to do. The facilitator reminded the participants to focus on what they were doing, and should do, and not to others.

In the second phase of the assignment, the participants were asked to list the strengths and weaknesses of the Finnish engineering education. Moreover, the task was to analyze what they were doing right now for the Finnish engineering education that they were proud of, and what they were sorry about. The researcher asked to underline the items that the working group cared most deeply about.

After each working group had presented their results, in about 5 minutes per working group, the facilitator asked the working groups to discuss the similarities and differences the working groups had noted between stakeholder groups and the presentations. Furthermore, they were asked to consider if there were any specifics issues or views that the group wanted to bring up to plenary discussion. Thereafter, the whole group discussed the results of the present situation analysis.

5. Focus on the future: ideal future scenario of the Finnish engineering education (80 min)

- **individual assignment: it would be great if…(10 min)**
- **small group work, mixed stakeholder groups: ideal future scenario (70 min)**

The ideal future scenario assignment was carried out again in mixed groups. The mixed groups were the same as in the historical analysis. This allows the group to bond more quickly and build on earlier learnings (Weisbord & Janoff 2000, 97). Compared to the Weisbord & Janoff (2000) description of Future Search, the researcher added in the beginning a short individual assignment. The participants were asked to write 3 – 5 sentences that described the Finnish engineering education in its ideal state. The sentences were to be written in the form: "It would be great if…"

The assignment for the group work was to make an ideal future scenario of the Finnish engineering education up to 2015. The groups were asked to draft first their vision, and after that to list the milestones how the vision was reached. Furthermore, the groups were asked to think of the most important barriers that need to be overcome and how this could be achieved. The groups prepared a 5 – 7 minute presentation for the ideal future plenary session next morning.

The researcher planned day 1 to finish in the middle of the ideal future assignment. One important reason was to benefit from the Zeigarnick effect: by breaking up in the middle of intensivework on a task, energy is stored that is discharged by completing the task next morning. (Weisbord & Janoff 2000, 93; Emery & Purser 1996, 180).

DAY 2

1. Introduction (15 min)

- **welcome and program of the day, facilitator (5 min)**
- **opening activity, participative group process: "Line" (Nummi 2007) (10 min)**

After welcoming the participants to the second working day, the researcher presented the program of the day. For reasons discussed in the opening of the first day, the researcher decided to add an opening activity to the program on the second day of the event. The opening activity of the second day was "Line" (Nummi 2007, 105).

The researcher had drawn a line on the floor with masking tape. The researcher asked the participants to select the spot on the line that reflects their feelings this morning. At one end of the line was the spot indicating very negative feelings, and at the other end, excellent feelings. Next, the researcher asked the participants to pair up and discuss why they had selected this spot on the line. Finally, the researcher asked publicly a couple of comments of the participants standing at both ends and in the middle of the line.

2. Focus on the future: ideal future scenario of the Finnish engineering education, continued from day 1 (100 min)

- **small group work, mixed stakeholder groups (20 min)**
- **small groups presentations (50 min)**
- **plenary discussion (30 min)**

First, the working groups finalized their assignments. Then the eight working groups had 5 - 7 minutes per working group to present their ideal scenario. The researcher asked the participants to make notes during the presentations on themes that they hear in presentations given by others that occur also in their own, and also write down new ideas that they think are especially good.

After the presentations of the working groups, there was a plenary discussion on the ideal future of the Finnish engineering education.

Confirming a common future is at the heart of a Future Search event (Weisbord & Janoff 2000, 100). In the phase of "an ideal future" assignment, the working groups defined for the first time their view of the desirable future.

3. Common ground and action planning with Open Space (Owen 2008 modified) (270 min)

- **small group work, mixed groups: rephrase the vision statements, list items, issues, viewpoints that need to be further processed for the strategy (30 min)**
- **synthesis group: proposal for discussion items and conveners, others on a coffee break (30 min)**
- **presentation of the synthesis group, plenary discussion and decision on the Open Space meetings rounds 1 – 2 (30 min)**
- **Open Space meeting round 1, 7 meetings on-going (45 min + 15 min)**
- **Open Space meeting round 2, 7 meetings on-going (45 min + 15 min)**
- **small group discussions, ad-hoc groups: need for new discussion themes (5 min)**
- **plenary discussion and decision on the Open Space meetings round 3 (10 min)**
- **Open Space meeting round 3, 6 meetings on-going (35 min + 10 min)**

As the next step it was time to rephrase the vision statements in the working groups. The aim of this process was to move the whole group towards common ground and creating a common future.

In addition of rephrasing the vision statement, the groups were asked to list the themes, issues and viewpoints that need to further work when formulating the national strategy for the Finnish engineering education. Furthermore, the groups were asked to collect examples, project ideas and key issues that were introduced in the presentations of ideal scenarios. The researcher asked to put on a separate list those issues that the working group members disagreed on. Moreover, the researcher asked the working groups to select their representative to the synthesis group.

After the group work, the researcher presented the work method – an application of Open Space - that was used in action planning (see Appendix 8 for a description of the Open Space method). Thereafter, all other participants except the synthesis group had a coffee break. During the coffee break the synthesis group made the ground proposal for the themes and conveners of the Open Space meetings. The meetings were divided into two 45-minute time slots with 15 minutes break in-between, during which the participants found out what was discussed and decided in the meetings they did not participate.

After the synthesis group presented their proposal, it was possible for everybody to propose a new topic and to act as a convener and discussion leader in the meeting. The list of the synthesis group was complemented with new themes. In the end there was a list of 14 meetings to be organized in two series of 7 meetings.

The conveners were responsible for leading the discussion and making notes of the discussion on the flip charts. The participants were asked to participate in those meetings where they thought their knowledge and skills could be most useful. It was up to the participant to choose whether he or she wanted to participate in only one meeting or all seven meetings during the first and the second 45-minute time block.

After two series of meetings, the researcher asked the participants to discuss in small groups if there was a need to continue the work on some of the topics, and if there was a need for new topics. The small groups were formulated ad-hoc of the persons next to each other. Next, the researcher asked everybody to come to the front of the meeting room, and topics and conveners of meetings for round three were formulated together. The third time slot ended up with six parallel meetings. For the third time slot, participants had 35 minutes of working time and ten minutes to familiarize themselves with the discussions in meetings they did not participate in.

In this phase of confirming the common future and creating an action plan, the researcher made major modifications to the Future Search process compared to Future Search as presented by Weisbord &

Janoff (2000). There were several reasons behind this decision. Bunker & Alban (1997, 211) categorize the reasons for adapting a large group intervention, like Future Search, into five classes: inevitable refining of a method, unique circumstances, special purposes, the nature of audience, and cultural settings.

The two main reasons for the application of Open Space in action planning were cultural reasons and inevitable refining of the method. The Finnish culture is non-hierarchical, which suggests using methods that give a lot of responsibility to the participants. Furthermore, Open Space is a method that fits well to strategy planning in complex situations where there are a lot of questions to solve and participants have a wide variety of knowledge and skills (Nummi 2007, 87 – 88). Pepe Nummi, a professional facilitator from Grape People encouraged the researcher to apply a third-generation large group intervention method Open Space in action planning, which according to his experience, often works well in action planning.

4. Summary, feedback, next steps (80 min)

- **individual assignment: prioritization and commitment (15 min)**
- **plenary dialogue: summary, report and next steps (50 min)**
- **closing activity, participative group process "Talking Stick" (Nummi 2007, also called Structured Round, see for example Rees 2005) (15 min)**

The results of all 20 meetings of the Open Space were posted on the wall. All participants had 10 stickers with their own name in their conference folders. The researcher asked the participants to post the stickers onto those issues and themes they are most interested in processing further and promoting after the conference.

The researcher presented the plan for compiling the report of the results of the event. It was agreed that the researcher compiles a draft report using the flip charts and the documentation that the project team did during plenary sessions and working groups and sends the draft report for comments in the middle of January 2007. When asking for comments, the researcher benefited from the name-stickers the participants used for pointing out their special interests. It was agreed that the report will be published on 7.2.2007 in a seminar "Welfare from technology".

The researcher was prepared to organize small group discussions before the plenary session, but estimated that the group was ready and willing to discuss right away as a whole group. As a result, the feedback of the event was discussed in a plenary session.

Weisbord & Janoff (2000, 82 – 83) do not have any closing activity in the Future Search. However, Rees (2005) and Nummi (2007) point out that just like opening activities, closing activities are important for successful group work. Opening activities bring the group together and the closing activities send it off at the end. Therefore, the researcher planned a closing activity to the conference program. The event ended with a "Talking Stick" (also called Structured Round, see for example Rees 2005). "Talking Stick" is an old Indian tradition, where people stand in a circle and share in turn their comments and feelings of the event (Nummi 2007).

APPENDIX 7: MEMBERS AND RESPONSIBILITIES OF THE COLLABORATION GROUP SECRETARIAT

The researcher, **Kati Korhonen-Yrjänheikki**, had a two-fold role in Collaboration Group. She was the initiator of the Group, wrote the work plan and was the superior of the Members of the Secretariat. However, she also participated in the work process of the Group as a representative of TEK. She was present at all workshops, meetings and dissemination seminars of the Group, either as a participant or Chairman if Jukka Mäkelä could not participate. The researcher was also Chairman of the Steering Group of the research on sustainable development in engineering education. The researcher was a co-editor of the interim report of Collaboration Group "National Strategy for the Finnish Engineering Education" (Allt & Korhonen-Yrjänheikki 2008). Furthermore, the researcher was a co-editor of the "Profile Map of the Finnish Engineering Education" especially responsible for formulating the proposals for action, finalizing the criteria for a Good Campus, editing the descriptions of the higher education institutions as well as the final revision. As a superior providing feedback and proposals for development, especially concerning the formulation of proposals for action, the researcher participated also in publications on developing teaching and learning in engineering education (Mielityinen 2009a) and sustainable development and engineering education (Takala 2009).

Sanna Allt was the General Secretary of Collaboration Group until her maternity leave that started in December 2008. She facilitated all the workshops of the Group that were organized between September 2007 and November 2008. She carried out the main responsibility for editing the interim report of the Group "National Strategy for the Finnish Engineering Education" (Allt & Korhonen-Yrjänheikki 2008). She carried out the main responsibility for preparing the Profile Map of the Finnish engineering education (Allt, Korhonen-Yrjänheikki & Savolainen 2009) until end of November 2008, when her maternity leave started.

Tiina Länkelin was responsible for selecting the venues for the workshops, meetings and dissemination seminars of the Group in accordance with the principles described by the researcher. The list of the event venues can be found in Appendix 9. She was also responsible for practical arrangements of the workshops, meetings and dissemination seminars. She had an important role in documenting the discussions in the events. Furthermore, she proofread the Collaboration Group publications.

Ida Mielityinen was responsible for facilitating two two-day workshops on development of teaching and learning in engineering education that were organized on 16.-17.10.2008 and 15.-16.1.2009. Furthermore, she facilitated workshops of the Collaboration Group on 9.2.2009 and 9.3.2009. For the preliminary material of the 16.-17.10.2008 workshop, she collected and synthesized studies on learning needs for engineers and summarized the key concepts related to the development of teaching that were disseminated for the participants before the workshop. Several representatives of industry were prevented from participation to the workshop on 15.-16.1.2009. Therefore, she carried out a 3-hour group interview for industry representatives on 29.1.2009. She was responsible for compiling the results of the above-listed workshops and the group interview, and edited the publication focused on the development of teaching and learning in engineering education: "Finland needs world's best engineering competence and skills" (Mielityinen 2009a).

Annina Takala carried out research on sustainable development and engineering education, consisting of an extensive literature review and 66 interviews of experts on sustainable development. The research had a separate Steering Group and Takala acted as the Secretary of the group. She was responsible for documenting the research results as well as editing the action plan aiming to develop engineering education to face the challenges of sustainable development. The results of the research and action plan were published as the report “Engineering education – for the benefit of people and environment” (Takala 2009).

Jussi Nousiainen acted as co-facilitator in the workshops focused on teaching and learning in engineering education on 16.-17.10.2008 and 15.-16.1.2009. His responsibility was, in particular, to facilitate the energizers during the work process. Jussi Nousiainen was in charge of preparing press releases on the results of Collaboration Group. The primary role of Jussi Nousiainen was to disseminate the results of Collaboration Group among Members of the Finnish Parliament. However, the lobbying was not done and funded as part of the activities of Collaboration Group but as a separate function of TEK.

Pirre Hyötynen participated in the documentation of the workshops. Furthermore, she analyzed the results of the first preparatory assignment of the Group for the 1.-2.10.2007 workshop. In-between September 2007 and July 2008 Hyötynen also carried out an international case study on strategic partnerships of universities providing engineering education (Hyötynen 2008). The work was not done as part of the work of the Collaboration Group, although it supported the work process. The results of the case study are therefore not documented as part of this study.

Jarna Savolainen collected together with Sanna Allt statistics describing higher education institutions providing engineering education for the publication “Profile Map of the Finnish Engineering Education” (Allt, Korhonen-Yrjänheikki & Savolainen 2009). She was also responsible for the final editing of statistics and designing the Figures and Tables for the publication. Moreover, Jarna Savolainen participated in the documentation of the workshops of the Group.

APPENDIX 8: APPLIED PARTICIPATIVE WORK METHODS IN THE COLLABORATION GROUP AND CASE EXAMPLES

1. WORLD CAFÉ

1.1 Overview of the Method

World Café is a participative group work method that was developed in 1995. Brown & Isaacs (2005, 3), the main developers of the methodology, describe the methodology as "a simple yet powerful conversational process for fostering constructive dialogue, accessing collective intelligence, and creating innovative possibilities for action, particularly in groups that are larger than most traditional dialogue approaches are designed to accommodate."

The World Café methodology is grounded in the body of research on social nature of learning (Lambert et al. 1995, Wenger et al. 2002 ; In: Brown & Isaacs 2005, 51). It proposes the revision of the traditional view of conversation and action as separate processes to become an iterative cycle where conversation is in the middle as a core process as illustrated in Figure A.

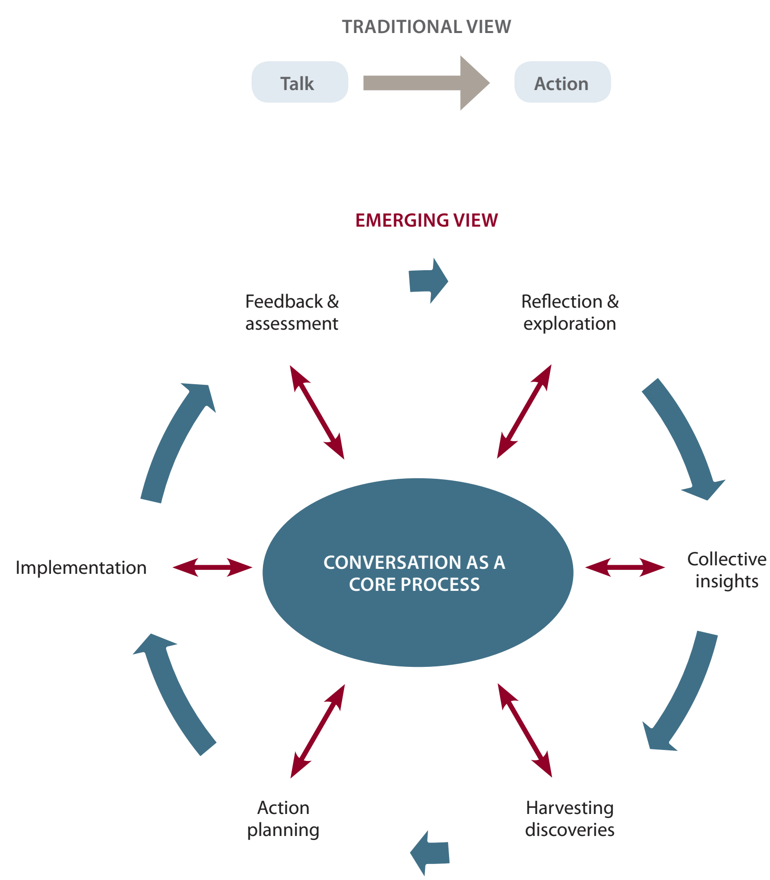

Figure A. The relationship between talk and action traditionally and when applying World Cafe methodology (Brown & Isaacs 2005, 37).

In a World Café people work in groups of 4 – 5 people, having a dialogue on a predetermined question. Each group has a small table and "table cloth" they write and draw on during the conversations using colorful pens. All groups may have the same topic, or they may be multiple threads of inquiry on a common theme.

After a round of conversation, one person usually stays at the table, while others move to the next table "as ambassadors of meaning". The one person that stays in the table acts as a "content steward" and explains to the new group what was previously discussed before the conversation goes on. Sometimes the "content steward" changes after the second round of conversations if the goal is to build new relationships and to foster a sense of community, and the data is not used later, for example, in action planning. Sometimes the final round for making a synthesis is made at the original table.

The method can be applied also so that it is not the people but ideas that move. Then each participant is given a card on which to write the key idea or insight developed during the first round of conversation. Thereafter, everyone exchanges cards with a person from another group and they are used as seeds for continuing the dialogue.

After several rounds of conversations, the final stage of World Café is the plenary dialogue aiming to share and harvest collective discoveries. Before opening the whole group dialogue it is recommendable to allow a few minutes' silence for personal reflection and note taking. Posing of catalytic questions by the facilitator may help the whole-group synthesis in a plenary dialogue. Encouragement of participants to share key personal meanings enables both "head knowledge" and "heart knowledge" to be revealed. Using a graphic recorder may help the group to gain a sense of the whole as it unfolds. Brown & Isaacs (2005, 153) recommend involving different forms of visual language in sharing the collective discoveries, like theatre, poetry and interactive technology tools.

The duration of a World Café may vary between 1.5 hours to several days. It may also become part of the regular meeting structure . The World Café design is based on seven principles (Brown & Isaacs 2005):

1) Set the context: define purpose, participants and practical parameters
2) Create hospitable space: trust is a necessity for powerful conversations
3) Explore questions that matter: open-ended, simple and inspiring questions
4) Encourage everyone's contribution: take into consideration different learning styles
5) Cross-pollinate and connect different perspectives: note the importance of participant diversity
6) Listen together for patterns, insights, and deeper questions
7) Harvest and share collective discoveries: document collective knowledge using written word, visual means and innovative ways

1.2 Case Examples in the Present Study

1.2.1 Case example 1: World Café with separate threads of inquiry and content steward

For the first time, World Café was used in the Collaboration Group at a workshop organized on 12.11.2007 that was focused on the mission, scenarios and structural development of the Finnish engineering education. The workshop was facilitated by Sanna Allt. World Café was used for discussing and analyzing the strengths and weaknesses of different criteria for promoting structural development of the Finnish engineering education. The group was divided into five sub-groups, each discussing different criteria.

The first round of discussions lasted 30 minutes. Thereafter, the groups moved to the next table every 10 minutes except for one person who stayed as a "content steward" (Brown & Isaacs 2005) for the whole exercise. In the end, the groups moved to their original table. Thereafter, content stewards presented briefly the criteria discussed at their table. As a final stage, the participants voted for the most important criteria using stickers. After counting the results of the voting, the floor was open for a plenary discussion.

1.2.2. Case Example 2: World Café with separate threads of inquiry without content steward

In 9 out of 10 workshops where World Café was applied in the Collaboration Group, one person stayed as a "content steward" in the group while others moved to discuss to the next table. At the first workshop focused on the development of teaching and learning (on 16.-17.10.2008), facilitated by Ida Mielityinen, World Café was used for defining the learning needs for engineering graduates.

Content steward was not used, and the whole group moved to the next table and continued to work on another learning need. As a consequence, part of the results of the work were lost since nobody was fully able to understand, only by reading and observing the drawings on the table cloth, what had been discussed previously at the table.

1.2.3 Case example 3: World Café on the various threads of inquiry with Fishbone Diagram and Mind Mapping

At a Steering Group of the research on sustainable development and engineering education that was organized on 30.1.2009, World Café was applied as a working method combined with visual tools of Fishbone Diagram (Rees 2005) and Mind Mapping. The researcher acted as facilitator.

World Café consisted of two discussion groups, one with four participants and another with three participants. One discussion group analyzed with Fishbone Diagram the empirical research results of the interviews related to the research on sustainable development and engineering education. This was accomplished from two aspects, both having a separate Fishbone Diagram: 1) sustainable development and methodologies 2) objectives of sustainable development from the viewpoint of engineers. The other group focused on creating a mind map on the preferred structure of the research report.

After this, the groups were changed, except for one person who stayed in the group as content steward. And finally, participants got back to the original groups and familiarized themselves with the additions made before it was time for the whole-group discussion.

1.2.4 Case example 4: World Café with flavors of Open Space and a synthesis group

At the second workshop focused on teaching and learning in engineering education (on 15.-16.1.2009), a variation of World Café was applied for defining the learning objectives of engineering education in polytechnics and universities. The workshop was facilitated by Ida Mielityinen.

Participants were divided into nine groups, each with 4 – 5 participants. Eight of the groups worked for 40 minutes focusing on defining learning objectives for engineering education. Each working group had a different learning objective. The members of the ninth working group formed a synthesis group. They were not assigned any specific learning objective but were asked to listen to the discussions in working groups and to make notes in order to prepare an overall synthesis of the discussion on learning objectives. Thus, they were free to change their working group whenever they felt necessary.

In the second phase, everybody was allowed to change discussion groups except for one person who stayed in the group as content steward. However, like in Open Space (see Owen 2008), everybody was free to select the working group where they felt they could offer the most contribution. The synthesis group continued to visit the working groups and made notes like in the previous working phase. This working phase lasted 30 minutes.

In the third phase, people were asked to get back to their original groups. The eight working groups that had focused in the first phase on defining one learning objective continued by making a mind map of the relations of the defined learning objective to other learning objectives. The synthesis group was asked to prepare a synthesis of the discussions in working groups during the first and second phases of the discussions. The groups worked for about 40 minutes, except for the synthesis group that spent some more time.

As a final stage, the synthesis group presented their view of the synthesis of the discussions in defining the learning objectives for engineering education, after which the plenary was open for discussion for all participants.

1.2.5 Discussion of the Case Examples

As the examples above illustrate, World Café was the most widely applied methodology during the work of the Collaboration Group, and it was applied also in the workshop of the Steering Group of the research on sustainable development 30.1.2009.

Members of the Group became familiar with the methodology since variations of World Café were used in 10 out of 20 different events of the Group either during the whole workshop or during part of the workshop. Therefore, they felt comfortable and were able to focus on discussion instead of work process.

In all World Cafés during the work process of the Collaboration Group, the sub-groups worked on separate threads of inquiry on a common theme. For the most part, people tended to write on the flip-charts, but drawings were used as well. As illustrated in case example three, Mind Mapping and Fishbone Diagrams were used as visual tools in a few workshops.

The empirical observations in all case examples of the Collaboration Group support Brown & Isaacs (2005) that the method works well in fostering productive relationships, collaborative learning and creation of collective insight around real-life challenges and key strategic questions.

Mind-mapping and Fishbone Diagram seemed to enhance the discussion in the World Cafés described in case examples three and four. As suggested by (Brown & Isaacs 2005, 74), it seems that visual tools, like mind mapping and Fishbone diagram, enable different learning styles and enhance productiveness of the methodology.

Moreover, like case example two illustrates and Brown & Isaacs (2005) argue, "content steward" needs to stay at the table if the produced material is later needed, for example, in action planning. Otherwise, part of the material is lost and discussions are not fully understood just by observing the writings and drawings on the flip-chart.

Case example four of World Café suggests that by adding more self-organization to World Café, and using "the law of two feet" like in Open Space (Owen 2008), it could be possible to motivate participants to contribute especially to those aspects they feel to obtain most knowledge of. Finally, a synthesis group might be a useful tool that contributes to summarizing the discussion results.

2. OPEN SPACE

2.1 Overview of the Method

Open Space is a group communication methodology that is "effective in situations where diverse group of people must deal with complex and potentially conflicting material in innovative and productive ways." (Owen 2008, 15). The size of the group may vary between 10 and several thousand people.

Open Space was developed in the 1980s by Harrison Owen, who found that the most effective moments in a traditional conference are often coffee breaks. Therefore, he wanted to develop a group working methodology where people could interact in a self-organized way towards a shared objective.

In an Open Space there is only one law, namely the law of two feet. Everybody is asked to share his or her expertise in the best way and change working groups whenever it seems appropriate. The four principles of the methodology are: whoever comes to the working groups are the right people, whatever happens is the only thing that could have happened, whenever the meeting starts is the right time, and when the meeting is over, it is over.

Before the event, a facilitator has to prepare the site for the event and also focus himself or herself for the event. Owen (2008, 62 – 63) suggests several hours of meditation or physical practice aiming to achieve clarity of self and purpose, combined with openness to the environment and others. At the event itself, the role of facilitator is less doing than being. Owen (2008, 56 – 63) notes that it is the responsibility of the facilitator to create an environment of safety, a unique time and space suitable for the group. After setting the context at the beginning of the event, the facilitator needs to be authentically present but not intervene in the working groups (except in extreme cases). Trust the people and let go. Owen (2008, 61) argues that "...there is exactly one way to guarantee the failure of an Open Space event, and that is to try to control it."

When an Open Space begins, people sit in a large circle. Facilitator welcomes the group, focuses people on the theme and objectives of the event and explains the above-described rules and principles of Open Space. Next, the facilitator asks everybody to present an issue or issues they feel need to be discussed in order to achieve the objectives of the event. All the presented issues are posted on the wall on the community bulletin board where the facilitator has created a matrix for meeting rooms and time slots.

People that bring up a topic for discussion become the meeting conveners and are also asked to make sure that a reasonable record of discussions is prepared in the group. When all the ideas for issues to be discussed have been proposed, people are asked to sign up for the meetings. Then it is time to let the meetings begin.

Usually an Open Space lasts 1 – 3 days. The results of the working groups are disseminated right after the meetings are over, and the results are typed and printed. It is possible to separate the action planning phase and call a plenary session for bringing up the issues for discussion.

Owen (2008, 148 - 152) suggests closing up the event with a "Talking Stick" ceremony (also called Structured Round, see Rees 2005). In other words, at the end of the event everybody has a reserved time slot for reflecting shortly the results of the event.

2.2 Case Examples in the Present Study

2.2.1 Case example 1: Open Space for feedback on the strategy and proposals for action

Open Space was applied at the dissemination event on 12.2.2008. The first part of the event was reserved for presenting an overview of the strategy framed by the Collaboration Group as well as feedback from the Members of the Group and the Ministry of Education provided by the Secretary of State Heljä Misukka. In the afternoon, Open Space was applied as a tool to get feedback on the strategy from the engineering education community external to the Collaboration Group that could be used in preparing the action plans. Total of 118 persons participated in the event, of which 101 were external to the Collaboration Group. Sanna Allt acted as the facilitator.

The duration of the Open Space was only three hours, and therefore, it was decided to try to shorten the process for bringing up the discussed items. This was done so that the facilitator had listed on the screen ten key topics discussed in the Collaboration Group. The items discussed were:

- The funding of engineering education to correspond to the significance of engineering in the national strategy of Finland
- Profile Map and structural development in engineering discipline
- The contribution of engineering to the well-being of people and environment (sustainable development)
- Increased internationalization
- The dual model in engineering
- Learning objectives need to be set based on anticipated learning needs
- More professional management needed in HEIs
- Intensive co-operation with industry needs to be documented
- Development of continuing professional development is a key issue
- Research, development and entrepreneurship

The facilitator asked if the group agreed on the list of discussed items, or is there a need to remove or add items. The group was satisfied with the proposed topics, and thereafter, the facilitator asked for volunteers to convene the meetings. Notes were made on the flip-charts during the meetings. However, separate documenters were also assigned by the Secretariat to each meeting in order to make sure that all discussions were recorded. All meetings were on-going at same time in a spacious conference room. One extra flip-chart was reserved for any comments the participants wanted to make that they felt they could not address in any of the discussion groups.

After almost three hours of work, the plenary was opened for comments from all participants. The researcher participated in the Open Space assignment, and as the leader of the strategy project at TEK, was asked to make a short summary of the key findings she observed. Notes were later disseminated to all participants.

2.2.2 Case example 2: Open Space for formulating sub-visions and proposals for action

At a Collaboration Group workshop organized on 1.-2.10.2007, Open Space was used for formulating sub-visions for the Finnish engineering education as well as proposals for action to enable the desirable future to be realized. The number of participants at the workshop was approximately 20. The workshop was facilitated by Sanna Allt.

The methodology used was a far-stretched version of Open Space. The reasons why the researcher defines the applied methodology as a variation of Open Space is because of the self-organizing core of the work process: the participants were able to select the topics for discussion, the groups were completely self-organized and "the law of two feet" was applied the way in the traditional Open Space. As Owen (2008, 183 - 189) points out that self-organization and trust in people is essentially why Open Space works, and we are still in the way of developing working methods that enhance self-organization.

Unlike a traditional plenary circle at the beginning of Open Space, the identified topics for discussion were based on a preliminary questionnaire for the group combined with discussion in pairs at the event, structured round, and thereafter prioritizing topics using stickers. Based on the described process, 17 sub-visions were accepted as discussion topics for preparing proposals for action.

The self-organized groups selected 2 – 3 discussion topics, in other words, sub-visions for the Finnish engineering education that they wanted to work on developing proposals for action.

Unlike in traditional Open Space (Owen 2008), after the group work, the proposals for action were presented in a 5-minute presentation to others. Thereafter, participants assessed proposals for action with three different colors of stickers. Orange stickers were reserved for proposals that the participants themselves were able to promote without a need, for example, to change Universities Act or Act on Polytechnics. The participants were asked to mark the proposals that could be forwarded as such to the Ministry of Education with a green sticker. Furthermore, red stickers were reserved for proposals that needed to be further developed.

Thereafter, it was time for a Structured Round (Rees 2005): every participant had the floor for one minute for to bring up the most important argumentation and possible proposals for change. Because one of the aims of the event was to compile proposals for action for the Finnish Ministry of Education for the preparation of the National Plan for Education and Research 2007 – 12, the rest of the workshop was used for finalizing the proposals that according to the majority, belonged to the "green class" as described above. The groups were self-organized.

2.2.3 Discussion of the case examples of Open Space

Open Space worked well in the first case as a tool to obtain simultaneous feedback for the strategy as well as proposals for further action from a large number of people, and in the second case, for identifying sub-visions for the Finnish engineering education as well as proposals for action. The self-organizing nature of the methodology seems to motivate people for participation, no matter if the group size is 20 or 120 people as suggested by Owen (2008).

One drawback of case example one was that although the participants did not present proposals for change for the prepared preliminary list of topics during identification of the issues for discussion, one of the participants later wrote on the flip chart of free comments that there would have been a need to specify more clearly the objectives of each meeting, for example in a form of a specific question.

It is obviously better if the participants are able to decide on the exact formulation of the discussion topics, as was done in case example two. However, this would have taken an additional two hours at the beginning of the workshop (Owen 2008) that was not possible to organize because of the time limits of the event.

In the second described case, participants got used to the self-organizing nature of the work, because the event lasted two days. In order to fully benefit from the tool, it seems that the minimum of one whole working day is needed, as proposed by Owen (2008). It may be that this is the minimum amount of time spent together in order for the shared context to function as energizing "Ba" promoting knowledge creation, as described by Nonaka et al. (2000).

3. IDEALOGUE (STEAL WITH PRIDE)

3.1 Overview of the Method

Idealogue, also called "Steal With Pride" that describes the process, is a brainstorming technique developed by Pepe Nummi , Greg O'Shea and Kari Helin (Nummi 2007, 65).The tool is suitable for creating a shared context, at the beginning of a creative process or preparation of an action plan.

The strengths of the technique lie in its ability to combine individual and group brainstorming and to motivate people to come up with new combinations of ideas. There is an individual work phase in the beginning that increases motivation and understanding on the individual level. On the other hand, when stealing ideas from others, everyone needs to be able to explain thoroughly their own ideas. Furthermore, while listening to the ideas of others, people need to ask "why" that often enhances further development and combination of ideas. Stealing ideas is accomplished in small groups of 2 – 4 people, which facilitates creation of trust. Change of groups takes place without prior plans and everybody is able to select the group he / she wants to continue to share ideas in. (Nummi 2007, 58).

A typical Idealogue process consists of seven phases (Nummi 2007):

1. Agreement on the focus of the exercise
2. Individual assignment: Own ideas on the paper (3 – 4 minutes)
3. Groups of 2 – 4 people discuss their ideas, steal ideas from each other, develop them further and everybody writes the best new ideas on their own paper. (10 – 60 minutes)
4. New groups of 2 – 4 people and again discuss ideas, steal best ones, develop them further and everybody writes on their own paper the best new ideas. This phase is repeated 2 – 4 times. (10 – 60 minutes)
5. Selection of the best ideas in the groups of 2 – 4 people. The four best ideas are written on a flipchart. (10 minutes)
6. Idea Exhibition: Flip charts are taped on the wall and everybody takes a tour. Usually there is no need to present the ideas, because everybody is familiar with them. (5 minutes)
7. Assessment of ideas: Ideas are discussed and assessed in a whole-group discussion (10 minutes)

3.2 Case Examples in the Present Study

3.2.1 Case example 1: Idealogue as a tool for action planning

Idealogue was used for action planning at the second workshop focused on the development of teaching and learning that was organized on 15.-16.1.2008. The reserved time for action planning with Idealogue was 90 minutes. The workshop was facilitated by Ida Mielityinen.

For the first, participants were asked to write on the paper three proposals for action based on the results of the first part of the development work of teaching and learning in engineering education, the two-day workshop held in October 2008. To remind the participants of the key results, the facilitator disseminated a one-page summary of the results. Furthermore, the participants were asked to write three proposals for action based on the results of the on-going workshop. The individual work phase lasted 10 minutes.

Thereafter, the participants were asked to stand up and form small groups to discuss their ideas for action proposals. Participants were asked to steal with pride the best ideas from each other.

After three discussion rounds in new groups, the facilitator asked every group to select 5 – 7 best ideas. One person from each group typed the selected best ideas to the virtual learning environment.

As a final stage, the whole group discussed for about 20 minutes the brainstormed ideas that were projected on the screen so that all ideas could be seen.

3.2.2 Case example 2: Idealogue as a tool for action planning

At a Steering Group of the research on sustainable development and engineering education that was organized on 30.1.2009, Idealogue was used as a tool for action planning. The researcher acted as facilitator.

In the beginnig, the participants were asked to spend 5 minutes on individually brainstorming the proposals for action based on the research results. Thereafter, the participants discussed for 10 minutes in groups of 2 – 3 persons. The aim was to present their own ideas, steal the best proposals from others and possibly synthesize a new proposal and write it on the paper.

As a third stage, the participants were asked to change discussion partners and to repeat "the steal with pride" process. This time 15 minutes was reserved for discussion, because participants were also asked to select together 3 – 5 best proposals for action.

The groups presented in 3-minute presentations the best ideas to the others. Next, everybody got three stickers to mark the proposals for action they found most important. And finally, it was time for a 20-minute plenary discussion focusing especially on the prioritized items.

3.2.3 Discussion of the Case Examples on Idealogue

One of the primary application areas of Idealogue is action planning (Nummi 2007) and the method worked well in both of the described cases as a tool for individually and collectively brainstorming proposals for action.

The researcher suggests that the strengths of Idealogue lie in its ability to energize the "Ba", thus enhancing creation of new knowledge as described by Nonaka et al. (2000): There is a clear intention in action planning. Participants are allowed a lot of autonomy. There are a lot of redundant ideas. The regular autonomous change of groups brings some creative chaos. Whether requisite variety is met depends on the selection of participants to the event.

Nummi (2007) points out that one of the weaknesses of Idealogue is that the application of the tool takes time. Also in both of the described cases the researcher argues that ideally there would have been a need to reserve more time for brainstorming and cultivation of ideas during the "steal with pride" discussion rounds in order to make all of them as concrete as possible.

However, the researcher is well aware that if facilitators of case example one or two would have decided to spend more time on action planning with Idealogue, there would have been a need to shorten - or probably to leave out - one of the previous work phases, which might have caused other difficulties. For practical resourcing reasons, it was not possible to organize a third event on the development of teaching and learning in engineering education only for action planning with Idealogue. Concerning case example 2, proposals for action were further cultivated at the next meeting of the Steering Group (24.3.2009).

4. DYNAMIC FACILITATION

4.1 Overview of the Method

Dynamic Facilitation allows to discuss a problem simultaneously from various perspectives: worries, key issues, facts and solutions. However, in order for the participants to discuss the issue openly from all the aspects, they need to trust each other (Nummi 2007). Therefore, Nummi (2007) urges beginning the dynamic facilitation with an exercise that connects participants in personal level.

First the group needs to agree on the topic discussed. After this, the facilitator puts four flip-charts on the wall, one for each aspect: facts, worries, key questions and solutions. Everyone is allowed to comment and is asked to say to which category his / her contribution belongs. The facilitator records the comments on the flip-charts. If someone criticizes an idea, the critique is recorded under worries.

When understanding of the problem increases, the dialogue of the group deepens and the roots of the problem are analyzed. Sometimes there are short silent moments during the discussion, which is where the facilitator may ask if all the important aspects are covered. In the end, when it seems that nobody asks the floor, the facilitator takes a new flip-chart and asks the group to summarize the ideas to carry forward from the discussion.

The strengths of Dynamic Facilitation lie in the creation of a shared context among the group and in the deepened understanding of the root causes of the issue discussed. Furthermore, the technique enables people to share both their worries as well as ideas for solutions. The weakness of the technique is that only one person can speak at a time and as a result, in large groups some one may feel outsider.

4.2 Dynamic Facilitation – Case Example in the Study and Discussion

Dynamic Facilitation was applied as one working method at the first workshop focused on the development of teaching and learning (16.-17.10.2008). The workshop was facilitated mostly by Ida Mielityinen. However, during Dynamic Facilitation the group was divided into four sub-groups each having its own facilitator.

An opening exercise was facilitated by Jussi Nousiainen before the exercise applying Dynamic Facilitation. Since most of the participants of the workshop were external to the Collaboration Group, there was a need to get to know each other. Also, as suggested by Nummi (2007), it is recommendable to include an icebreaker exercise before Dynamic Facilitation to make people feel comfortable through connecting them in personal level.

Dynamic Facilitation was used in the first part of the workshop to analyze how learning needs are at present taken into consideration, when planning and developing engineering education. The participants discussed the topic in four subgroups. The facilitators recorded the discussion on four flip-charts entitled facts, worries, key issues and solutions.

Because of the small groups - 12 instead of 50 participated in the event - it was easier for everybody to get the floor. It seemed that the discussion clarified to the participants some of the challenges related to learning objectives. However, what was not achieved, was the shared context and understanding among the whole group that should have been one of the key strengths of the tool (Nummi 2007).

There was a need to get to know what was discussed in the other groups. There were several similar topics, but also different aspects. Reading the flip charts afterwards does not facilitate sharing the deeper levels of discussion. It seems that Dynamic Facilitation works only as whole-group assignment since otherwise its key strength, the ability to create a shared context, is lost. The researcher argues that in the described case it would have been better to introduce small group discussions occasionally during Dynamic Facilitation than to divide the group to several sub-groups each having separate discussions and facilitators.

5. STRUCTURED ROUND

5.1 Overview of the Method

Structured Round is not a stand-alone group work methodology, but rather an exercise to be used to make sure that everyone has a chance to speak about an issue without interruption. It reinforces the idea that all input is valuable and helps to equalize the influence of all participants. Furthermore, it encourages the whole group to develop a position on an issue, thus increasing the chance that the group will be productive. (Rees 2005, 125 – 127)

Rees (2005) argues that Structured Round should not be used to come up with new material. Structured Round is a tool that can be used when the group needs to address a complex issue thoroughly and reach an agreement. It can be used when unstructured discussion seems unproductive, there is confusion or disagreement, several people are silent, while a few are dominating the discussion, or when it is time to summarize where everyone is on an issue in order for the group to move forward. Some topics may call for several rounds so that people are able to respond to what others have said and revise their original statements.

5.2 Case Examples of Structured Round in the Present Study

5.2.1 Case example 1: Structured Round to hear everyone's opinion before moving further

Structured Round was used as one part of action planning at the Collaboration Group workshop on 1. – 2.10.2007 that was facilitated by Sanna Allt. The aim of action planning was to formulate proposals for the National Development Plan for Education and Research 2007 – 12 .

As a result of brainstorming in small groups of individual choice, the group formulated a multitude of proposals for action. Thereafter, it was time for a Structured Round: every participant had the floor for one minute to emphasize the most important proposals, and if needed, to criticize and to suggest changes. It was not allowed to interrupt or criticize speakers. The facilitator recorded proposals for prioritization and suggestions for change on a separate flip chart. Thereafter, work continued in small groups to finalize proposals for action bearing in mind comments made during Structured Round. The groups were self-organized.

5.2.2 Case example 2: Structured Round as a final stage of small group work

Structured Round was used in the workshop focused on the development of teaching and learning in engineering education on 15.-16.1.2009, facilitated by Ida Mielityinen. At the event, Structured Round was used as the final stage for discussing and comparing different teaching and assessment methods. Representatives of small groups all focused on advocating one assessment method – lecture combined with an exam, group work, portfolio, learning diary, e-learning and individual assignments – discussed with Structured Round with the attempt to promote the strengths of the assessment method that was their group's focus.

5.2.3 Discussion of the Case Examples on Structured Round

The Structured Round worked very well in the first described case when it was used as one stage in the middle of action planning before the work continued in self-organized small groups. The Structured Round worked well as a tool for summarizing where everyone is on the issue and helped the group to move forward, as suggested also by Rees (2005) as strengths of the method.

In the second case, the tool was successful in emphasizing different aspects. However, as also brought up by Rees (2005, 126), Structured Round does not work well as a summary if there still remains a need to come up with new material. This would have been the case, so ideally there would have been a need to continue to work with, for example, Open Space or World Café to further discuss the strengths and weaknesses and suitability of different assessment methods to various learning needs and objectives.

APPENDIX 9: WORKSHOPS, MEETINGS AND DISSEMINATION SEMINARS OF THE COLLABORATION GROUP IN CHRONOLOGICAL ORDER INCLUDING APPLIED PARTICIPATIVE WORK METHODS

Date	Nature of event, working methods*	Duration	Location	Facilitator(s)	Group external participants**
30.8.2007	meeting (conventional)	2.5 h	TEK, Helsinki	no	no
1.-2.10.2007	workshop (open space, mind mapping, structured round)	14.5 h	Hotel Aulanko, Hämeenlinna	Sanna Allt	no
12.11.2007	workshop (world cafe)	9 h	Hotel Hilton Airport, Vantaa	Sanna Allt	no
29.11.2007	workshop (world cafe, structured round)	9 h	Hotel Hilton Airport, Vantaa	Sanna Allt	no
10.12.2007	workshop (world cafe)	3 h	Hotel Radisson Kamppi,Helsinki	Kati Korhonen -Yrjänheikki	no
19.12.2007	meeting (conventional)	3.5 h	TEK, Helsinki	no	no
14.1.2008	meeting (conventional)	3 h	Hotel Holiday Inn Convention Centre, Helsinki	no	no
12.2.2008	dissemination seminar (presentations & open space)	7 h	Hotel Holiday Inn Convention Centre, Helsinki	Sanna Allt (3 h)	yes, (101/118)
10.3.2008	workshop (world cafe)	8 h	Hotel Crowne Plaza, Helsinki	Sanna Allt	no
28.4.2008	workshop (world cafe)	7 h	Hotel Vantaa, Vantaa	Sanna Allt	no
26.5.2008	workshop (world cafe)	7 h	Hotel Hilton Strand, Helsinki	Sanna Allt	no
22.9.2008	workshop (traditional group work, open space)	8 h	Hotel Kalastajatorppa, Helsinki	Sanna Allt	yes (21/44)
16.-17.10. 2008	workshop (dynamic facilitation, world cafe,idealogue)	15 h	Hotel Haikko, Porvoo	Ida Mielityinen Jussi Nousiainen (assisted)	yes (44/51)
17.11.2008	workshop (open space)	7 h	Hanasaari Conference Center, Espoo	Sanna Allt	no
15.-16.1. 2009	workshop (world cafe + mind map, world cafe + fish bone, structured round, timeline, idealogue)	15 h	Hotel Haikko, Porvoo	Ida Mielityinen Jussi Nousiainen (assisted)	yes (45/50)
9.2.2009	workshop /meeting (world cafe, conventional)	7 h	Hotel Crowne Plaza, Helsinki	Ida Mielityinen (3 h)	no
9.3.2009	workshop /meeting (world cafe + fishbone & conventional)	6.5 h	Finlandia Hall, Helsinki	Ida Mielityinen (3 h)	no
20.3.2009	meeting (conventional)	6 h	Hotel Crowne Plaza, Helsinki	no	no
12.5.2009	dissemination seminar (presentations & dialogue circle)	6.5 h	Hotel Holiday Inn Convention Centre, Helsinki	Anne Flinkkilä (1 h)	yes (124/144)
22.9.2009	workshop (presentations & world cafe + fish bone)	4 h	Hotel Kalastajatorppa, Helsinki	Ida Mielityinen (2.5 h)	yes (6/25)

*Note: * Ranking and prioritizing material is not recorded as a separate work method. In addition to the different participative work methods and open plenary discussions, some workshops contained also short presentations by the Secretariat on status of the work and next steps.*
*** Members of Secretariat are not counted in the total number of participants.*

APPENDIX 10: PARTICIPANTS OF THE WORKSHOP ”PROFILE MAP OF THE FINNISH ENGINEERING EDUCATION” 22.9.2008

*Members of Collaboration Group are marked with **

Marita Aho*	Confederation of the Finnish Industries EK
Böckelman Thomas	Novia University of Applied Sciences
Joensuu Antti*	Ministry of Employment and the Economy
Kankkunen Jyrki	North Carelia University of Applied Sciences
Karppanen Erkki	Mikkeli University of Applied Sciences
Kauppinen Petteri*	Ministry of Education
Kemppainen Tommi*	Helsinki University of Technology
Kimari Risto*	Oulu University of Applied Sciences
Kivikoski Markku*	Tampere University of Technology
Knuutila Timo*	University of Turku
Korhonen-Yrjänheikki Kati*	Finnish Association of Graduate Engineers TEK
Kähkönen Jari	Kajaani University of Applied Sciences
Lahtinen Markku*	Tampere University of Applied Sciences
Lehmusvaara Antti	Saimaa University of Applied Sciences
Lehtomäki Kari*	Savonia University of Applied Sciences
Leiviskä Kauko*	University of Oulu
Linna Matti	University of Vaasa
Lähdeniemi Matti*	Satakunta University of Applied Sciences
Mertanen Olli*	Turku University of Applied Sciences
Mykkänen Tarmo*	Ministry of Education
Mäkelä Jukka*	Finnish Parliament
Nevaranta Jorma	Seinäjoki University of Applied Sciences
Nivala Jukka	Metropolia University of Applied Sciences
Nivala Keijo	Central Ostrobothnia University of Applied Sciences
Paronen Mikael	Arcada University of Applied Sciences
Pirttilä Anneli*	Saimaa University of Applied Sciences
Puusaari Pertti	HAMK University of Applied Sciences
Pynnä Seppo	Satakunta University of Applied Sciences
Pöyhönen Ilkka*	Lappeenranta University of Technology
Rantanen Hannu	Lappeenranta University of Technologys
Rasmus Reijo	Tampere University of Applied Sciences
Rissanen Juha	Kymenlaakso University of Applied Sciences
Roslöf Janne	Turku University of Applied Sciences
Saarikangas Hannu*	Union of Finnish Engineers
Salminen Janne	Lahti University of Applied Sciences
Salminen Mikko R.	Jyväskylä University of Applied Sciences
Saxén Henrik*	Åbo Akademi
Torvela Mikko*	The Finnish Union of Engineering Students
Tuominen Jorma	Vaasa University of Applied Sciences
Uusimäki Matti	Kemi-Tornio University of Applied Sciences
Uutela Pekka	Rovaniemi University of Applied Sciences
Westerlund Kim	Novia University of Applied Sciences
Virtanen Ilkka*	University of Vaasa

APPENDIX 11: MEMBERS AND MEETINGS OF THE STEERING GROUP ON THE RESEARCH OF SUSTAINABLE DEVELOPMENT AND FINNISH ENGINEERING EDUCATION (TAKALA 2009)

Members of the Steering Group

- Kati Korhonen-Yrjänheikki, The Finnish Association of Graduate Engineers TEK, Chairman
- Annina Takala, The Finnish Association of Graduate Engineers TEK, Secretary
- Marita Aho, Conferederation of Finnish Industries EK
- Sirpa Halonen, Turku University of Applied Sciences
- Kaisa Harju, SanomaWSOY (Member of the Educational Committee of TEK)
- Mika Honkanen, Finnish Ministry of Employment and the Economy
- Simo Isoaho, Tampere University of Technology
- Petteri Kauppinen, Finnish Ministry of Education
- Tapio Nikula, Keuda Vocational College (Member of the Educational Committee of TEK)
- Sanna Perkiö, Member of the Parliament, The Coalition Party
- Veikko Porra, Helsinki University of Technology
  (retired; also Member of Educational Committee of TEK)
- Pekka Rytilä, Member of Technology Committee of TEK
- Hannu Saarikangas, The Union of Finnish Engineers UIL
- Henri Seppä (student, Member of the Educational Committee of TEK)
- Pia Talja, GEHealthcare Finland
- Pentti Viluksela, Metropolia University of Applied Sciences
- Sanna Allt, The Finnish Association of Graduate Engineers TEK

Meetings and Workshops of the Steering Group

Date	Nature of event, working methods	Duration	Location	Facilitator
21.5.2008	meeting (conventional)	2 h	TEK, Helsinki	no
20.8.2008	workshop	3 h	TEK, Helsinki	Sanna Allt
24.11.2008	meeting (conventional)	3 h	TEK, Helsinki	no
30.1.2009	workshop (world cafe combined with fishbone diagram and mind mapping, idealogue)	4 h	TEK, Helsinki	Kati Korhonen-Yrjänheikki
24.3.2009	meeting (conventional)	2 h	TEK, Helsinki	no
22.4.2009	meeting (conventional)	3 h	Restaurant Tekniska, Helsinki	no

APPENDIX 12: LIST OF THE PARTICIPANTS OF THE TWO TWO-DAY WORKSHOPS ON THE DEVELOPMENT OF TEACHING AND LEARNING IN ENGINEERING EDUCATION

Participants of the workshop 1 "Teaching and Learning in Finnish Engineering Education" on 16.-17.10.2008

*Members of the Collaboration Group are marked with **

Alaviiri Tapio	The Finnish Union of Engineering Students IOL
Albäck Mats	Central Ostrobothnia University of Applied Sciences
Alikoski Satu	Helsinki University of Technology
Andersson Ida	Nokia Oyj
Blomqvist Karl	Arcada University of Applied Sciences
Bruce Tytti	Lappeenranta University of Technology
Haavisto Joona	Metropolia University of Applied Sciences
Hyppönen Olli	Helsinki University of Technology
Hyvönen Kari	Saimaa University of Applied Sciences
Jaako Juha	University of Oulu
Jääskeläinen Maarit*	TAMK University of Applied Sciences
Kallberg Eero	TAMK University of Applied Sciences
Kallioinen Saila	Tampere University of Technology
Kankkunen Jyrki	North Carelia University of Applied Sciences
Karppanen Erkki	Mikkeli University of Applied Sciences
Keskitalo Juhani	HAMK University of Applied Sciences
Kimari Risto*	Oulu University of Applied Sciences
Kivistö-Rahnasto Jouni	Tampere University of Technology
Knuutila Timo*	University of Turku
Korhonen-Yrjänheikki Kati*	The Finnish Association of Graduate Engineers TEK
Koskinen Jussi	Satakunta University of Applied Sciences
Kurvonen Lauri	Finnish National Board of Education
Kähkönen Jari	Kajaani University of Applied Sciences
Laajala Tiina	Oulu University of Applied Sciences
Latikka Juha	Academy of Finland
Laukkanen Emmi	Tampere University of Technology
Lehmusvaara Antti	Saimaa University of Applied Sciences
Lehtinen Riitta	Metropolia University of Applied Sciences
Lehtomäki Kari*	Savonia University of Applied Sciences
Linna Matti*	University of Vaasa
Mertanen Olli*	Turku University of Applied Sciences
Myllymäki Hanna-Riikka	University of Helsinki (Palmenia)
Myller Eeva	National Union of Finnish Students
Naukkarinen Johanna	Tampere University of Technology
Niemi Tiina	Tampere University of Technology
Nikoskinen Keijo	Helsinki University of Technology
Nivala Jukka	Metropolia University of Applied Sciences
Nokso-Koivisto Aleksis	OTUS Research Foundation
Pulkkinen Lari	Metropolia University of Applied Sciences
Pöyhönen Simo	AKAVA
Rahkonen Aimo	University of Oulu

Rasmus Reijo	TAMK University of Applied Sciences
Ristimäki Seija	Metropolia University of Applied Sciences
Salminen Risto	Metropolia University of Applied Sciences
Salminen Risto	Lappeenranta University of Technology
Silven Olli	University of Oulu
Skogster Patrik	Rovaniemi University of Applied Sciences
Tiilikka Anne-Mari	The Federation of Finnish Technology Industries
Tuohi Raija	Turku University of Applied Sciences
Ylhäinen Pertti	Metropolia University of Applied Sciences
Zabihian Mari	Kemira Oyj

Participants of the workshop 2 "Teaching and Learning in Finnish Engineering Education" on 15.-16.1.2009

*Members of the Collaboration Group are marked with **

Alikoski Satu	Helsinki University of Technology
Andersson Ida	Nokia Oyj
Blomqvist Karl	Arcada University of Applied Sciences
Huvinen Outi	Helsinki University of Technology
Hyppönen Olli	Helsinki University of Technology
Hyvönen Kari	Saimaa University of Applied Sciences
Isoaho Simo	Tampere University of Technology
Jaako Juha	University of Oulu
Jutila Suvi	University of Oulu
Jääskeläinen Maarit*	TAMK University of Applied Sciences
Kallberg Eero	TAMK University of Applied Sciences
Kallioinen Saila	Tampere University of Technology
Keskitalo Juhani	HAMK University of Applied Sciences
Knuutila Timo*	University of Turku
Korhonen-Yrjänheikki Kati*	Finnish Association of Graduate Engineers TEK
Koskinen Jussi	Satakunta University of Applied Sciences
Kurenniemi Jukka	TAMK University of Applied Sciences
Kurvonen Lauri	Finnish Board of Education
Laajala Tiina	Oulu University of Applied Sciences
Laukkanen Emmi	Tampere University of Technology
Lavikka Ville	Lappeenranta University of Technology
Lehmusvaara Antti	Saimaa University of Applied Sciences
Lehtomäki Kari*	Savonia University of Applied Sciences
Myller Eeva	National Union of Finnish Students
Määttä Eljas	Kajaani University of Applied Sciences
Naukkarinen Johanna	Tampere University of Technology
Niemi Tiina	Tampere University of Technology
Nikoskinen Keijo	Helsinki University of Technology
Nivala Jukka	Metropolia University of Applied Sciences
Nokso-Koivisto Aleksis	OTUS Research Foundation
Porras Jari	Lappeenranta University of Technology
Puurunen Helena	University of Vaasa
Pöyhönen Simo	AKAVA
Rantala Pekka	Oulu University of Applied Sciences

Rasmus Reijo	Tampere University of Applied Sciences
Rissanen Juha	Kymenlaakso University of Applied Sciences
Ristimäki Seija	Metropolia University of Applied Sciences
Roihuvuo Jyri	North Carelia University of Applied Sciences
Roslöf Janne	Turku University of Applied Sciences
Räsänen Ilpo	North Carelia University of Applied Sciences
Saarikangas Hannu*	Union of Finnish Engineers UIL
Salminen Risto	Metropolia University of Applied Sciences
Schrey-Niemenmaa Katriina	Metropolia University of Applied Sciences
Silven Olli	University of Oulu
Taivalantti Kirsi	Mikkeli University of Applied Sciences
Taukojärvi Sari	Finnish Association of Graduate Engineers TEK
Tuohi Raija	Turku University of Applied Sciences
Vähä-Pietilä Perttu	Tampere University of Applied Sciences
Ylhäinen Pertti	Metropolia University of Applied Sciences
Äijänen Tapani	Jyväskylä University of Applied Sciences

APPENDIX 13: THREE THEORIES OF STAKEHOLDER IDENTIFICATION IN CORPORATE CONTEXT

Stakeholder salience (Mitchell et al. 1997)

A pivotal contribution to the identification of stakeholders in the corporate context is made by Mitchell et al. (1997) classifying stakeholders with the attributes of power, legitimacy and urgency. By building on the three-edged typology, it presents a theory of stakeholder salience.

The latent stakeholders in the low-salience class are those that possess only one attribute: power (dormant stakeholders), legitimacy (discretionary stakeholders) or urgency (demanding stakeholders). The expectant stakeholders are in the moderate class and possess two of the stakeholder attributes. Stakeholders possessing power and legitimacy attributes are called dominant. Dependent stakeholders have urgent legitimate claims, and dangerous stakeholders' claims are characterized with urgency and power. And finally, definitive stakeholders are those that possess all of three attributes, and thus, belong to the high-salience class and should receive most of the management attention. The Mitchell et al. (1997) framework for stakeholder identification is presented in Figure B.

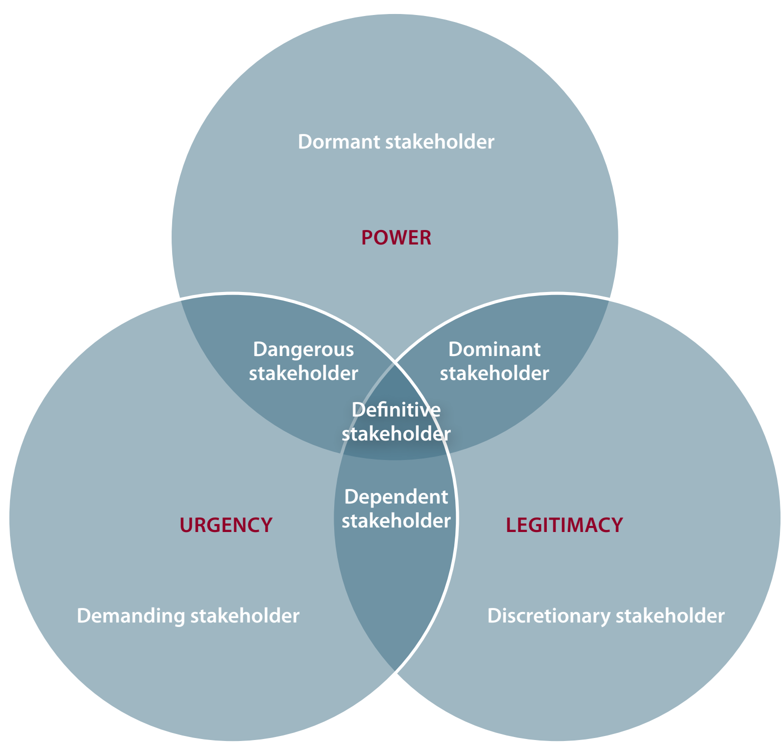

Figure B. Mitchell et al. (1997) framework for classification of stakeholders with the attributes of power, legitimacy and urgency.

Mitchell et al. (1997) define power as "a relationship among social actors in which one social actor A, can get other social actor B, to do something that B would not have otherwise done". Power can be coercive, utilitarian or normative in nature (Etzioni 1964). Coercive power is based on physical resources of force or threat, utilitarian power on material or financial resources, and normative power on symbolic influences like prestige, esteem, love and acceptance.

Legitimacy is defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions" (Mitchell et al. 1997, 869). Legitimacy is attained in a system with multiple-level analysis: individual, organizational and societal (Wood 1991).

Urgency is "the degree to which stakeholder claims call for immediate action" (Mitchell et al. 1997). Urgency as an attribute in stakeholder relationship exists only when relationship or claim is of time-sensitive nature and important or critical to the stakeholder.

Value creation approach to stakeholder identification (Cummings & Doh 2000)

Cummings & Doh (2000) present a complementary framework for the Mitchell et al. (1997) approach to stakeholder salience. They argue that it is necessary to understand the value-creation processes that stakeholders are part of, otherwise the key value creators of destroyers might be ignored and their power, legitimacy and urgency misjudged. The framework of Cummings & Doh (2000) for stakeholder identification, presented in Figure C, is based on stakeholder interaction within a company's three important value creation contexts: market, political/social and technological. Stakeholders are divided into customers, suppliers, competitors and complementors. In the political/social context suppliers are called policy-makers and customers are actors. In the technological context suppliers are called key adopters and customers are end-user adopters.

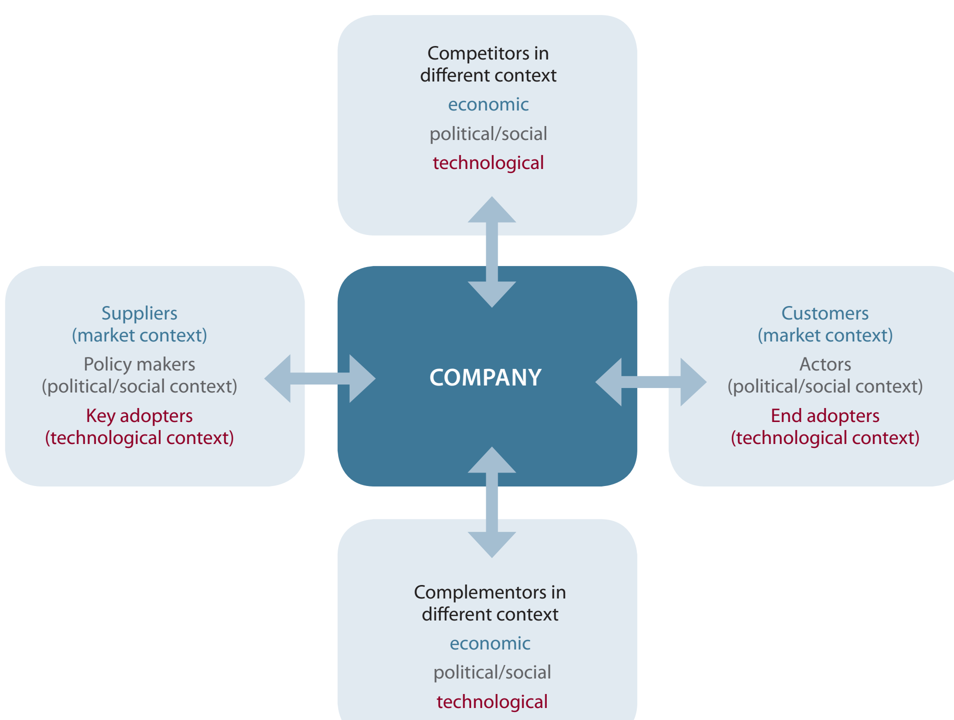

Figure C. Author's summary of Cummings & Doh (2000) value creation approach to stakeholder identification.

In order to succeed in the market context, companies need to add economic value by effectively and efficiently transforming capital, goods and labor inputs into products and services. Whereas in the political/social context, companies seek to gain political advantage through obtaining information from the key social actors about issues that might affect them, and then try to influence public policy through political activities. In order to enhance social legitimacy in the political/social context, companies seek to influence and respond to broad social actors and groups. Finally, in the technological context companies aim for dominance position in a technological system by persuading stakeholders to adopt their technology and the related business model.

Cummings & Doh (2000) argue that company wealth is increasingly dependent on intangible assets, in other words expertise and knowledge of the stakeholders and acceptance of the company's business model. Therefore, the importance of stakeholder value creation analysis in the technological context cannot be underestimated. And moreover, this kind of knowledge creation requires more complicated and non-traditional ways of learning.

In the political/social environment, Cummings & Doh (2000) claim that the key stakeholders are those that are able to influence the broader business environment and have a direct bearing on the company's competitive position within the industry. Social legitimacy process is a complex mixture of power and influence that involves many actors pursuing different interests.

Stakeholders' interest for interaction and learning as key criteria for identification (Antonacopoulou & Meric 2005)

Antonacopoulou & Meric (2005) argue that there is a need to extend stakeholder theory from contractual power relationships to examining stakeholder relations as knowledge relations. The approach to stakeholder analysis is value-creation like Cummings & Doh (2000) propose, but stakeholder interaction and mutual interests are at the core and contractual power relationships are turned into interdependency contracts emphasizing importance of pursuing mutual and collective interests. Knowledge and learning are not commodities to be exchanged, but rather feedback systems supporting and aiding different communities of practice.

Stakeholders interact because they share common interests and depend on each other to accomplish these. Knowledge and learning are the two key processes that influence the way stakeholder relations are formed. Learning partnerships consist not only of information dissemination but ways of understanding, insight, skills and expertise that lie both at individual and collective levels. Stakeholders are not only actors but interactors, because they are members of communities of practice and part of organizational learning process. Furthermore, stakeholder connections are both source and space for learning, and thus power of learning.

If stakeholders are defined as partners of a company's knowledge creation process and as important sources of learning, the identification of key stakeholders differs considerably from the analysis focusing on contractual power - interest relationships: "As far as learning is concerned, firms may take a greater advantage from non-instrumental stakeholders than from completely controllable ones." Antonacopoulou & Meric (2005, 135). The approach stems rather from building and maintaining interdependent relationships than management of stakeholders. This approach of managing connections and promoting interaction between stakeholders is at the core of social capital. The three dimensions of social capital, structural, relational and cognitive dimensions as defined by Nahapiet & Ghoshal (1998), reinforce the importance of interdependency between stakeholders.

Antonacopoulou & Meric (2005, 143) emphasize the importance of emotional and moral commitment in stakeholder relations with multiple and competing interests. Furthermore, the key role of reflexive critique in embracing learning for mutual benefit. They argue that reflexive critique encourages a mode of knowing that calls forth the situated nature of learning and that new methodologies are needed to encourage learning in inter-organizational collaboration. The researcher argues that these methodologies are participative action-research-oriented group communication methodologies. The situated nature of learning is elaborated by Senge et al. (2004) and presented explicitly as U-theory by Scharmer (2009).

APPENDIX 14: PHASES OF THEORY U AS A SOCIAL TECHNOLOGY (SUMMARIZED FROM SCHARMER 2009)

Co-initiating common intent

Listen to what life calls you to do through observing yourself and listening to others. Trust your heart intelligence. Engage in dialogue with interesting players in the field. Connect with people professionally and personally. Co-initiate a diverse core group that inspires a common intention. It is of key importance to select the right collaborators. Key decision makers, activists – people who would give life and soul –, people with little voice in the current system and key knowledge suppliers need to be involved.

Co-sensing the field of change

Form a highly committed prototyping core team for a certain period of time and clarify the essential questions. Take deep-dive learning journeys individually and with the group. Observe - use shadowing, participation and dialogue. Suspend the voice-of-judgment and connect with wonder. Practice deep listening. Use stakeholder dialogue interviews. Use participative working methods, for example World Café. They function as collective sensing organs that enable the system to see itself.

Co-presencing inspiration and common will

Let go and let come. Deal with three forms of resistance: voice-of-judgment, cynical view of situation (voice-of-cynism) and fear of letting go. In the classical language of virtue this equals to commitment to truth, love and courage. Individually and collaboratively, get the field of the past and future in ourselves to talk and listen to each other. Personal everyday practice – intentional silence or exercise - helps to connect to future resonance. And so does the love in what you do. Also, create circles of presence. Circles of presence are groups of 2 – 6 people that feel personally bonded and share a common intention of serving a global field from a certain perspective. The ideal meeting place is simple, beautiful and spacious with plenty of natural light. Develop a working process that suits the group. The basic building blocks are trust among participants, sharing of personal stories, cultivation of deep listening and intentional silence. The process is likely to change, when the group evolves.

Co-creating strategic microcosms

Crystallize your vision and intent. Energy follows attention. Therefore, the biggest leverage we have is what we pay attention to and how we attend a situation. Ability to set priorities and manage time is essential. Form core groups with high commitment. Commitment is the key issue. Move into action before you have figured out the entire plan forward. Prepare a prototype of the future that you want to create. By learning through failures, prototyping maximizes learning. Don't get stuck in the initial form of idea. Maybe it was just to get you going. Iterate and adapt.

In preparing prototypes, integrate head, heart and hand. Don't only think about it – feel it. In breakthrough innovations, the rational mind is usually the last participant on the scene. Be aware of three enemies: blind actionism (executing without improvisation and mindfulness), analysis paralysis (endless reflection without a will to act) and endless talking without connection to source and action.

Prototyping is a mini U-process: clarify intention, form a task force, engage with other practioners and places that matter, share learnings, reflect and listen to your inner source of inspiration, crystallize jointly the next step and involve other players to move forward.

Co-evolving through growing innovation ecosystems

After reviewing and assessing prototypes by various key stakeholders, the next step is to co-evolve the right kind of an institutional ecosystem and supporting infrastructure that operate from the generative Field 4 of social emergence, both individually and collectively. Mostly the institutional infrastructures that would bring together stakeholders who need one another to transform the system are currently missing. And there is a need to develop these infrastructures as the final phase of the U. A creative process needs a sheltered interior place (cocoon) from which something new can emerge. This means the physical space as well as the mental space. Collective awareness may be evolved through Field 4 media productions, in other words the social presencing theater. The social presencing theater synthesizes all creative arts, theater, social change techniques, energy awareness methods, contemplative practices, and dialogue. It turns the audience into co-creators.

APPENDIX 15: FEATURES OF A GROUP COMMUNICATION PROCESS AND POTENTIAL PROBLEMS

1. DEFINITION OF A SOCIAL GROUP AND THEORETICAL PERSPECTIVES

There are several types of social groups: reference group, social category, culture, crowd and working group, and consequently, variety of ways to define a social group (Stangor 2004). Members of a social group are meaningfully related to each other. Among features characterizing a group are actual and perceived similarity, feeling of belonging, interaction, interdependence, influence and group structure - norms, roles and status (Baron & Kerr 2003, Stangor 2004).

Forsyth (2010, 3) defines a group as follows: "two or more individuals who are connected by and within social relationships." Stangor (2004, 21 – 24) is also in favor of a broad conceptualization and suggests that entativity - the feeling or perception that a collection of individuals is a social group - is a factor that summarizes all the key features characterizing a group. Therefore, his definition of a social group is "a collection of three or more individuals who are perceived, by themselves or others, to be a group".

Baron & Kerr (2003) divide the theoretical perspectives explaining human reliance on groups into five theoretical aspects: conditioning and social comparison theories, social identity and self-categorization theories, exchange theory, socio biological theory, and optimal distinctiveness theory.

The conditioning perspective suggests that from infancy we learn to depend on others for comfort, food, information and love. Social approval is desired, because it is associated with a wide array of positive outcomes. (Baron & Kerr 2003)

Social comparison theory claims that we learn about ourselves through comparison with others (Festinger 1954; In: Baron & Kerr 2003, Stangor 2004). People group together to compare attitudes, beliefs, behaviors (Stangor 2004), opinions and ability-related performances to those of others (Baron & Kerr 2003). Thus, others are used to providing a basic understanding of social reality (Festinger 1954; In: Stangor 2004, 69).

According to social identity theory, self-image and self-esteem are heavily dependent upon the groups we identify with (Tajfel & Turner 1986; In: Baron & Kerr 2003). Self-categorization theory is also linked to social identity. It suggests that people consider themselves sometimes as individuals and sometimes as group members and group categories may become important to us and affect our sense of identity (Stangor 2004). However, group categories must be salient or noticeable to have this effect (Hogg et al. 1990 In: Baron & Kerr 2003).

Exchange theory provides a broad view of benefits associated with groups: "…people gain certain advantages through group membership and, therefore, individuals will try to join those groups that provide them with the greatest gains." (Baron & Kerr 2003, 3). In addition to benefits, group membership has also its costs: the time and effort spent, opportunities lost by belonging to the group, and emotional costs associated with group activity. However, if profit is greater than costs, then the individual is satisfied with the relationship.

Socio-biological theories on explaining human reliance on groups draw heavily on the work of Charles Darwin. They argue that grouping together has survival value. People in groups are able to protect themselves better from predators and enemies in groups than alone. And, co-operation for the purposes of farming, child-rearing, hunting and caring for the sick and injured brings benefits (Baumeister & Leary 1995, In: Baron & Kerr 2003).

Optimal distinctiveness theory suggests that humans seek to find a comfortable balance between the need to be socially cherished through belonging to a group and the desire to be distinctive (Brewer 1991, In: Baron & Kerr 2003).

2. FEATURES OF A GROUP PROCESS

Baron & Kerr (2003, 7) define group structure as "the way groups are organized and how various positions in the group are related". They include in the dimensions of group structure roles, status, subgroups and communication network and discuss norms as a separate item. Stangor (2004, 19) includes in the group dimensions norms, roles and status, and defines group structure as "the stable rules and relationships that define the appropriate rules and behaviors for group members". For Brown (2000, 67 – 122) the structural dimensions of a group are roles, status, communication networks and leadership.

In addition to group structure as described above, other aspects discussed in this Appendix regarding features of a group process are stages of group development and rewards and incentives including member satisfaction. Leadership is not treated as a separate item but is discussed together with different features of a group process. Subgroups are discussed as part of the communication network.

Norms

The social norm is a way of thinking, feeling or behaving in a way that is perceived as appropriate (Stangor 2004, 20) and therefore expected – and often demanded – from members of the group (Baron & Kerr 2003, 6). Baron & Kerr (2003, 6) point out that "such socially established shared beliefs regarding what is normal, correct, true, moral and good generally have powerful effects on the thoughts and actions of group members." The most important norms are those that define the basic values that group members believe in as well as their underlying goals and purposes (Bar-Tal 2000, Feldman 1984; In: Stangor 2004).

Norms in a group serve to reduce uncertainty imposed by an unpredictable or threatening environment. They are often critical for group success or failure, especially if involved in a group-external conflict. Codes of behavior also make social life more predictable and efficient. (Baron & Kerr 2003,7)

Roles

Members occupy different social roles in almost all long-term groups. Social roles, in other words expected behaviors associated with a given position, may be formal or informal (Baron & Kerr 2003). Informal roles fulfill psychological needs in the group. For example, the clown role relieves tension in the group. Stangor (2004, 21; 141 - 142) points out that a number of research projects have discovered that the two most common and important roles in a group are task role, to focus the group to get the task done, and socio-emotional role, to make the group happy.

People may have multiple roles that can lead to role conflict, when the demands of one role are incompatible with those of another. This leads to intellectual and psychological discomfort (Baron & Kerr 2003, Stangor 2004). Stereotypical expectations on gender roles may force individual women and men to play a role different from what they would prefer. The problem is particularly acute for women that are expected to play socio-emotional roles rather than task-oriented (Stangor 2004, 143 – 144). One more potential problem is role ambiguity, when the objectives or demands of the role are not clear to the person (Stangor 2004, 142). In order to avoid problems of role conflict and ambiguity, group leaders should clarify the expected role(s) of participants and make sure that competent women and men are equally encouraged to contribute to the group process (Stangor 2004, 142 – 144).

Most people are reluctant to confront authority, when they are placed in a subordinate role (Baron & Kerr 2003). As a result of pressure from an authority, people can often be pressured into committing a variety of costly, harmful, or even immoral actions if pressure is severe enough.

Status

Social roles are usually associated with different degrees of status. Status refers to the authority, prestige, or reputation of a group member in relationship to other members of the group. The status that one accrues as a result of being a member of a social category – for example age, gender or race – is called diffuse status. (Stangor 2004, 144 – 145).

When the forming stage is over and group members get to know each other, other forms of status become important (Stangor 2004, 144 – 145). Baron & Kerr (2003) argue that status is generally dependent on how crucial the contribution of the individual is to the success and prestige of the group, and how much control over group outcomes the individual has. Stangor (2004) classifies the theories presented to explain status into dominance contests, specific status and group norms. Members of a group may gain dominance status because of their dominance and activeness in social interaction, in other words, talking loud and a lot. Specific status is related to particular knowledge or skill that is important for accomplishing the task of the group. Furthermore, one method to gain status is to conform to group norms in behavior or to express positive feelings about the group.

Those high in status in a group generally have a stronger impact on group decisions than those lower in status (Stangor 2004, Baron & Kerr 2003). Individuals low in diffuse status are more often ignored, although they would offer intelligent and creative advice. One of the tasks of the leader is to ensure that people with low diffuse status are able to contribute to the group process (Stangor 2004).

Communication networks

Communication networks reflect the status and role characteristics of a group (Baron & Kerr 2003, 10 – 11). Communication networks in groups differ from their centralization (Baron & Kerr 2003, Scott 2000, Brown 2000). Baron & Kerr (2003, 10) and Brown (2000, 119) argue that in centralized communication networks, individuals in a central position often become leaders. They do not specify in detail what kind of centrality they mean, but by it seems that they primarily mean global centrality as defined by Scott (2000, 82 – 86).

The interactionist approach to behavior developed by Kurt Lewin suggests that human behavior, thus also openness of communication, is dependent on personal characteristics and influence of other people in the social environment (Stangor 2004, 11 – 12). Therefore, comments made by a group member are affected not only by his or her own beliefs, but also by what he or she thinks the others believe and how they will react to his or her opinions.

Stangor (2004) suggests that generally the more a group discusses the issue at hand, the better the quality of the group decision. However, this is only true if the group discusses the information that is pertinent to the task. Stangor (2004, 249 - 252) argues that time pressure, overwhelming amount of information and large group size are factors that are likely to increase problems in information sharing. Another difficulty is that groups may neglect discussing relevant information because of conformity pressures, or then they stop discussing prematurely and fall to the illusion of group effectivity.

Therefore, Stangor (2004, 249 - 252) suggests that one of the key tasks of the group leader is to have an impact on the social environment, as suggested by Kurt Lewin, and to foster an open climate that encourages equal participation and sharing of information. Furthermore, the task of the leader is to push the group to continue the discussion until he or she is convinced that all relevant information has been addressed.

A group may consist of subgroups based on, for example, similar interests, orientation, age or social role (Baron & Kerr 2003). Existence of cliques and subgroups is important because they have an impact on the flow of information that is important for decision making (Baron & Kerr 2003, Stangor 2004). The positive effect of subgroups is that they may provide a power base so that also minority positions gain consideration in the group. However, subgroups may also be a source of conflict (Baron & Kerr 2003). People high in status may form a subgroup from which they exclude those lower in status (Stangor 2004).

Stages of group development

Groups proceed through a variety of stages over time. Stangor (2004) classifies the theories describing stages of group formation into group-level and interactionist approaches. Group-level approaches propose that groups pass through a series of stages over their existence. The stages of a group are not always the same. Sometimes a phase may be avoided, while another phase may be repeated. (Wheelan 1994, Arrow 1997; In: Baron & Kerr 2003, 17). The interactionist approach argues that group development involves not only changes in the group, but changes in the relationship between individual members and the group (Lewine & Moreland 1994; In Stangor 2004, 135).

Tuckman & Jensen (1977; In: Baron & Kerr 2003, 17) is an example of a group-level approach to examining the stages of group development. In the forming stage group members are most concerned about being accepted and learning more about the group. When its members feel more secure, they start to confront their differences and vie for power. If the group gets over the conflicts – the storming phase – it develops some consensus about roles, status and procedures. This phase is called norming. In the performing stage the group is at its best concerning achieving its goals. Finally, in the phase of adjournment, the goals of the group are reached or dropped, and group experiences emotions associated with separation.

Planning, rewards and member satisfaction

Stangor (2004, 253) argues that satisfaction of group members is an important determinant concerning group outcome. If the participants feel that their input is valued, they have control over the planning of the group process, the given rewards are fair, and other members pleasant, they are likely to perform better. However, in too cohesive groups there is also a risk of becoming too sociable, or discussing rather shared than unshared information, because doing so makes people feel better about themselves and others.

Stangor (2004, 247) argues that the importance of planning is often overlooked when discussing features important for group performance. Research indicates that planning may have positive effects on group outcomes and satisfaction of members (Hackman & Morris 1975, Vinokur et al 1985 In: Stangor 2004). Setting of specific, difficult but attainable goals has been found to strongly relate to positive group performance. This is because clear but challenging goals improve co-operation, communication, commitment and possibilities for monitoring the results (Locke & Latham 1990, Weldon & Weingart 1993; In: Stangor 2004, 248-249).

3. POTENTIAL PROBLEMS OF A GROUP COMMUNICATION PROCESS

Group Conformity Pressures, Groupthink and Group Polarization

Janis (1972,9) defines groupthink as "a mode of thinking that people engage in when they are deeply involved in a cohesive-in-group, when the members' strivings for unanimity override their motivation to realistically appraise alternative courses of action". Stangor's (2004, 197) definition of groupthink is "a process that occurs when a group makes poor decisions as a result of a flawed group process and strong conformity pressures." Collins & O'Rourke (2009, 15) define groupthink as a phenomenon that occurs when members of the group publicly conform to beliefs that they may privately disagree with. Nahapiet & Ghoshal (1998) call the risk to groupthink as collective blindness: "Strong norms and mutual identification that may exert a powerful positive influence on group performance can, at the same time, limit its openness to information and to alternative ways of doing things, producing collective blindness that sometimes have disastrous consequences. (Nahapiet & Ghoshal 1998, 245)". The conformity pressure leading to groupthink may be a result of majority or minority influence (Schein 2006). Collins & O'Rourke (2009, 15) argue that minority can influence the majority especially when they are confident and unwavering in their position and do not have anything obvious to gain.

Asch (1952: In Bunker & Alban 1997) argues concerning groupthink that in conditions where people are identifiable and the situation is ambiguous in a sense that people have little confidence that they are making the right choice, and if a person is faced with a unanimous majority, people tend to go with the group rather than to state their own opinion. According to Stangor (2004, 197), the factors that increase the risk of groupthink are high cohesiveness and social identity of group, time pressure and stress, isolation from other sources of information and authorative leadership. The high conformity pressure limits discussion and members with conflicting opinions may not be given the opportunity to speak.

Baron & Kerr (2003) & Stangor (2004) point out that results concerning relation of cohesiveness and high social identity in causing groupthink are not unambiguous. The risk to groupthink is also dependent on the source of cohesion (Forsyth 2010). High cohesiveness and social identity of group also provide benefits in terms of commitment. If the group norm is to commit (Forsyth 2010), to be creative, and to spend time discussing, cohesiveness may lead to good decisions (Stangor 2004) if other conditions increasing the risk to groupthink are missing (Forsyth 2010). Interpersonal cohesiveness seems to increase the risk to groupthink (Forsyth 2010). In the early stages of group membership, groupthink may result from the desire to be accepted by an attractive group rather than cohesiveness per se (Longley & Pruitt 1980; In: Baron & Kerr 2003, 97).

Despite the great benefits and opportunities social capital creates, Nahapiet & Ghoshal (1998) and Nonaka et al. (2000) suggest that capital that is useful for facilitating certain activities may be harmful for others. Knowledge assets not only foster knowledge creation but can also hinder it. "Successful experience leads to excessive exploitation of the existing knowledge, and in turn hinders the exploration of new knowledge… Core capabilities may turn to core rigidities or a competence trap which hinders innovation rather than promotes it." (Nonaka et al. 2000, 25)

The proposed strategies for dealing with the dilemma of groupthink can be classified into two main categories: change of mode of communication from face-to face to anonymous interaction by applying the Delphi method (Turoff 1975; Hiltz & Turoff 1993; Kuusi 1999, 2003) and development of face-to-face group communication processes.

The suggestions for developing the group process to avoid groupthink include fostering of a culture of trust (Bunker & Alban 1997, Nahapiet & Ghoshal 1998, Forsyth 2010), truthfulness, courage (Heikkerö 2008) and openness (Nahapiet & Ghoshal 1998, Stangor 2004, Forsyth 2010), reserving plenty of time for discussion (Stangor 2004) including an analysis of pros and cons of all proposals (Forsyth 2010), more small group assignments (Nahapiet & Ghoshal 1998, Baron & Kerr 2003, Stangor 2004, Forsyth 2010), advising leaders not to advocate any one plan early in the discussion (Baron & Kerr 2003, Forsyth 2010), making members of group more openly accountable for their role in discussion (Baron & Kerr 2003, Forsyth 2010), openness to group-external knowledge (Baron & Kerr 2003, Stangor 2004, Forsyth 2010) and appreciating diversity and criticism (Nahapiet & Ghoshal 1998, Baron & Kerr 2003, Stangor 2004, Forsyth 2010) or even resorting to devil's advocate – an individual who is given a task to be critical and to express conflicting opinions in the group (Stangor 2004, Collins & O'Rourke 2009, Forsyth 2010).

It is noteworthy that when examining large group face-to-face group working methods like Future Search (Weisbord & Janoff 2000), World Café (Brown & Isaacs 2005) and Open Space (Owen 2008), most of the actual work takes place in small groups. Moreover, trust and shared context are emphasized as key ingredients for success. These are listed above as factors preventing the risk of groupthink.

Another process related to groupthink is the problem of group polarization (Baron & Kerr 2003). Forsyth (2010, 334) defines group polarization as "The tendency for members of a deliberating group to move to a more extreme position, with the direction of the shift determined by the majority or average of the members' predeliberation preferences." Group polarization can only occur if group members have an initial leaning toward a given opinion or decision, but this does not mean that it would necessarily occur (Baron & Kerr 2003, Stangor 2004).

Group polarization is the result of both normative and informational conformity and dependent on, for example, group structure and type of task (Stangor 2004). Group polarization may be more likely in tasks in which the individual group members are not themselves involved in the outcome of the decision (Baron et al. 1974). Various theories have been presented for explaining group polarization, but still more empirical evidence is needed to clarify factors that increase the risk of group polarization (Baron & Kerr 2003, Stangor 2004).

Sackman (1975) and Spears et al. (1990; In Baron & Kerr 2003, 102) argue that group polarization is a especially relevant problem in anonymous group communication when applying the Delphi method. Spears et al. (1990; In: Baron & Kerr 2003, 102) suggest that high group status increases the risk of group polarization. Thus, it seems that dealing with the problem of groupthink by switching the mode of communication from face-to-face to anonymous as suggested by Turoff (1975), Kuusi (1999, 2003), and Hiltz & Turoff (1993), is somewhat problematic, because of the increased risk of group polarization.

Group Motivation Losses

Groups as such are not demotivating, but under certain conditions individuals may suffer from loss of motivation (Baron & Kerr 2003, 66) and do not work as hard in the group as they do when they are alone (Stangor 2004, 221). Latané et al. (1979) introduced the term social loafing to describe loss of motivation when being in a group makes individual identification less likely. Furthermore, claimed that as group size increases, so does the risk of social loafing as well as problems in co-ordination.

Latané et al. (1979, 832) propose overcoming the risk of social loafing by intensifying the feeling of individual responsibility: "We think the cure will come from finding ways of channeling social forces so that the group can serve as a means of intensifying individual responsibility rather than diffusing it". Harkins (1987) argues that social loafing is not only reduced by making individuals more identifiable, but also individual effort needs to be evaluable. Stangor (2004, 223) divides the causes of social loafing into three categories: reasons related to group size and norms, reasons related to task attractiveness and significance, and reasons related to de-individuation and free riding.

Even if identifiability is low, the risk of social loafing can be diminished or eliminated if the individual finds the task attractive (Zaccaro 1984; In: Baron & Kerr 2003, 53; Stangor 2004, 224), group identity is strong (Stangor 2004, 224), group is cohesive enough (Worchel et al. 1998, In: Baron & Kerr 2003, 53) or if there are special costs for poor group performance (Baron & Kerr 2003, 52). Smith et al. (2001) suggest that people low in need for cognition are more eager for social loafing.

Free riding is a type of social loafing, when being in a group creates opportunities for letting the other group members do the work (Baron & Kerr 2003, Stangor 2004). Although free riding is a type of social loafing, the conditions under which it occurs are somewhat different from "the original loafing effect" (Baron & Kerr 2003, Stangor 2004). Individuals free ride if they think that their contribution does not matter. Anonymity increases the risk of free riding, because it removes the threat of social sanction for violating the norm of reciprocity and social responsibility (Baron & Kerr 2003, 57 – 58).

One more form of social loafing that is related to free riding is "the sucker effect" (Kerr 1983). The sucker effect may occur if an individual feels that she or he is being exploited by a free rider, and therefore as a means of equity she or he decides to reduce individual effort. However, if one has high capability and strong commitment to group outcome, it is also possible that one exerts exceptionally high effort to compensate the low capabilities of other group members. This is called social compensation (Baron & Kerr 2003, 63 – 65).

Paradox of chaos and control and task interdependence

Bunker & Alban (1997, 204 – 206) argue that one of the challenges in group communication of large groups is the paradox of chaos and control: both too much and too little task structure may lead to anxiety and acting out. They suggest that a clear task structure combined with individually-determined participation, like in Future Search, is an effective way to balance with chaos and control. Langfred (2000) suggests that autonomy has a positive influence on work group effectiveness when task interdependence is high and negative effect when task interdependence is low. An example of a large group working method with even more creative chaos and autonomy of participants than Future Search (Weisbord & Janoff 2000) is Open Space (Owen 2008). The key principle of Open Space is trust in people and their capability of self-organizing. Selection of participants is based on voluntary self-selection.

The researcher suggests that the knowledge creation theory of Nonaka & Takeuchi (1998) supports the findings of Bunker & Alban (1997) and Langfred (2000) indicating that autonomy of participants combined with clear shared intention and interdependence promotes knowledge creation. The dilemma of task structure becomes apparent in the "dialoguing Ba", when an individual's mental models and skills are shared and converted in face-to-face dialogue into common terms and articulated concepts. Nonaka et al. (2000, 17) suggest that "Selecting the individuals with the right mix of specific knowledge and capabilities is the key to managing knowledge creation in dialoguing Ba." Thus, it seems that the more autonomy is allowed in the group working process, the more important it is that the selected participants experience high task interdependence.

APPENDIX 16: STATISTICS ON FINNISH UNIVERSITIES PROVIDING ENGINEERING EDUCATION IN 2009

Source: KOTA-database, except for DIA-selection the Student Admission Committee of Engineering Discipline.

Statistics 2009	TKK / Aalto	TUT	LUT	OY	ÅA	UTU	UV
Number of students	14 384	11 241	4 330	4 128	661	459	418
Undergraduate students	11 856	9 761	3 860	3 567	512	414	386
FTE undergraduate students	7 841	6 381	2 575	2 319	341	275	248
Postgraduate students	2 528	1 480	470	561	149	45	32
Accepted students in joint DIA selection	1 216	967	354	468	49	70	56
Share of accepted students in joint DIA-selection	38%	41%	63%	52%	70%	37%	79%
Accepted students total	1 933	1 638	929	535	106	95	150
Enrolled students	1 375	1 100	658	336	58	65	75
Enrolled / Accepted	71%	67%	71%	63%	55%	68%	50%
M.Sc. Degrees	1 163	794	423	345	65	7	15
Lic.Sc. Degrees	43	10	5	2	2	2	0
D.Sc. Degrees	155	84	38	36	12	6	2
D.Sc. / M.Sc.	13%	11%	9%	10%	19%	86%	13%
Share of women of completed degrees in eng.	26%	25%	30%	21%	16%	16%	11%
Share of 2007 graduates unemployed 1 year after M.Sc. Degree	1.4%	2.7%	2.8%	3.6%	3.2%	nn	nn
Teaching staff (man years)	548	383	139	171	44	19	18
Undergraduates / teaching man years	22	26	28	21	12	22	21
FTE undergraduates / teaching man years	14	17	19	14	8	15	14
Research publications / teaching man years	5.1	4.3	4.5	3.5	10.4	5.3	2.3
Staff exchange: man years abroad / all man years	2.4%	2.6%	0.6%	2.6%	1.8%	0.0%	0.0%
Foreign staff man years / all man years	3.7%	10.8%	0.3%	13.4%	10.6%	0.4%	2.2%
Students abroad / undergraduate students	2.3%	2.3%	2.5%	2.6%	3.1%	0.5%	0.3%
International exchange students / undergrad.stud.	3.3%	4.0%	2.1%	3.6%	6.3%	0.0%	2.3%
Total expenditure (1 000 €)	261 579	133 613	53 508	57 252	21 749	6 980	3 995

Statistics 2009	TKK / Aalto	TUT	LUT	OY	ÅA	UTU	UV
Share of external funding	44%	40%	40%	44%	57%	49%	24%
Public funding in undergrad. education / student (€)	3 932	4 015	3 642	5 777	6 123	2 297	3 098
Public funding in undergrad. education / FTE student (€)	5 946	6 142	5 459	8 887	9 194	3 458	4 823
Total expenditure of undergrad. education / student (€)	4 474	4 627	4 048	5 977	6 822	2 556	3 269
Total expenditure of undergrad. education / FTE student (€)	6 765	7 078	6 068	9 194	10 243	3 847	5 089
Number of participants in continuing ed. (all disciplines)	7 681	2 235	1 380	4 249	8 840	6 759	1 000
Continuing education expenditure in eng. (1 000 €)	10 794	2 691	244	217	27	128	1
Continuing education expenditure total (1 000 €)	10 794	2 691	2 703	3 625	3 777	5 928	2 089
Continuing education share of external funding	77%	51%	65%	81%	51%	67%	42%

APPENDIX 17: INTAKE TO DIFFERENT DEGREE PROGRAMS OF ENGINEERING AT HEIs PROVIDING ENGINEERING IN FINLAND IN 2009

Data compiled from Allt, Korhonen-Yrjänheikki & Savolainen (2009)

Degree program	Total intake year 2009	Universities	Polytechnics
Information and communication technology	2 186	614: TUT (140+40), TKK (60 + 95), OY (120), LUT (50), UTU (40), ÅA (39), UV (30)	1 572: Metropolia (300), OAMK (150), TuAMK (148), JAMK (60+48), RAMK (85), VAMK (83), TAMK (80), Savonia (65), K-PAMK (60), MAMK (60), SAMK (55), LAMK (55), Saimaa (50), PKAMK (50), Arcada (40), KAJAK (40), KyAMK (40), Novia (38), SeAMK (35), HAMK (30)
Mechanical engineering / Machine design & production	1 554	440: TKK (170), OY (105), LUT (85), TUT (80)	1 114: OAMK (140), TuAMK (137), TAMK (100), SAMK (95), Metropolia (90), Savonia (75), SeAMK (60), Novia (52), Saimaa (50), LAMK (50), HAMK (50), K-PAMK (45), VAMK (40), K-TAMK(40), JAMK (30), P-HAMK(30), KAJAK (30)
Construction engineering	1 306	145: TUT (75), TKK (70)	1 161: Metropolia (120+60),TAMK (100+55), OAMK (105+35), Novia (79), TuAMK (67), Savonia (60), Saimaa (50), KyAMK (50), PKAMK (50), RAMK (50), SAMK (50), JAMK (40), SeAMK (40), MAMK (40), KAJAK (40), VAMK (40), HAMK (30)
Electronics & electrical engineering	1 120	435: TKK (165), OY (110), TUT (80), UV (50), LUT (30)	685: Metropolia (50+110), Savonia (40+38), TAMK (70), TuAMK (68), K-TAMK (67), SAMK (50), VAMK (50), Novia (42), MAMK (40), K-PAMK (40), PKAMK (20)
Industrial management	657	345: TUT(50+60), LUT (105), TKK (45+50), OY (35)	312: K-PAMK (60), Metropolia (55), HAMK (40), TuAMK (40), Novia (32), Savonia (30), K-TAMK (30), SAMK (25)
Environmental engineering	487	155: OY (45), TUT (40), TKK (40), LUT (30)	332: MAMK (55), HAMK (50), LAMK (50), Metropolia (40), PKAMK (35), TAMK (30), Savonia (30), VAMK (30), Novia (12)
Automation technology	375	135: TUT (75), TKK (60)	240: HAMK (40), Metropolia (40), SeAMK (40), OAMK (35), JAMK (30), Savonia (30), Novia (25)
Process, paper and textile engineering	369	172: OY (80), ÅA (72), TUT (20)	197: TAMK (85), Saimaa (50), JAMK (47), LAMK (15)
Biotechnology	299	84: TKK (49), TUT (25), UTU (10)	215: TuAMK (95), HAMK (45), Metropolia (40), SeAMK (35)
Chemical engineering	283	155: TKK (105), LUT (50)	128: K-PAMK (48), Metropolia (40), SAMK (40)
Media technology	225	0	225: Metropolia (110), K-PAMK (40), JAMK (30), HAMK (25), LAMK (20)
Car and transport technology	212	0	212: Metropolia (120), TuAMK (52), TAMK (40)
Energy technology	194	94: TKK (57), LUT (37)	100: KyAMK (60), Arcada (40)
Logistics	190	0	190: JAMK (85), HAMK (40), KyAMK (40), SAMK (25)
Materials engineering	180	135: TUT (70), TKK (65)	45: Metropolia (25), MAMK (20)
Forest technology	166	80: TKK (80)	86: LAMK (40), Savonia (26), KyAMK (20)
Applied physics	115	115: TKK (65), TUT (25+25)	0
Surveying and geomatics	115	35: TKK (35)	80: Metropolia (40), RAMK (40)
Welfare technology	80	0	80: Metropolia (30), OAMK (30), JAMK (20)
Plastics technology	75	0	75:Arcada (40), PKAMK (20), LAMK (15)
Fire officers, product development	60	0	60: Savonia (35), HAMK (25)
Maritime management	60	0	60: SAMK (45), KyAMK (15)

APPENDIX 18: SUMMARY OF EVALUATIONS OF FINLAND 2015 -SCENARIOS IN THE ARGUMENT DELPHI PANEL

This Appendix provides a summary of the Delphi panelists' evaluations of the probability and desirability of the Finland 2015 scenarios framed based on the thematic interviews in the first round of the Delphi study. Scenarios can be found in Appendix 1 that contains the questionnaire in the second round of the Delphi study regarding the development of the business environment. Panelists' evaluations of the presented core items list on each scenario is discussed in the analysis of the reliability and validity of the Argument Delphi in Chapter 3.2.3.

The median of the panelists' evaluations of the probability and desirability of the scenarios is presented in Table A. The probability of the Finland 2015 scenarios divided by the stakeholder group is presented in Table B. Desirability of the Finland 2015 scenarios divided by the stakeholder group is presented in Table C.

Panelists find the scenario "A global Information Society of materialistic values" the most probable scenario of Finland in 2015. 16 out of 21 panelists find the scenario probable (14 panelists) or highly probable (2 panelists). The scenario seems to describe a probable threat, since 18 out of 21 panelists are of the opinion that the scenario is undesirable (15 panelists) of highly undesirable (3 panelists).

The scenario "A Learning Society and global welfare" describes the kind of future development that the panelists would like to experience. All panelists find the scenario desirable (5 panelists) or highly desirable (16 panelists). However, with regard to the the probability of the scenario, panelist views differ. 10 panelists find the scenario probable and 10 panelists evaluate it as improbable (9 panelists) or highly improbable (1 panelist). Political decision makers are the most pessimistic: 4 out of 5 found the scenario improbable.

Change factors that are common to both scenarios "A global Information Society of materialistic values" and "A Learning Society and global welfare" are deepening globalization, growing importance of information and communication networks, the significant role of technology in societal development, competence, skills and learning among key factors of production, mobility of the population, and urbanization.

Although several change factors in the scenarios are shared, the resulting image of the future is, to a large extent different, due to the remarkable differences in the set of values. Different set of values lead to very different models of operation, for example, in educational, social and industrial policies.

The key difference between the scenarios are the views on welfare, plurality and interdisciplinarity. In the scenario "A global Information Society of materialistic values", society is characterized by strong emphasis on individual well-being at the expense of community welfare, intolerance and narrow-mindness. The definition of well-being is primarily limited to economic position. Whereas the future in the scenario "A Learning Society and global welfare" is characterized by plurality, tolerance, multiculturalism and multidisciplinarity. Mental well-being and spiritual values are important aspects alongside economic state.

Panelists find the scenarios "Slowing down the development of Information Society" and "Chaos, terrorism and environmental catastrophes" improbable and highly undesirable. 16 out of 21 panelists evaluate the scenario "Slowing down the development of the Information Society" improbable (13 panelists) or highly improbable (3 panelists). 20 out of 21 panelists find the scenario undesirable (8 panelists) or highly undesirable (12 panelists).

The scenario "Chaos, terrorism and environmental catastrophes" is evaluated as improbable (15 panelists) or highly improbable (4 panelists) by 19 out of 21 panelists. Two political decision makers find the scenario probable. All panelists are of the opinion that the scenario is either highly undesirable (19 panelists) or undesirable (2 panelists).

Table A. Median of the panelists' evaluations on the probability and desirability of the Finland 2015 scenarios.

Finland 2015 scenario	Probability (median)	Desirability (median)
1: Slowing down the development of the Information Society	improbable	highly undesirable
2: A global Information Society of materialistic values	probable	undesirable
3: A Learning Society and global welfare	probable / improbable	highly desirable
4: Chaos, terrorism and environmental catastrophes	improbable	highly undesirable

Table B. Probability of the Finland 2015 scenarios divided by the stakeholder group.

Stakeholders	Scenario 1: Slowing down the development of the Information Society	Scenario 2: A global Information Society of materialistic values	Scenario 3: A Learning Society and global welfare	Scenario 4: Chaos, terrorism and environmental catastrophes
university / polytechnics	probable (2/6) **improbable (4/6)**	**probable (5/6)** improbable (1/6)	**probable (4/6)** improbable (2/6)	**improbable (6/6)**
industry	probabale (1/6) **improbable (5/6)**	**probable (6/6)**	probable (3/6) improbable (2/6)	**improbable (6/6)**
political decision makers	**improbable (5/5)**	**probable (5/5)**	probable (1/5) **improbable (4/5)**	probable (2/5) **improbable (3/5)**
research organizations	probable (2/4) improbable (2/4)	**improbable (4/4)**	probable (2/4) improbable (2/4)	**improbable (4/4)**

Table C. Desirability of the Finland 2015 scenarios divided by the stakeholder group.

Stakeholders	Scenario 1: Slowing down the development of the Information Society	Scenario 2: A global Information Society of materialistic values	Scenario 3: A Learning Society and global welfare	Scenario 4: Chaos, terrorism and environmental catastrophes
university / polytechnics	**undesirable (6/6)**	desirable (2/6) **undesirable (4/6)**	**desirable (6/6)**	**undesirable (6/6)**
industry	**undesirable (6/6)**	**undesirable (5/6)**	**desirable (6/6)**	**undesirable (6/6)**
political decision makers	desirable (1/5) **undesirable (4/5)**	**undesirable (5/5)**	**desirable (5/5)**	**undesirable (5/5)**
research organizations	**undesirable (4/4)**	**undesirable (4/4)**	**desirable (4/4)**	**undesirable (4/4)**

The dissertation sheds light on how to develop the Finnish engineering education to face the anticipated challenges of the future based primarily on the views of the key stakeholders. The study can be regarded as a strategic prospective foresight study, the focus being on option and commitment reasonability. The theoretical discussion for developing the participant selection framework for a group communication process in the described context addresses the stakeholder concept and identification, creation of knowledge, and member and group characteristics.

The results of the study have high practical value for the development of the Finnish engineering education. The participant selection framework and the experiences gathered during the three group communication processes with stakeholders, are useful in developing engineering education also outside Finland. The researcher also contributes to the development of futures research methodologies by discussing the differences in knowledge creation between anonymous and face-to-face group communication methodologies. The study was conducted during 2001 – 10 as part of research and development projects on Finnish engineering education at Academic Engineers and Architects in Finland – TEK.

www.tek.fi/engineeringfuture.pdf

TEK
TEKNIIKAN AKATEEMISET

RATAVARTIJANKATU 2
00520 HELSINKI
(09) 229 121