Home Economics and Craft Studies Research Reports 40

Tarja-Kaarina Laamanen

Generating and transforming representations in design ideation

Academic dissertation,

To be publicly discussed,
by due permission of the Faculty of Behavioural Sciences at the University of Helsinki
in the Auditorium 229 at Helsinki University, Siltavuorenpenger 10,
on March 18th, 2016, at 12 o'clock.

2016
University of Helsinki
Faculty of Behavioural Sciences
Department of Teacher Education

Supervisors
Professor Pirita Seitamaa-Hakkarainen, University of Helsinki
Professor Kai Hakkarainen, University of Helsinki

Rewievers
Professor Matti Vartiainen, Aalto University
Associate Professor, Mia Porko-Hudd, Åbo Akademi University

Opponent
Associate Professor, Marte S. Gulliksen, University College of Southeast Norway

Layout: Miia Venermo

ISBN 978-951-51-1947-6 (pbk)
ISBN 978-951-51-1948-3 (PDF)
ISSN-L 1798-713X
ISSN 1798-713X

Unigrafia, Helsinki 2016

Abstract

The complexity of the current world is contributing to an increased dependency on innovative approaches and competences for solving open-ended problems and adjusting to multi-layered work environments. Creative ideation is valued not only in traditional creative fields such as design, craft and art, but also in all areas of work life. In design ideation the focus is on seeing beyond the obvious and developing personal constraints on the design task. Therefore, it can be seen as increasing the creativity in problem solving in general. Ideation is important as it is the basis for the rest of the design process. However, the research concerning design ideation is still sparse in Finland, as previous research has emphasised the entire design process. Accordingly there is lack of knowledge, concepts and definitions of ideation to support communication in designing and design education.

The aim of this study was to understand design ideation and aspects that inspire and guide designers in the idea generation process. The study explored the conceptual and material premises for ideation, ways of creating novel standpoints towards ideation and the nature of the design context. The study used multiple qualitative methods; data were collected from a virtual e-learning database, by interviewing and using a mobile, context-sensitive data-collecting tool. The data-analyses applied qualitative content analysis.

The study explored student teachers' and professional designers' design thinking in the ideation focusing on material resources and materially embodied practices for generating and transforming representations. The findings illustrated that interpreting sources of inspiration requires processes such as the use of analogical thinking and abstraction. In addition, creative ideation is a gradual development of ideas. The designer constrains the design situation through creation of visual-material ideas until a suitable idea(s) emerge.

The findings encourage viewing design ideation as a multi-modal process in which representations are important triggers for ideation. The exploratory process of generating and transforming representations is a holistic making-related activity that is best supported by interaction with peers and different types of externalization methods. The study proposes two objectives that design tasks in education should address. Firstly, the ideation phase should include deliberate practices and a variety of techniques for manipulating representations to develop visual ideas. Secondly, the ideation process should embed meaning-making for personal engagement and exploration to pursue ideation towards wider contexts of learning.

Keywords: Idea generation, design representations, design practices, creativity, materiality, design learning

Tiivistelmä

Maailman monimutkaistuessa tarve innovatiivisille lähestymistavoille ja avoimien ongelmien ratkaisutaidoille työelämässä kasvaa. Ideointitaitoa arvostetaan perinteisillä luovilla aloilla kuten muotoilussa, käsityössä ja taiteessa, mutta myös työelämässä yleisesti. Suunnittelun ideointivaiheessa tavoite on ilmiselvien ratkaisujen välttäminen ja suunnittelua sääteleviä tekijöiden löytäminen rajaamaan suunnittelua. Siksi ideointi tarjoaa mahdollisuuden ongelmanratkaisutaitojen kehittämiseen yleiselläkin tasolla.

Ideointi on tärkeä lähtökohta suunnitteluprosessille. Suunnittelun ideointivaihetta on tutkittu Suomessa vähän. Suunnittelua koskevan tutkimuksen painotus on ollut koko suunnitteluprosessin tutkimuksessa. Siten suunnittelun ideointivaiheesta ei ole ollut vielä tarpeeksi eriteltyä tietoa, käsitteitä tai määritelmiä kommunikaation tueksi suunnittelussa ja sen opetuksessa.

Tämän tutkimuksen tavoitteena oli ymmärtää suunnittelun ideointia sekä niitä tekijöitä inspiroi ja ohjaa ideoiden synnyttämisessä. Tutkimus kohdistui ideoinnin käsitteellisiin ja materiaalisiin lähtökohtiin, luoviin tapoihin lähestyä suunnittelutehtävää, sekä suunnittelun kontekstin luonteeseen. Tutkimus oli monimenetelmäinen. Aineisto kerättiin virtuaaliselta oppimisalustalta, haastattelemalla sekä käyttämällä kontekstisensitiivistä mobiilisovellusta. Aineisto analysoitiin laadullisella sisällönanalyysillä.

Tutkimuksessa tutkittiin opettajaopiskelijoiden ja muotoilijoiden suunnitteluajattelua ideointivaiheessa. Tutkimuksen näkökulma kohdistui suunnittelun ideoinnin materiaalisiin resursseihin sekä käytänteisiin, joita suunnittelijat hyödyntävät työstäessään representaatioita. Tulokset havainnollistavat, että inspiraationlähteitä muokataan luovasti analogisen ja abstraktin ajattelun avulla. Lisäksi ideointi on vähittäistä ideoiden kehittämistä. Ideointiprosessissa visuaalismateriaalinen tutkimus tuottaa representaatioita, joilla suunnittelija rajaa suunnittelutilannetta kunnes alkuidea tai ideoita syntyy.

Tutkimuksen tulokset rohkaisevat näkemään ideoinnin monimateriaalisena ja –aistisena prosessina, jossa representaatiot ovat tärkeitä inspiraation laukaisijoita. Representaatioiden muokkausprosessi on kokonaisvaltaista käsityöllistä tekemistä, jota tukee parhaiten ryhmässä tapahtuva suunnittelu sekä erilaiset ulkoistamisen keinot. Tutkimuksen tuloksista esitettiin kaksi päätelmää suunnittelun opetuksen kontekstiin. Suunnittelun tehtävien tulisi ensinnäkin tukea tarkoituksenmukaisia suunnittelun käytänteitä ja sisältää erilaisia tekniikoita ideoiden visuaaliseen tuottamiseen. Toiseksi, ideoinnin tulisi tähdätä merkitysten tuottamiseen, jotta henkilökohtainen sitoutuminen ja kokeileva ote kantaisi suunnittelukohdetta laajempiin oppimisen konteksteihin.

Avainsanat*:* Suunnittelun ideointi, suunnittelun representaatiot, suunnittelukäytänteet, luovuus, materiaalisuus, suunnittelun oppiminen

Acknowledgements

To start a PhD degree studies was an easy and exciting decision. However, I did not at the time understand what kind of a journey I was about to take, nor did I have a clear map to follow. This project was an example of an open-ended design process that required constraints and a lot of guidance along the way.

I was privileged to work with two experts who were knowledgeable, enthusiastic, and inspiring supervisors. I owe my deepest gratitude to Professor Pirita Seitamaa-Hakkarainen for patience and endless supervision that made possible for me to conduct and finish this project. I thank Professor Kai Hakkarainen of insightful discussions, comments and theoretical instruction. Your door was always open: you both listened and you advised.

The Craft Studies education was very many years the home unit where I studied and occasionally also worked as university lecturer. I wish to thank all former colleagues and my teachers Kirsti Salo-Mattila and Marja Anttila who in the first place believed in me and encouraged to proceed with the doctoral studies. I also have been very fortunate to have such a positive seminar group of fellow doctoral students. You have provided valuable comments and insights during this journey. I thank my university "room mates" Päivi Fernström and Tellervo Härkki for sharing the everyday anxieties as well as the moments of joy related to research process as well as to life in general. I would also like to thank my dear friends Anna Kouhia and Hanna Kuusisaari for being part of my life both supporting me within and outside the academic world.

The pre-examiners of my thesis, Professor Matti Vartiainen, Aalto University and Mia Porko-Hudd, Åbo Akademi University, I thank for constructive, encouraging, and valuable feedback. I am also grateful to the family member and academic expert Markku Jokisaari of all discussions during these years and for his recent remarks, which improved my thesis.

This thesis could have not been possible without the students and designers who participated to this study and kindly devoted their time and energy for the research purposes. I also thank the teacher of the Experiential textile design module Ana Nuutinen. I learned from you all, thank you very much. I would also like to thank Kari Salo for providing the technical support with CASS, it was very important.

Very crucial to this thesis were the personal grants from the Jenny and Antti Wihuri Foundation, the Finnish Cultural Foundation as well as the Alfred Kordelin Foundation. In addition the Academy of Finland project "Handling Mind, Embodiment, Creativity and Design (#1265922)" provided not only financial support, but also inspiring collaboration opportunities. I also wish to thank the Aino-home Foundation (Aino-koti säätiö) for covering the costs of portable laptop.

My deepest gratitude goes to my friends and family outside the academia. During these doctoral studies and in life in general there have been ups and downs, but you have stood beside me. Titta, I thank you from the bottom of my heart as well as my friends already from the childhood and teenage; Jake, Miia, Niina and Anu. I am grateful to Miia also for designing the layout and cover on top of her usual work. Armi, I thank you for sharing your experience, wisdom and being a role model. Eeva, thank you being a colleague and friend, its nice to have you back in Finland. I thank you all for the good times.

I am so lucky of having such a great family. I thank my parents for providing me a creative environment to grow up. Your acknowledgement for crafts, hard work, reason and respect to the nature has been a great influence. I hope to follow these values in my life and work. I am deeply thankful to my sisters and their families. I feel gratitude of our understanding and support to each other. Jarno, I thank you for all these years, I love you.

Helsinki, February 2016

Tarja-Kaarina Laamanen

List of original publications

This dissertation is based on the following publications, which are referred to in the text by their corresponding roman numerals (I-V)

I Laamanen, T-K., & Seitamaa-Hakkarainen, P. (2008). Sources of inspiration and mental image in textile design process. *Art, Design and Communication in Higher Education, 7*(2), 109–119.

II Laamanen, T-K., & Seitamaa-Hakkaranen, P. (2014). Constraing the open-ended design task by interpreting sources of inspiration. *Art, Design and Communication in Higher Education, 13*(2), *135–156.*

III Laamanen, T-K., & Seitamaa-Hakkaranen, P. (2014). Interview study of professional designers' ideation approaches. *The Design Journal, 17*(2), 194–217.

IV Laamanen, T-K., Seitamaa-Hakkarainen, P., & Hakkaranen, K. (2014). Tracing design work trough contextual activity sampling. In M. Aaron (Ed.), *Design, User Experience and Usability: Theories, Methods and Tools. Lecture Notes in Computer Science Vol. 8517* (pp. 142–152). Proceedings of the Third International Conference, DUXU 2014 held as Part of HCI International 2014, Crete, Greece.

V Seitamaa-Hakkarainen, P., Laamanen, T-K., Viitala, J., & Mäkelä, M. (2013). Materiality and emotions in making. *Techne Series: Research in Sloyd Education and Craft Science A. 20, 3, 5–19.*[1]

[1] The article overviews two studies. Tarja-Kaarina Laamanen was responsible of the data collecting, analysis and interpretation of the results concerning her respective study. Jemina Viitala was responsible responsible of the data collecting, analysis and interpretation of the results concerning her respective study. Pirita Seitamaa-Hakkarainen and Tarja-Kaarina Laamanen wrote the article together with Jemina Viitala and Maarit Mäkelä.

Contents

1 Introduction

1.1 Design as a context for thinking, doing and learning

Humans change their environment as well as create and transform it. Creations are practical, but embody and express meanings. Thereby, environments have become a complex of ideas, institutions, knowledge, communications, systems, things, and places (Baynes, 2009). Designers have to use more and more advanced tools in their daily practices, integrate knowledge across many disciplines and take part in solving complicated problems that may be beyond their trained field of expertise (Hakkarainen, Palonen, Paavola & Lehtinen, 2004). Besides professional designers, other professionals in many knowledge-intensive and creative occupations engage in such creative activities. Moreover, the emerging "maker culture" (Anderson, 2012) enables ordinary people to pursue various craft- and design-related interests as hobbies. Such societal transformations highlight the importance of in-depth understanding of design processes.

Design is a line of creative activity that can be utilized in all areas of human life. It is a combination of doing and thinking, based on exploratory and investigative practices and processes. Open-ended design tasks are complex and often do not have enough constraints for posing immediate solutions. Therefore, the design process often involves gradual knowledge gathering, iterative efforts of examining tasks from different angles as well as testing various solutions from different directions (Dorst, 2006). It requires cognitive efforts that go beyond the given information. Therefore, design thinking has the potential to suggest imaginative and apposite solutions that, at their best, resolve conflicts and uncertainties (Cross, 2011). There is an increasing awareness of the impact of design decisions on economies, the environment and societies (Welch & Loy, 2013). On the one hand, culture is dependent on professional designers that are competent in dealing with open-ended situations and framing them to suggest possible solutions. On the other hand, citizens, policy makers and other stakeholders have important, although different, roles as users, collaborators and facilitators of design. They should be provided with a general understanding of designing to support more informed and sustainable participation and related choices and decisions.

The present investigation aims at understanding design by examining the earliest phases of the design process. Many critical decisions are made in the early phases of design, where the design situation is initially framed and *the design idea,* the soul of the final outcome, is generated. During the early phases initial directions emerge for addressing the principal questions of design, such as why this is a meaningful idea or solution, why is such a design worth pursuing, and how it satisfies the needs of (potential) customers. An analysis of such issues is

critical because the western countries have developed since the industrial revolution towards producing and consuming increasing numbers of products with accelerating speed, in many ways jeopardizing life for future generations. When facing diminishing material and energy resources, societies must reflect on the reasons and justifications behind every design (Fletcher, 2008). Beyond considerations of technological advancement, concurrent practices of design and education must address contemporary ethical and environmental changes (Cassim, 2013).

The fundamental aspect of an early phase of designing is called ideation, which means using various sources of inspiration to envision potential design ideas and solutions creatively meeting given design constraints. To ideate, as well as to design, is a task common to everyone to some extent. However, to ideate innovative artefacts or other complex creative and constructions for serving specific needs is a challenging task requiring years of professional design training. Design ideation is demanding because of its creative goal of invention and discovery; it requires that the designer perceive situations in new ways, find hidden patterns and connections between seemingly unrelated phenomena and figure out novel and sometimes highly original solutions. It is critical to examine to what extent design ideation can be practised and trained.

However, sometimes creative process connotes uncontrolled and accidental occurrences in the mind. It is also a common belief that creativity is an inherited gift of the lucky few (see Boden, 2004). Design and ideation, in particular, are viewed through these myths perhaps because the phenomenon of ideation is partly invisible; there is a lack of definitions, concepts, and language for communicating the skills, knowledge, and practices of design ideation. Therefore, research on design ideation is vital for a more educated understanding of designing.

In the present study, design ideation is seen as a process for generating and transforming representations. Psychological research defines representation as any notation or sign or set of symbols that "re-presents" something (Eysenk & Keane, 2000; Boden, 2004). Generally, "it stands for something in the absence of that thing or perhaps substitutes that thing; typically that is some thing or human created artefact in the external world or an object of the imagination" (i.e., the internal world) (Eysenk & Keane, 2000, p. 244). External representations are referred to as either written or graphical inscriptions (Eysenk & Keane, 2000; Zhang, 2001). In design, representation is a visual or material construction, such as a plan-program, concrete image, or prototype (or mock up) of an artefact being designed (Schön, 1983). In the process of design, such external representations dynamically interact with internal representations that are mental constructions on which design thinking relies. For designers, manipulating representations is like having a conversation with the developing design object. It is an activity that advances design thinking (Visser, 2006). Therefore, composing

and decomposing external representations is essential for the development of domain-specific knowledge in designing (Lawson, 2004; Eastman, 2001; Goldschmidt, 1997). Studying ideation involves examining interplay between internal and external representation; the latter inspires and concretizes, materializes and embodies ideas that evolve in the creative design process. Hence, ideation serves as a context for learning materially mediated ways for creating new knowledge to constrain and frame the design process. This creation process opens a possibility to learn skills needed in the domain of designing.

1.2 Enhancing design ideation practices in textiles teacher education

Design education is conducted under variety types of pedagogical contexts in Finland. Higher education for professional designers involves completing a bachelor's level degree in designing at universities of applied sciences or a master's level degree in design universities. In both contexts, students become socialised into the industrial design process. They focus primarily on conceptual design, which includes ideating and manipulating representations (such as drawing, modelling and prototyping) of the design object and designing the final solution that meets the relevant constraints. They become designers for different fields of industry or stay freelance designers, who interact and collaborate with several stakeholders during the design process.

In higher education of textile teachers, students do not become designers, but desiging is an important and integrated part of their education. The textile teacher students are expected to learn the holistic process of making crafts (Kojonkoski-Rännäli, 1995; Pöllänen, 2009; 2011), which includes the generation of ideas, designing, the mastery of techniques and the production of visual and material artefacts as well as a reflective evaluation of the process. In addition, textile teachers are given pedagogical training for constructing their identities as future craft teachers (see Collanus, Kairavuori & Rusanen, 2012). Textile teachers receive a master's degree and become qualified for teaching crafts and craft-based designing from comprehensive schools to adult education. Therefore, craft teaching plays a crucial role in transmitting to young people the basic competencies of design.

Textile teacher education is a part of general teacher education in Finland and it is research-based in nature. It means that teaching is built upon high quality research and that the research is a basis for organizing the education programme (Nygren-Landgärds, 2000). The future National Core Curriculum 2014 underlines various kinds of design tasks and utilization of multimodal experiences as a part of ideation. In addition, the importance of documenting the designing and making processes is emphasized (FNBE, 2014).

Textile teacher education should be capable of preparing craft teacher students for meeting these ambitious goals that highlight holistic, inquiry-based learning where different types of materials are the basis for pursuing craft expression, design and technology based activity. Therefore, an urgent need emerges for gaining a deeper understanding of how ideas are generated and how students' ideation processes can be encouraged and supported. Design ideation is especially difficult for novices, yet the practices that would facilitate the search for inspiration and generation of initial ideas are not necessarily taught in a consistent manner. Therefore, it is important for craft teacher students to learn a *design thinking process* and engage themselves in solving the authentic design tasks. The growth of design capability proceeds gradually in environments that foster creative working and thinking such as knowledge gathering and constraining open-ended design tasks that is typical of expert designers and their communities (Sawyer, 2012).

In general, the very nature of designing requires a prospective designer to throw him- or herself into the unknown, instead of settling into already known patterns. This requires a great deal from the teacher: accepting uncertainty, maintaining motivation and engagement in spite of initial frustrations and fitting the open design tasks into restricted time, space and material resources. Similar to the previous Finnish national core curriculum 2004, the new one does not give straightforward instructions for pedagogical models or define materials or techniques to be used (Pöllänen, 2009). It provides a flexible framework for conducting teaching in schools. Finnish teachers have significant responsibility as well as freedom in preparing the school curriculum and organizing learning (Collanus, Rusanen & Kairavuori, 2012; see also, Hargreaves & Shirley, 2009). Therefore, teachers are themselves pedagogic designers who face open-ended design situations and potentially experience a lack of support in planning. There still appears to be a gap between curriculum demands and actual practices (Syrjäläinen & Seitamaa-Hakkarainen, 2014). One of the obstacles still might be the fear of failing, which discourages the risk taking and playful attitude necessary in designing. This may lead teachers to use familiar, ready-made models and instructions for students to execute. These types of practices reinforce the conventional ways of making rather than revive traditions or invent new modes.

In this study, I will integrate various theoretical perspectives concerning design research and report empirical studies aimed at examining design ideation. Having an understanding of professional ideation practices may assist and encourage educators to support ideation related practices in shaping their pedagogies.

1.3 Objectives and aims of the study

To meet the current needs presented above, the overall aim in this dissertation is to understand the role of ideation in the design process. I will approach this aim by studying the generation of design ideas in educational and professional contexts. The general objective is to understand how designers and students generate ideas. More specific objectives are to: i) specify the role of representations in participants' design ideation process, ii) investigate the participants' ways of framing the idea spaces explored and their approaches to ideation and iii) examine the tools and materials designers used in everyday design activities and their emotional experiences.

Creativity and materiality are intertwined areas that create background for my research on ideation. Materiality involves physical and sensory aspects of making and designing, as well as materials, artefacts, and objects, their usage, and their immaterial purposes and meanings. According to Nigel Cross, "Designers are immersed in material culture, and draw upon it as their primary source of their thinking" (2006, p. 9). Within frames of cognitive research, creativity is examined as a process of generating and transforming representations (Boden, 2004) that beyond mental constructions is increasingly seen to also involve using external and materially embodied textual, visual, or concrete epistemic artefacts (Kirsh, 2011; Zhang, 2001). Beyond being abstract ideas (meaningful mental entities), such artefacts become successively materially embodied in the design process. Thereby, the emerging contextual research on design ideation has emphasised the physical and material settings of the design ideation. Designers use various internal, external, personal and social resources for extending and transforming representations in a way that enriches and advances design ideas. The importance of cultural knowledge, tools, and practices in design activity is highlighted by various sociocultural approaches on design (Ewenstein & Whyte, 2007; 2009; Tan & Melles, 2010).

Creative working with diverse representations in the ideation process may be seen as a central aspect of cultivated design practice. Design takes place in social communities and relies on physical artefacts and tools as mediators in creative design ideation practices. The key theme of this thesis is the design as a creation of novelty and innovation in and through materially oriented practices and a materially constrained environment. The perspective of the distributed and embodied cognition (Hutchins, 1995) has great potential to break the mind-centred and individually focused comprehension of ideation. In this study, ideation is understood as a part of the exploratory process of making.

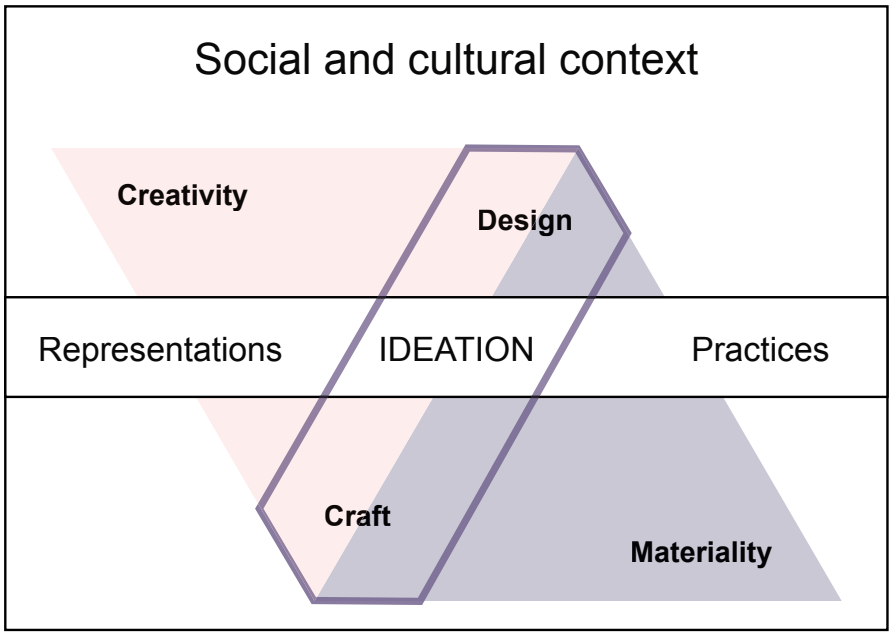

Figure 1. Conceptual framework of the study

Figure 1 depicts the conceptual framework of the present dissertation. The research focus *design ideation* is in the middle of broader topics. Creativity and materiality create theoretical background for the present study. Materiality is seen to consist physical and sensory aspects of making as well as the use of tools and artefacts and related meanings. Creativity includes here psychological processes of seeing design tasks in novel ways as well as the creative environment influencing creative processes. Craft and design are joint fields of study where the topic of design ideation is seen as very central. The present study is focused on the practices of generating and transforming representations in idea generation in individual designers' processes. However, different interactions and communication situations are central to design practices and have significant importance for the ideation. The work of the designer appears as a mixture of individual work, asynchronous communication, face-to-face meetings and interaction with design materials and tools (Bucciarelli, 2002; Ewenstein & Whyte, 2007). Therefore, the design ideation emerges and is supported by the social and cultural context presented on top of the conceptual framework (see Figure 1).

Ideation is an integral part of the craft design process and constitutes a central aspect of everyday craft practices. However, systematic research on ideation in craft science is still sparse. The research has focused on analysing the whole design process (see Anttila, 1996; Lindfors, 1991; Seitamaa-Hakkarainen, 2000; Seitamaa-Hakkarainen & Hakkarainen, 2001; Sjöberg, 2009) from the generation of initial ideas to the creation of mock-ups and prototypes to the production of final designs and assessment of the overall process. The present investigation

aims to contribute to research on design ideation, thus extending prevailing analyses of the craft science to better account for the early phases of designing.

The research focus is design ideation and related representations and practices. Knowledge of design ideation has been recently extended in the field of industrial and technical design research (e.g., Eckert & Stacey, 1998; Goldschmidt & Smolkov, 2006; Jonson, 2005; Keller, Pasman & Stappers, 2006; Petre, Sharp & Johnson, 2006; Perttula & Sipilä, 2007) as well as design education research (Dazkir, Mower, Reddy-Best & Pedersen, 2013; Rodgers & Milton, 2001; Reading, 2009; Stones & Cassidy, 2010). These ideation studies have focused on tools and practices in the early phases of design, the usage of sources of inspiration, mental images in ideation and the role of previous experience. In line with that research, my aim is to identify and analyse the practices of ideation and the role of materials, visuals, verbalizations and related mental images as representations that direct and inspire the designer in the ideation phase.

This dissertation has two parts. The first part includes an introduction, theoretical framework, research questions, research design, results and general discussion of the study. The second part includes the five original articles. *Publication I* focused on multimodal sources of inspiration and external representations in order to understand the emergence of mental images in textile design in the context of teacher education. *Publication II* studied in more detail the interpretation of representations, creation of novel ideas and ways of reducing the openness of the design situation with material and conceptual practices in the context of textile teacher education. *Publication III* extended understanding of the usage of design representations and practices in framing the idea space by identifying designers' approaches to ideation. *Publications IV* and *V* studied the real- time design activities and analysed the possibilities of using the Contextual Activity Sampling System (CASS) data collecting method and tool.

2 Origin of ideas in design

2.1 Creative processes explaining ideation

Design ideation is traditionally considered the most creative and abstract aspect of the design process because it is inherently related to the imagination. While creating ideas is a common feature of daily life, ideation has challenged researchers since the time of the ancient philosophers. Creativity is difficult to comprehensively define because of its diverse expression; it is potentially involved in every type of activity that humans encounter (Runco, 2014; Welling, 2007). Nevertheless, novelty and practicality are the most common defining characteristics of creativity (Boden, 2004; Goldchmidt & Tatsa, 2005; Welling, 2007). In addition, some ideas are identified as more creative than others in terms of separating individual creativity and societal creativity from one another (Stenberg & Lubart, 1999). According to Robert Stenberg and Todd Lubart (1999) societal creativity is relevant for the society in previously unseen ways, leading for example scientific findings or new art movements. Individual creativity is valuable in everyday life and can be seen as capability of coming up with novel and useful solution for the problem, even though it was generated somewhere else previously (Stenberg & Lubart, 1999). Designers' creativity often extends everyday individual creativity having interaction and impact also on societal level.

Creativity is traditionally seen to appear either in creative people, a creative process, a creative product or a creative (social) context (Welling, 2007). Here the main focus is on the creative processes that facilitate and explain ideation and the processes that support the growth of creativity in design. I will highlight psychological processes of interpreting the prevailing design task in novel ways. However, the creative context is obviously the basis for nurturing these processes. The context refers to the external conditions that are physical, social and cultural frames of human relations in accordance with mechanisms, technologies and resources with which the product is made and the design process is managed (Eastman, 2001).

The ideation phase of designing is open-ended and the capability of going beyond the obvious is important. It can mean articulating and developing ideas from concepts and images found far from the design field (Goldschmidt, 2003). When a designer connects ideas from very different sources for a successful design, it would appear as a very mystical leap within an individual creative mind. In general, creative ideas are often understood as features or products of individual creative abilities, such as idea fluency (Boden, 2004). In fact, designers are embedded in a social and cultural environment that provides multifaceted inspirations that shape the creative process in various ways. Design ac-

tivity takes various forms depending on the type of design situation; specific forms are related to the designer, the artifact and other task variables that characterize and frame the activity (Visser, 2006; see also Cross, 2006).

However, the individual conception of creativity has deep historical roots. Nigel Thomas (1999) illustrate that the romantic view enforced the mythical idea of creative genius and the human as an enclosed system. Later, at the beginning of the 20th century, only objectively observed behaviour was allowed as a research target. Behaviourism denied imaginative processes as being too subjective for systematic academic research (Thomas, 1999). Research focused on observing behaviour in pre-set conditions, such as exposing animals and even humans to various positive or negative stimuli for the purpose of observing the responses and changes in their behaviour. Problem solving was seen as trial and error or reproduction of previously learned responses (Thorndike, 1911). However, Gestalt psychology (Duncker, 1926; 1945; Köhler, 1927; Wertheimer, 1954) revealed that rather than reproduction of learned responses, both animal and human problem solving includes insight, problem restructuring and mental leaps (Eysenk & Keane, 2000). Their investigations documented a human tendency to fixate functionally on certain ways of representing a problem as well as sudden qualitative transformations of problem representation; the latter plays a crucial role in insightful problem solving.

Although their efforts deepened understanding of various aspects of creative problem solving, many investigators did not accept that the gestalt switch (i.e., sudden transition from one to another ways of seeing a design situation) truly explained the ideation process. It was the contribution of Simon and his colleagues that provided a detailed account of the highly selective heuristic trial and effort process that characterizes problem solving of highly trained experts (Newell & Simon, 1972). Thus, the emergence of a cognitive revolution advanced significantly research on mental processes critical for understanding creative problem-solving in general and the construction and transformation of mental representations in particular in the 1980s (see Boden, 2004). Human cognition was examined in terms of symbolic information processing, an idea that relied on the development in computer models of the human mind and artificially intelligent systems capable of creatively solving non-trivial complex problems (Simon, 1969). The study on mental representations became a research target and the first experimental psychological studies were able to prove that people can, for example, mentally rotate objects (Shepard & Metzler, 1971) or scan objects in their minds (Kosslyn, 1973; 1980). Such investigations made ideation an object of rigorous investigation rather than an unexplainable and mysterious phenomenon based on untrainable individual gifts.

Subsequently, research on creative imagination expanded beyond mental processes to involve tools, artefacts and other external cognitive devices. Accordingly, the situated view on cognition proposed that humans manipulate

symbols with the hands and eyes, visually and manually interacting with a material world (Hutchins, 1995). Edwin Hutchins concludes that the human cognitive process is a cultural one; it takes place inside as well as outside the minds of people (Hutchins, 1995). This scientific insight can be seen in the work of designers who work in studio environments that are deliberately designed to facilitate their design processes conceptually, visually, emotionally, and socially; they rely not only on clearly articulated ideas, but also on various personal hunches, intuitions, and tacit impressions (Polanyi, 1966; Nonaka & Taceuchi, 1995). Based on these kinds of considerations, it may be argued that creativity involved in ideation requires not only within-mind cognitive processes, but also a fruitful interaction with the environment that provides various multimodal experiences and successively articulated impressions.

According to recent research, the material world in which we live and upon which we are dependent, shapes and enriches our imagination in various ways. The contents of our mental world reflect the social and cultural environment. Ideas, experiences, and memories involved in thinking have contradictory roles in ideation; they have the potential to act as stimuli and either reproduce old ideas (Purcell & Gero, 1996) and constrain proposed ideas or expand the space for creative new ideas (Goldschmidt & Sever, 2011; Goldschmidt & Smolkov, 2006). Cognitive creativity research has shown that people in general tend to fixate on existing ideas and thoughts (Ward, 1994; Ward & Sifonis, 1997; Ward, Patterson, Sifonis, Dodds & Saunders, 2002). Simultaneously, people are capable of significantly transforming representations across iterative creative efforts.

According to Thomas Ward and colleagues (Ward, Patterson & Sifonis, 2004) a successful strategy for developing new ideas is to select properties with higher-level abstractions from the source rather than the most representative features of the source. Associative theory suggests that the most obvious ideas are results of immediate associations and original ideas come late in the associative chain (Runco, 2014). Only through a series of sustained iterative efforts may genuinely original ideas emerge. Thereby, investing time for idea development is a basic requirement for going beyond the obvious. According to Cross (1997), insights in design are more often than not based on an iterative exploration process, which can be characterised as gradually building creative bridges between a problem and a solution rather than making an immediate, significant creative leap (Cross, 1997). Aha experiences that appear to occur immediately can almost always be seen as outcomes of long-standing and systematic efforts rather than events that suddenly emerge. This is in accordance with psychological research that examined insight as a part of a complex, time-consuming and social process (Czikszentmihalyi & Sawyer, 1995).

The theory of analogical thinking suggests that acquiring an abstract perspective on a task requires the capability to think in relational patterns (Holyoak, Gentner & Kokinov, 2001). Accordingly, one can identify similarities between

the familiar source (e.g., a highway) and an unknown target (the Internet) that can potentially serve the purpose of establishing an analogy (Holyoak & Thagard, 1997; Dunbar & Blanchette, 2001; Boden, 2004). According to Kevin Dunbar and Isabel Blanchette (2001), relying on underlying sets of structural relationships rather than any superficial similarity will lead to a higher level of creativity. However, the goals that one sets for the task will also affect a chosen approach (Dunbar & Blanchette, 2001).

The nature of the design task influences the creative orientation adopted by designers. Mark Runco (2014) exemplifies the concepts of convergent and divergent thinking that are used in psychology to describe the difference between conventional thinking and more creative ways of thinking. The tasks that require convergent thinking have one or very few correct solutions, whereas tasks that require divergent thinking can have multiple or infinite solutions (Runco, 2014). Divergent thinking is characteristically employed in design tasks that are usually open-ended in nature. However, design research has also illustrated that designers tend to approach design tasks, even those with tight constraints, by applying divergent thinking or interpreting relatively closed tasks as if they were ill-defined in nature (see Cross, 2006). Designers appear to utilize a mode of thinking that aims at finding new angles to the task. They are oriented toward improving and extending their design ideas rather than orienting toward an immediate mechanical implementation.

Designers' ways of thinking have been studied as inter-related processes of working with internal (imagination, silent thinking, traditional cognition) and external representations (materially embodied ideas and artefacts, distributed and embodied cognition) (e.g., Eisentraut & Günther, 1997; Ferguson, 1992; Goldschmidt, 1991; Goel, 1995; Suwa & Twersky, 1997). As mentioned, the perspectives of situated and distributed cognition have extended investigations toward the context of design thinking where interaction with the material, social, and cultural environment is a source of creative ideas (Keller et al., 2006; Petre et al., 2006; see also Paavola, 2006). Further, embodied cognition emphasises how bodies, tools, materials, and space relate in a work setting (Patel, 2008). Consequently, design thinking involves creativity that is, according to David Kirsh (2011), a socio-technical process involving resources, other people and body-based, multimodal activity. The research for understanding creativity in actual design practices provides valuable information for the development and support of design work. Recently developed new research methods such as the experience sampling method (ESM) and ecological momentary assessment (EMA) methods might capture various contextual aspects of design ideation and related creative events (Csikszentmihalyi & Larson, 1987; Shiffman, 2000).

2.2 Ideation as a vital process in design

Design and designing are such broad concepts that they can refer to almost any process that involves transformation, planning or execution of activities and constructing and shaping artefacts as well as services, virtual realities and social environments. In this study I have focused on the design ideation of tangible products and the definition for ideation follows the perspective of product design.

The cognitive science approach to design has provided numerous valuable characterizations of the design process. Design process models suggest that a design solution is developed through successive distinct phases of designing. Ideas are generated in early phases of the process, labelled as, for example, the conceptual or generation phase of designing (see, Howard, Culley & Dekoninck, 2008) or preliminary design phase (Goel, 1995). According to Vinod Goel (1995), the preliminary design phase involves the initial generation and exploration of ideas for creating alternative solutions. These undetermined alternatives emerge through incremental transformations of a few kernel ideas (Goel, 1995).

In the field of craft science, as modelled by Pirkko Anttila (1993), design ideation begins with a vague image of a finished product, which provides orientation for the basic planning and execution of the design activity (Anttila 1993, 1996; cf. Hacker, 1982). It is a beginning of the iterative process, where an image or idea is transformed into better-defined images or other representations. The image develops through a series of intermediate stages into a precise image of the end product. However, another model developed by Pirita Seitamaa-Hakkarainen (2000; Seitamaa-Hakkarainen & Hakkarainen, 2001) suggested that the design process and the process of generating ideas takes place through two interacting problem spaces, which are: 1) composition of visual elements and 2) construction of technical elements for the design process. The model also emphasizes the role of design constraints in structuring, framing, and constructing the design context.

The emerging contextual research on design ideation has underlined physical and material settings of the design ideation. In Ben Jonson's (2005) study, the goal was to capture tool usage in ideation as it happens in everyday design. In his view, ideation refers to early processes of generating, developing and communicating design ideas, concepts or sketches. Stella Tan and Gavin Melles (2010) proposed that ideation is a period when the designer begins actual investigation and research into the design problem and through exploration and creation of visual ideas, the idea or range of ideas are published (p. 462).

The ideation phase results an initial idea. Ben Jonson (2005, p. 613) defined an idea "as a basic element of thought that can be conceptual, visual, concrete or abstract in nature". Thus, it is a representation that can emerge in mental or material form. In design research, the terms design concept and design idea are sometimes used interchangeably. However, design concept is defined in several

design studies as a finished proposal, which incorporates an original idea, but also addresses the relevant objectives identified in the design problem (see Eisentraunt & Günther, 1997; Keinonen, 2006). In contrast, an initial design idea is an original thought or material representation that will be tried and tested.

Thereby, a design idea refers to a mental or material representation that has been manipulated in a generation-transformation process, but is not yet a structured presentation or concept (presentation drawing, model or prototype). This type of an initial idea may be a sketch, a material experiment, a mental image or primary generator that is the main idea or theme to be further elaborated and crystallised through the ideation process (Darke, 1979). Thus, an idea is not known beforehand, although quite often designers develop ideas from their own previous designs or utilize already existing influential designs and associated prototypical solutions; these are often referred as precedents in design research (Schön & Wiggins, 1992; Schön, 1988; Lawson, 2004a).

The ideation phase of designing is the beginning of the generating-transforming process in which a designer utilizes existing knowledge, skills, materials, and tools in order to create something new or change a situation. It involves evolutionary and dynamic processes of creating something new. The design process often appears to rely on a kind of case-based reasoning for adapting former cases and associated solutions for exploring, testing, and trying out innovative solutions for a new design (Akin, 1990; 2002; Oxman, 1990). Accordingly, designers tend to bring issues from their own previous successful cases (and lessons learned from failures) into their subsequent design cases. From this perspective, design ideation may not be strictly characterized as a process with a definite beginning and end (Heyligen & Neukermans, 2002; see also Dorst, 2011). Utilizing previous processes is economical and provides a designer with a chance to utilize his or her previous experiences. Continuity between cases supports designer's learning or other objectives that had emerged in earlier processes (Heyligen & Neukermans, 2002; Lawson, 2006).

2.3 Materially mediated design practices

Traditionally, creative activity in general and designing in particular has been considered a mental activity characterized by within-mind work with ideas. The present study, in contrast, examines designing as a process that involves efforts to advance ideas through repeated material explorations that provide various sources of inspiration and may significantly shape and transform ideas. A mere within-mind internal articulation of ideas and immediate attempts to implement mentally represented ideas, characteristic of novices, is not likely to elicit a productive and creative process.

Therefore, I see materiality as a crucial aspect of design ideation that assists in generating and elaborating, shaping, and concretizing, testing and validating

ideas. Materiality is a complex and multi-faceted concept that involves using various tools and instruments, shaping preferred materials and reflecting on sensory experiences, such as the "feeling" of the materials utilized. It involves exploring ideas by externalizing and materialising them. Further, the design process is engaging in successive sketching and prototyping as well as sharing and discussing of the produced material representations. Materiality mediates the physical properties of objects and artefacts in conjunction with expressing abstract, immaterial social and cultural associations and meanings (see Woodward, 2007; Narvaéz, 2000). The physical environment provides various affordances for design activity that may be considered as a part of materiality. Materiality is a key aspect of representation, which influences the conceptual and physical aspects of art, design and craftwork (see Jacucci & Wagner, 2007). Materiality appears to play, simultaneously, an essential role in both design thinking and concrete working to shape ideas.

For understanding design activity, the sociocultural perspective that emphasizes human relationships to material objects as well as the materially mediated relationships between humans, appears important (Wertch, 1991). Design takes place in a material culture (Cross, 2006; Narvaéz, 2000). Material culture is utilized as a source of inspiration in conjunction with designers shaping and transforming the material culture. The ultimate purpose of mediated action is to reach beyond concrete, physical boundaries for a wider field of intentional activity (Baynes, 2009). Beyond the physical environment, material cultures also embody and reflect designers' intentions, desires, emotions, and projections; hence, the material culture is also a dynamic and changing arena of creative activity. It is crucial that designers are able to read and understand the material culture and various features critical for the advancement of design (Baynes, 2009).

Designers appropriate professional design practices that are shared patterns of working in their field and cultivate their own personal routines and habits for pursuing design projects. From the perspective of Theodore Schatzki (2001), *design practices* may be considered as assemblages of design activity that involve goal-directed sequences of actions using certain materials, tools and knowledge relying on the tradition and history of design. Design activity involves applying cultural knowledge in particular settings of creative activity. Practice theories highlight both the inseparability of knowing and doing and the creative and improvisational aspect of practice (Schatzki, 2001). Rather than relying merely on mundane habits or repeated routines (they may also be needed), designers' practices are aimed at solving emergent problems and seeking novelty and innovation (Knorr-Cetina, 1999). Designing develops one's capability to see potential, to try out new ideas by sketching and prototyping, to make leaps of imagination as well as to systematically analyse, generalize and synthesize observations.

This study relies on an assumption that design is a materially mediated process: the mediation relies on heterogeneous sources of inspirations, various resources and artefacts being worked on across the process. Mental functioning can be viewed as being shaped or even defined by the mediational (i.e., different physical and symbolic) means it employs to carry out a task (Wertch, 1991). The concept of mediation and the perspective I will highlight here originates from the sociocultural research tradition and Lev Vygotsky's (1978) writings in which he proposed that psychological tools and technical tools mediate between subjects and their goals. In Vygotsky's theory, a psychological tool is different from a technical tool in directing "the mind and behaviour whereas the technical tool, which is also inserted as an intermediate link between human activity and the external object, is directed toward producing one or other set of changes in the object itself" (1981, p.140). Designers use both technical and psychological tools; the latter are transformed and evolved in various ways throughout the design process.

Nevertheless, sociocultural approaches and theories emphasising materiality in practice go beyond the individual designer's material actions. Accordingly, the knowledge of desigining is embedded in the material and social interactions shaped by the human and non-human systems. Designing can be said to be a sociomaterial activity where the social and material emerges equally in situated practice (Fenwick, Nerland & Jensen, 2012; Orligowski, 2007).

Luis Bucciarelli (1988; 1994) was a pioneer in the field of engineering for the research on social aspects of designers' daily practices. Research on design ideation practices has been conducted by Ben Jonson (2005), Ianus Keller et al. (2006), Devina Ramduny-Ellis et al. (2010) and Giulio Jacucci and Ina Wagner (2007). Specific attention to the role of visual representations as evolving design objects in the practices of architecture was addressed by Boris Ewenstein and Jennifer Whyte (2009). In these recent studies, design materials, representations and artefacts are treated not only as physical research objects, but also as objects that are embedded with experiences, emotions and knowledge that was needed, reflected and shared in the design situation (Ewenstein & Whyte, 2007; 2009).

2.4 Development of design expertise

Designing may be seen as a form of expertise. As any other form of expertise, designing may be interpreted as a deliberately cultivated cultural competence rather than represent any inherent talents or gifts (Cross, 2004; Weisberg, 2006). The growth of design expertise may be seen as a result of a sustained process of solving design problems and the long-term cultivation of skills and competencies. Creative expertise requires a passionate interest, curiosity and engagement, sometimes from childhood (Csikszentmihalyi & Sawyer, 1995). Thereby, expertise develops only through sustained deliberate practice, which means orienta-

tion towards systematic improvement of performance and stretching of competence (Ericsson, 2006; Csikszentmihalyi & Sawyer, 1995; Weisberg, 2006).

Beyond representing a professional field of activity, expert-like design activity should constitute an essential aspect of educational activity from elementary to higher education (Kangas, Seitamaa-Hakkarainen & Hakkarainen, 2013a; Vartiainen, 2014; Yliverronen, 2014; Welch & Loy, 2013). Kai Hakkarainen and his colleagues (Hakkarainen, Palonen, Paavola & Lehtinen, 2004) see designing as an important aspect of knowledge-creating learning in terms of working with challenging open-ended problems, determining constraints and iteratively working to improve knowledge and artefacts.

However, design can be challenging for newcomers. Design tasks are open-ended in nature and offer many views on the problem as well as a variety of solutions (Dorst, 2006). According to Cross (2011) experienced designers have a repertoire of previous design cases and their networks of colleagues on which they can lean. They rely on shared professional practices and tools that assist in dealing with complexity. They have developed competencies across various cases and projects and cultivated their personal approaches to design (Cross, 2011). Accumulated knowledge and competences as well as multi-faceted experiences of the field have transformed design experts' cognitive competences, thereby, assisting them in finding productive approaches to design problems.

Since the emergence of cognitive research in the 1980s, design studies have analysed experts' ways of approaching design problems. Pirita Seitamaa-Hakkarainen (2000) reviews thinking aloud studies, which show that design experts are very skilled at identifying problems, meaningfully constraining problem spaces, and using heterogeneous resources to produce original designs. The experts' successful designs rely on their sophisticated cognitive competencies that integrate cultural knowledge and practices (Akin, 1990). Experts appear to have structures of meaningful information occurring as mental images and mental models or schemas of previous situations. They can utilize effectively their earlier knowledge while creating new design ideas (Oxman, 1990; Eckert & Stacey, 2003).

In addition, designers are capable of using both mental and material resources for productively framing a design situation. Framing refers to "the creation of a standpoint from which a problem can be successfully tackled" (Dorst, 2011, p. 525; see also Schön, 1983). Rather than moving directly to solving the problem, designers typically work in parallel with defining and redefining the problem and possible solutions while remaining open to numerous possibilities of advancing (Cross, 2001). In interaction with material objects, they actively set boundaries of design, select particular objects and relations to which they must attend and construct situational coherence guiding their subsequent design moves (Schön, 1988; 1987).

In the educational environment, this solution-focused approach and the ill-defined nature of the design tasks tests students' prior understanding of designing and their institutionalized experiences of education (Newstetter & McCracken, 2001; see also Drew, Bailey & Shreeve, 2002). Linda Drew et al., (2002) study highlight the first and second year design students' approaches to a fashion design project. Students were found to have four types of approaches concentrating either to product-focused strategies or design-process focused strategies. Design education aims for process-focused strategies where the goal is experimentation for the discovery and development of design process as well as creation of own concepts (Drew et al, 2002; Shreeve, Sims & Trowler, 2010). These aims, however, may not be evident for all students (Drew et al, 2002).

Keith Sawyer (2012) has reported on the advantages of project-based studio learning that is typical in design. Such learning environments help students become capable of interlinking intention with making, ensuring that they master in conjunction the core knowledge and competencies of design and learn to use knowledge creatively (Sawyer, 2012). Novices often lack cognitive structures, knowledge and experience for approaching open-ended tasks (Seitamaa-Hakkarainen, 2000). Strong conventions in the culture or in the tradition may restrict students to perceived standards and prevent them from developing original design ideas (see, Law, Yip, Wong, & Cheung, 2013). Without guidance and attention these challenges may cause students to short cut the idea generation and development phase (Newstetter & McCracken, 2001) or focus on skilful performance and an end result (Law et al., 2013).

Many novices have developed maladaptive design practices, such as an orientation toward seeking quick, immediate solutions or recycling earlier solution models (Newstetter & McCracken, 2001). This may partially represent students' orientation toward completing tasks rather than engaging in a "design mode" oriented toward iteratively improving their ideas (Ng & Bereiter, 1995; Scardamalia, 2002). Thus, students' difficulties may represent too rigid master- or teacher-centred traditions of guiding design activity that may involve the teacher moving from one student to the next fixing minor limitations of their personal work without sufficient collective sharing and scaffolding of the ideation process and directing efforts at advancement (Drew, 2004).

In order to learn by design, students need to become familiar with designers' conceptual and material tools and practices and appropriate their "figured world of designing" (cf. Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2013b, see also, Holland et al., 1998). They need to be socialized to systematically advance and develop their design ideas, assuming personal and collective responsibility for all aspects of design from idea generation, to finding sources of inspiration and materialising and concretizing ideas as they assess the overall process.

Successful participation in design also requires teachers' guidance and facilitation. Instead of rule-based problem solving, design teachers could provide

authentic open-ended tasks that are guided by relevant constraints or parameters so that students could proceed to work out their own solutions. Too much openness or a lack of constraints may lead to traditional ways of making (Sawyer, 2012). Keith Sawyer (2012) illustrate that tasks that have constraints in balance allow students freedom, but also limit options so that reaching learning outcomes desirable at that point in the learning trajectory becomes possible. He continues that constraints lead to early failure, break students' misconceptions and guide them to more advanced conceptions. In addition, constraints prevent students from following patterns with which they are already familiar (Sawyer, 2012). Through sustained pursuit of open-ended design projects, students may gradually cultivate capabilities of dealing with uncertainty and produce increasingly creative solutions.

3 Design ideation and representations

In previous sections, various foundational aspects of the role of ideation in design were addressed. In the following, I will provide a more detailed account of design ideation from sources of inspiration to utilization of various forms of representation.

3.1 Sources of inspiration in design ideation

Sources of inspiration refer to all more or less conscious uses of previous designs and other objects and images for the pursuit of design (Eckert & Stacey, 2000). The design problem often lies in relation to what already exists; however, there is some evidence that the most novel ideas come from the sources of inspiration that are outside of the immediate design context (Bonnardel & Marméche, 2004; see also, Perttula & Sipilä, 2007). There is also evidence that an early commitment to a certain source of inspiration will prevent new insights and constrain transformation of the problem space (Ward, 1994; Ward et al., 2004). Therefore, sources of inspiration have a two-way role in ideation: they may trigger ideation, but they may also limit the production of a variety of ideas (Eckert, Stacey & Clarkson, 2000).

Nevertheless, designers could not do as well as they do without sources of inspiration (Eckert & Stacey, 2000; see also, Goldschmidt & Sever, 2010). According to design research, designers learn effectively to select and adapt sources of inspiration to the purpose of their design. When the use of sources is restricted, for example, in an experimental research setting, designers can use whatever source they see in the environment, whether it be a hole in the wall or a cable stitch in the researcher's jumper (see Goldschmidt & Smolkov, 2006; Eckert & Stacey, 1998). Thus, basically any detail can inspire the birth of new design (Petre et al., 2006; Eckert & Stacey, 2000).

Based on the literature, sources of inspiration are generated and transformed from existing material reality by manipulating different concrete representations. In addition, designers' mental images based on experiences and memories are important resources for inspiration (Eckert & Stacey, 2000; Eckert, Stacey & Clarkson 2000; Ashby & Johnson, 2010). Designers' own previous designs, sketches or other existing designs also have a prominent role in ideation (Petre et al., 2006; Eckert & Stacey, 2000; Eckert et al., 2000; Heyligen & Neuckermans, 2002; Schön, 1988). Designs occurring in the same domain may have an especially strong influence on the designers' work (Eckert et al., 2000), although these previous designs are used in different ways. Claudia Eckert and Martin Stacey (2000) state that the precedent design could be used as a starting point of

a design that is modified to generate new ideas. They also refer to the reuse of existing design components in a new design context.

Jane Darke (1979) refers to sources of inspiration that are generated by the designer in the ideation process as primary generators. Similar concepts are called 'design type' by Schön (1988) and 'kernel idea' by Goel (1995). The primary generator is a specific source of inspiration that is a broad initial objective or set of objectives that constrains and leads to the early solution conjuncture in ideation (Darke, 1979).

Designers appear to use sources of inspiration for different purposes. Sources of inspiration have a role in contextualizing the design ideas. Sources connect the design ideas to current time, a fashion or trend and thereby keep design ideas sensitive to the social, cultural and technological environment (Petre et al., 2006; Eckert & Stacey, 2000). Marian Petre and her colleagues (2006) also address various other functions that sources of inspiration play in textile design. They *provide information* (e.g., related to competitors' range, examples of styling and technologies); they are a *source of features* or a basis for adaptation (e.g., they suggest elements or ideas that can be incorporated into a design) and they are a *means of conveying ideas* (e.g., using a source as an example to explain a detail or idea) (p. 201). With these multiple purposes, sources of inspiration are embedded in designers' shared culture and language (Eckert & Stacey, 2000). Designers refer to sources of inspiration in order to capture or communicate their design intentions (McDonagh & Storer, 2004; Petre et al., 2006). Despite all their practical uses in the idea generating and transforming process, sources of inspiration are also elements for a mental analysis that classifies and experiments with design ideas (Eckert & Stacey, 2003; Petre et al., 2006).

3.2 Representations for generating and constraining design ideas

Constructing, transforming, and advancing various internal and external representations plays a crucial role in design and ideation. In design research external representations are either sources of inspiration or designer's visual, verbal and material constructions. Accordingly, there are two types of external representations that have been also designated as technical and epistemic objects in design research (Ewenstein & Whyte, 2007). Boris Ewenstein and Jennifer Whyte (2007) clarify that technical representations are used instrumentally as sources of information or references. Representations that are actively worked and developed further are epistemic objects as they contain the knowledge of the process (Ewenstein & Whyte, 2007, see Knorr Cetina, 2001).

Internal representations refer to mental images, concepts or design ideas. Using, that is, generating and transforming representations in designing requires that external and internal representations interact continuously (Visser, 2006) so

that "the reflective conversation with a design situation" is possible (Schön, 1992). Representations are constructed and used throughout the whole design process from early sources of inspiration to the development of ideas and to the presentation of a final solution. Moreover the designers' initial representations of the design problem can be considered as vital (Visser, 2006; Björklund, 2013). Willemien Visser (2006) states that designers' conceptions of the tasks guide his or her subsequent moves, choices and interpretations. Visser continues that the representations designers use, depend on designers' views of the task or conversely the generated representations influence designers' views of the task. Thus, in the design process representations evolve interactively with the designers' evolving views (see Visser, 2006, p. 121).

Designers face design tasks by actively constructing the solutions; they apply a solution-focused strategy (Cross, 2006; 2004). In order to follow this strategy, designers engage themselves in different practices for generating and transforming representations (Lawson, 2004; Eastman, 2001; Pei, Campbell & Evans, 2010; Goldschmidt, 1997). According to Cross (2011), there is a cognitive limit to the amount of complexity that can be handled internally in the design process (see also, Goldschmidt, 1991). It is argued, that practices of externalization are effective in controlling many separate factors, that may occur during the design project (Lawson 2004a; Cross 2011). Experimenting with material representations (i.e., constructing a sketch or a prototype) is much easier and more economical than constructing an actual object (Lawson, 2004a). The most versatile research on externalization in design is related to visualisation and sketching activities, but material explorations and verbalization have also been found to have important roles in design (Jonson, 2005; Jacucci & Wagner, 2007; Wagner, 2000). It appears important that the chosen externalization method provides a designer with a relatively quick way to express ideas, deal with the ambiguity of the process and constructively utilize unexpected emerging elements or novel interpretations and insights (Goldschmidt, 2003).

According to Cross (2006), the emergent aspect in a sketch is something that was not intended to be there, but which arises as a result of overlaps or relationships between externalized elements (Cross, 2006; also Goldschmidt 1991; 2003). Donald Schön and Glen Wiggins (1992) illustrate that while sketching, a designer sees how the design object evolves through drawings and recognizes revisions needed for improving the sketch when considering different constraints involved. Accoridng to Schön and Wiggins sketching enables iterative development of the object such that each version reveals new features and aspects that have to be elaborated and refined. The process of iteratively making and reflecting the design propels and guides idea generation (Schön & Wiggins, 1992). It brings new perceptual and conceptual knowledge into the design process and constrains the task (Purcell & Gero, 1998). Eckert and Stacey (2003) have stated that this type of process also occurs when a designer is toying with sources of

inspiration and browsing and selecting them. In other words, any representation or material object can potentially be perceived in a variety of ways and developed further into a design idea (Schön & Wiggins, 1992; Eckert & Stacey, 2000).

3.3 Representations as a part of design thinking in ideation

Creative activity relevant for designing has been studied in cognitive psychology. In his dual-coding theory Allan Paivio (1971; 1986; 2007) argued that thinking involves two distinctive subsystems: verbal and nonverbal. The verbal system is specialized for processing language and plays a central role in conceptual design. Accordint to his model the nonverbal system, in turn, processes nonlinguistic objects and events, mostly visual in nature. Since his pioneering research, investigators have been aware of the importance of visual cognition in general and mental imagery in particular. Accordingly, these systems represent reality in different ways; the verbal subsystem helps conceptually and the visual system assists in terms of mental imagery (Paivio 1971; 1986; 2007). Paivio's model (1971; 1986; 2007) of cognitive processing conferred major status on the role and importance of imagery. However, Akter Ahsen (1984; 1986) challenged Paivio's theory and emphasized the role of bodily experiences in mental processing. In his triple code model, ISM (Image-Somatic-Meaning), the somatic realm, the body, is presented together with the image and meaning making. Ahsen argued that without the bodily response in the experience of the image, the world would appear as a mere surface impression (Ahsen 1984). As follows, we will examine three critical aspects of design thinking: 1) mental imaging, 2) sketching and materialising and 3) conceptualizing.

Mental imaging

Design process is often laden with visual imagination and therefore, mental imagery plays a crucial role in design. According to Paivio (1991) a mental image has had various meanings in imaginative writing, such as poetry or fiction, and psychology. He continues that the concept of mental imagery may refer to figures of speech, on the one hand, and on the other, images "in the mind" that arise for example when thinking about familiar places. A mental image is also understood as a visual memory or image, which could be consciously drawn upon when needed (Paivio, 1991).

In design literature, the term 'mental image' appears often as a synonym for the terms 'internal' and 'mental' representation originating from the psychological research terminology (see Eckert & Stacey, 2003). Internal representations are understood as the mental images that designers activate and process through

their imagery in relation to external reality (Stacey & Eckert, 2010). Conceptualizing internal representations and external representations into separate classes is useful for research purposes. In practice, the separation between these representations is less evident because of their constant interaction in design activity (Stacey & Eckert, 2010). Nevertheless, the ability to mentally visualise is experienced as a crucial aspect of designing (Eckert & Stacey, 2003).

The present study advocates a holistic view of mental imagery as essential in embodied cognition. This defines mental imagery as part of other basic skills, such as physical activities, and an ability to understand meanings in context (see, Ahsen, 1984). Mental images are an integral part of ideation practices and are informed by different resources in designers' activities, such as conversations, domain knowledge, available materials and artefacts, personal memories and associated emotions. Such diverse resources inspire mental images that designers need for working, communicating and elaborating their ideas. Nevertheless, there are not many studies concerning the role of these resources and their relation to generating mental images in design.

Claudia Eckert and Martin Stacey (1998; 2000; 2003) and Marian Petre et al. (2006) have conducted research concerning sources of inspiration and the role of mental images in the field of knitwear design. The sources of inspiration convey information and can be used in early phases of design for making multimodal associations (tactile, visual, olfactory, and kinaesthetic sensations) visible and explicating contextual design ideas so as to arouse mental images related to the future design (Mcdonagh & Storer, 2004; Eckert & Stacey, 2000). While collecting and selecting sources of inspiration, designers create associations and even imagine complete designs (Eckert & Stacey, 2000; 2003).

According to Eckert and Stacey (2000; 2003), sources of inspiration serve as some sort of anchors for structuring designers' mental images. Designers form and recall complex visuospatial chunks, which means organized groups of elements or design objects and their contexts. These chunks serve as exemplars of classes of possible designs. They bear knowledge of past design solutions and provide a vocabulary for new designs (Eckert & Stacey, 2000). Eckert and Stacey, (1998; 2003) also reported that designers' mental images provide a means for communicating about new designs. They state that designers can refer to previous designs (their own, in magazines or shops) that are familiar to their colleagues and explain new ideas based on revisions of that mental image. Accordingly, colleagues are able to imagine the redesigned garment following the verbal description (Eckert & Stacey, 1998; 2003).

The activity of generating mental images or imagining a design object is a cognitive function of mental imagery that utilizes all sensory modes (appearance, feel, smell, sound or flavour) (Thomas, 2014; 1999). Mental imagery together with perception makes possible the very basic psychological capability of occupying imaginary and real space simultaneously (O'Connor & Aardema,

2005). As the above example of designers in a knitwear design process illustrated, imagination enabled designers to draw upon experiences from different times and places and fit them to the present reality. Imagination also supports perception in general functions of recognition so that objects, such as a leg of a chair that is only partly visible, can be recognized and identified as part of this particular type of furniture (O'Connor & Aardema, 2005). This function obviously becomes a more sophisticated in creative thinking

Designing can be seen as alternating between perception and imagination, but perception is not only visually and passively receiving information. It also involves experiencing and constructing multimodal contexts and activities in which perception is involved (Arnheim, 1969). This happens not only when sketching and interpreting the sketch, when collecting sources of inspiration and toying with associations and revising them mentally (Eckert & Stacey, 2000), but also when evoking experiences or objects that have never existed (O'Connor & Aardema, 2005). To summarize, developing mental images and imagery abilities has a special purpose for designing and ideating, but not as an isolated ability of cognition.

In design, mental imagery is often discussed in relation to creativity and conceived as a mainspring of insight and originality (Liddament, 2000). Vygotsky (2004) argued that imagination is the basis of all creative activity. He advocates it as an important component of cultural life that enables artistic, scientific and technical creation: "In this sense, absolutely everything around us that was created by the hand of man, the entire world of human culture, as distinct from the world of nature, all this is the product of human imagination and of creation based on this imagination" (p. 9). However, it is sometimes considered that creativity requires a good imagination or inherited capabilities to create novel ideas. Such conceptions have reinforced the private "in the mind" nature of the creative work and hidden the important role previous experience and external resources play in human cognition. From Vygotsky's (2004) perspective, in contrast, everything the designer's imagination creates is ultimately based on elements taken from reality, including culturally and historically mediated experiences, interpretations and meanings. In designing, imagination creates complex combinations of elements that are hinted at by reality. Therefore, designers attempt to accumulate their experiences in various ways (visiting museums, traveling, talking to people), to enrich their imagination (cf. Vygotsky, 2004). Thus, creativity is dependent on sustained participation in concrete culturally mediated activities that guide to stretch the imagination and gradually cultivate creative capabilities.

Sketching and materialising

A close interaction between internal and external representations follows from the central role of visual imagery in design; visual images are anchored in the powerful human visual system that involves using external visual input and manipulating visual images on paper or digital surfaces by drawing and sketching. In design research there is common agreement that sketching and sketches not only support the individual design process, but also play a vital role in design-related social communication in group meetings or other shared creative activities (Bucciarelli, 2002; Cross, 2011; Perry & Sanderson, 1998; van der Lugt, 2005). In design research, a sketch usually refers to a representation that has been drawn on paper. However, ideation involves not only drawing on a paper, but the term also covers various forms of representations (e.g., mind maps, material collages and models) and mediums (see Charlesworth, 2007).

Sketching has different roles in the different phases of the design process. Sketches created at the ideation phase are commonly referred to as thinking sketches (Ferguson, 1992), study sketches (Goldschmidt, 1991), experiential drawings (Lawson, 2004a) or idea sketches (Verstingen, Hennessey, Van Leeuwen, Hamel & Goldschmidt, 1998). Beyond that Eujin Pei et al. (2010) have extended the list of ideation related drawings to include referential sketches and memory sketches. These types of early sketches are mostly for private use, in contrast to presentation sketches or other more detailed representations that are used to introduce the idea to stakeholders (Verstingen et al., 1998).

In the early phases of design, commitment to ideas is weak and unstable; sketches are usually inaccurate and fuzzy (Goldschmidt, 2003; Goel, 1995). These indefinite drawings have the potential to store unexpected clues that refer to ideas or concepts outside the original drawing (Goldschmidt 2003; 1991). The designer reinterprets or sees in new ways the figural properties of the sketch, which leads to the emergence of new figures and new mental images (Goldschmidt, 1991; 2003). Lawson (2004a) noted that drawings can proceed from the general to the particular or vice versa. He states that there is no rule on how sketching should proceed; it depends on the task and the designer. Goldschmidt (1991) describes how a designer begins by generating partial images, which may have their origin in existing designs and precedents that have been derived from metaphors or analogues. The designer draws and redraws a series of sketches or collection of different types of sketches until satisfactory images emerge (Goldschmidt, 1991). This is the iterative, dialogue kind of process between the designer and drawing also emphasized by Schön (1983).

Although the role of sketching by drawing is undeniable in design, it is found to be somewhat problematic from the novice designer's perspective. Insufficient skills in drawing can prevent a novice from using this skill to generate ideas (Goldschmidt, 2003). Developing design ideas and insights also through materi-

ally mediated making might provide support for designing (Charlesworth, 2007; Mäkelä, 2007; Jacucci &Wagner, 2007; Kosonen & Mäkelä, 2012; Ramdyny-Ellis et al., 2010; Youmans, 2011). As a process, "making provides intuitive and simultaneous manipulation, mobilizing tacit knowledge and enabling participation" (Jacucci & Wagner, 2007, p. 73).

When crafting materials, the designer is able to use past knowledge and skills of the chosen material's effect to utilize it for ideation (Ramdyny-Ellis, Dix, Evans, Hare & Gill, 2010). Working with unfamiliar material may prevent the creation of the most obvious ideas and also support reflection (Ramdyny-Ellis et al., 2010; Kosonen & Mäkelä, 2012). Kosonen and Mäkelä (2012, p. 233) stated that "deliberate work with unfamiliar materials causes emergence of coincidents, failures, and surprises essential for the ideation process". Analogically with modelling, material experimentation allows viewing the object from different perspectives. This in turn, allows observing relations that would be otherwise hard to notice and make unforeseen inferences and interpretations (Kirsh, 2010). According to Robert Youmans (2011), physical modelling of design ideas may prevent functional fixation. In the study of technical design, fixation occurred less in designs that had been developed with the support of physical materials.

There is a consensus that visual-material sources of inspiration and related practices are central to idea development. When the modality of representation is visual at both ends, it is cognitively more economical to use visual means than to translate from another modality to the visual one (Goldschmidt & Sever, 2010). However, the verbal-conceptual processes during early design may have equal importance.

Conceptualizing

Finally, I will address linguistic representations that play an important role in ideation and conceptual designing. They are related to the linguistic or verbal system addressed earlier in the context of Paivio's framework. In design, verbalisation has been found to be an important conceptual tool (Jonson, 2005) addressing that conceptualizing is central for design idea generation (Lawson, 2004b). Similarly with sketching or materialisation, verbalisation involves both externalizing design ideas in texts and documents and conceptually analysing and developing the design idea. Schön (1988) has suggested that language has a role in constructing "design worlds" that are the designer's configurations of objects, relations, and qualities and act as holding environments for design knowledge (Schön, 1988). Notes and other inscriptions are often used as a part of sketches and descriptive words or sentences as a part of visual displays (such as mood boards) for communicating design (Eckert & Stacey, 2000).

Research concerning the role of verbal and written practices in the design process is relatively sparse, although language as a vital symbol system for human thinking and communication in general is well acknowledged. According to Roger Säljö (2001), language is, metaphorically, a personal and collective cultural system for recording common knowledge, concepts and understanding. He continues that with such concepts as colour, form and weight, people learn to see shared and diverging features in the design objects and learn how they should be regarded in other circumstances. It is essential to be able to share experiences through language. Linguistic phenomena, terms and concepts for physical activity can be translated and used to guide forming and shaping materials. Therefore, the designer can not only perform actions, but needs to also discuss those actions. Developing discourses is the most definite way of collecting experiences and creating a sense of reality (Säljö, 2001).

Apparently verbal accounts are important sources of inspiration in ideation; words, texts and narratives effectively arouse associations and mental images and inspire ideas. In Jonson's (2005) study, designers used verbalisation alone or in combination with other conceptual tools most often in the ideation process. Even most of the Aha moments emerged in the presence of verbal tools. Jonson (2005) concluded, in accordance with Paivio's approach, that ideation is a dialogue between visualization and conceptualization.

Gabriela Goldschmidt and Anat Sever (2010) suggest that verbal sources of inspiration are different from visual ones, because some ideas are possible only for verbal expression, but cannot be represented via visuals and vice versa. They also see words as more open to manipulation in the process of translating into visual images (Goldschmidt & Sever 2010). In their experimental study, Goldschmidt and Sever (2010) used texts that were non-technical descriptions or parts of tales that either had some or little relation to the given design task. The results indicated that involvement of any textual source of inspiration stimulated more originality in students' designs than occurred in contexts without inspiring texts. It also appeared that students who could adopt clear ideas from the texts produced more original design ideas.

The importance of single words as inspiring triggers for design has become evident in Cross' (2011) analysis of a protocol where the team was supposed to design a carrying or fastening device for transporting a hiker's back bag by bicycle. The turning point for their designing process occurred when one team member introduced the word 'tray' into the conversation. Although similar types of words had emerged earlier, this particular word appeared to hold critical features for conceptualizing an appropriate solution to the problem (Cross, 2011). Thus, it is possible to capture the essence of a product's meaning in a few words (Lenau & Boelskifte, 2004; Nonaka & Taceuchi, 1995). The single word holding rich meaning in a certain design situation is conceptualized by Schön (1988) as design type. According to Schön (1988), experienced designers have a repertoire

of design types that act as references, examples, precedents or otherwise supporting categories for their personal approach in designing.

Similarly, design communities develop their own language containing specific concepts with meanings not necessarily apparent to the outsider (Lawson, 1997; Eckert & Stacey, 2000). In a study by Eckert and Stacey (2000), knitwear designers hardly sketched during discussions, but they referred to sources of inspiration and reached an understanding with content-rich language. Lawson (2004b, p. 445) crystallizes the notion that "design conversations are extraordinarily compact since they are full of references which in turn point to huge chunks of information". According to him, analysing shared language and other representations used in expert design conversations is a way to understand the ways knowledge is handled in the design process (Lawson, 2004b).

In general, design is a social process that usually involves at least two people: the designer and the client (Schön, 1988; Visser, 2006). Therefore, verbalisation is an important means for communicating, reflecting on and sharing the process of ideation. In an educational context, relations with the community and teacher have specific importance for learning design. Schön's (1983) analysis of a teacher discussing an architectural design with a student stressed the importance of reflection as a part of sketching as well as a part of a teaching moment. In addition, learning reflective practice through writing is an integral part of design education (Schumack, 2008; Sjöberg, 2009). It may be a diary type of documentation that takes place during the design process or construction of more structured essays, locating the design process in academic discourse and design theory (Schumack, 2008).

4 Research questions

The overall aim of this study was to understand the origin of ideas in design and what inspires and guides designers in the ideation process. In order to follow this aim, this study had one general research question and three sub-questions.

How did designers and students generate ideas in their respective contexts?

This broad problem statement is focused on the research streams of design ideation, the creative process, materiality, design practices and representations that I previously introduced in the theoretical part of this research. Three subordinate research questions were posed to address the main research question:

1. *What was the role of the sources of inspiration, mental images and external representations in participants' design ideation processes?*

2. *How did participants frame the idea spaces explored and what kind of approaches on ideation can be identified?*

3. *What kinds of tools and materials did designers use in their everyday design activity and what were the qualities of associated emotional experiences?*

In order to follow the general aim and answer the research questions above, I conducted four separate sub-studies and published five original articles refereed in international journals. I approached ideation by collecting data from students and professional designers. Each of these studies had specific research questions in which I analysed elements, processes and design approaches that contribute to ideation, as well as the material nature of designing and implications to learning. Table 1 presents the identification name for the sub-study, related publication, research questions and context of the sub-study. I focused on the design context of students in the first two studies and on professionals in the two following sub-studies.

Table 1. The research questions, identification name of the sub-study, the publication and contexts of the studies.

Research questions	Study	Publication	Design context
(1) What was the role of sources of inspiration, mental images and external representations in participants' design ideation process?	Inspiration study	I Laamanen, T-K. & Seitamaa-Hakkarainen, P. (2008). Sources of Inspiration and mental image in textile design process. *Art, Design and Communication in Higher Education,* 7(2), 109-119.	Higher education: Textile design
(1) What was the role of sources of inspiration, mental images and external representations in participants' design ideation process? (2) How did participants frame the idea spaces explored and what kind of approaches to ideation can be identified?	Interpretation study	II Laamanen, T-K. & Seitamaa-Hakkarainen, P. (2014). Constraining the open-ended design task by interpreting sources of inspiration. *Art, Design and Communication in Higher Education*, 13 (2), 135-156.	Higher education: Textile design
(2) How did participants frame the idea spaces explored and what kind of approaches to ideation can be identified?	Ideation approach study	III Laamanen, T-K. & Seitamaa-Hakkarainen, P. (2014). Interview study of professional designers' ideation approaches. *The Design Journal, 17*(2), 194-217.	Professional design: Fashion, interior and textile design
(3) What kinds of materials and tools did designers use in their everyday design activity and what were the qualities of associated emotional experiences?	Design activity study	IV Laamanen, T-K., Seitamaa-Hakkarainen, P. & Hakkaranen, K. (2014). Tracing design work through contextual activity sampling. In M. Aaron (Ed.). *Design, User Experience and Usability: Theories, Methods and Tools*. Lecture Notes in Computer Science Vol. 8517 (pp. 142-152). Proceedings of the Third International Conference, DUXU 2014. Part of HCI International 2014, Crete, Greece. V Seitamaa-Hakkarainen, P., Laamanen, T-K., Viitala, J. & Mäkelä, M. (2013). Materiality and Emotions in Making. Techne Series: *Research in Sloyd Education and Craft Science* A. 20, 3, 5-19.	Professional design: Fashion, interior and textile design

Inspiration study (Publication I). In this study, the focus was on multimodal sources of inspiration and external representations created by the students in order to understand the emergence of mental images in textile design. The aim was to analyse the dynamics between these elements in accordance with the design ideation process.

Interpretation study (Publication II). In this study, the aim was to examine in more detail students' processes of interpreting representations in their creation of ideas. The focus was on how they created new ideas and managed to reduce the openness of the design situation with material and conceptual practices.

Ideation approach study (Publication III). In this study, the aim was to extend understanding of the usage of design representations and practices in framing the idea space by identifying professional designers' approaches to ideation.

Design activity study (Publications IV and V). In this study, the aim was to study the real- time design activities and analyse the possibilities of using the Contextual Activity Sampling System (CASS) data collecting method and tool.

5 Research design

In this section, I discuss the research design and methods for this dissertation's sub-studies. Because the sub-studies were conducted as case studies, I briefly summarize the rationale behind the decision to undertake a case-study research design.

5.1 Research method

Yin (2014, cf. Stake, 2005) argued that the case study is a suitable venue for empirically investigating a contemporary phenomenon within its real-life context. Therefore, multiple- case studies are particularly appropriate in novel areas such as in the research of design ideation, within which an in-depth understanding is important. My decision to use a qualitative (multiple case studies) research approach is in line with the previous research efforts addressing this dissertation's topics. As in previous design ideation studies, my goal was to collect multiple qualitative data in sub-studies. The rich nature of research data characterizes, to some extent, this dissertation also with a multimethod approach as presented by Yin (2014) and Brewer & Hunter (2006). The selection of a qualitative research approach is reflected most evidently in the data collection and data analysis practices.

Focused interviews with design process materials

Design ideation is a challenging phenomenon to study, as it includes not only concrete practices, but also covert processes that are not observable in the conventional sense. One way to gain insights into designing is to interview designers as suggested by Cross (2011). The interview has a dominant position in qualitative research (Flick, 2008). The focused interview used in this study is a specific form of interview, which is suitable for arousing personal memories that are not always easy to represent. In a focused interview, the topic of conversation is determined in advance and interviewees are selected based on their experience of the same situation (Hopf, 2004, p. 205). In this study, the interviewees were students of a particular design module sharing the similar type of learning environment. In addition I interviewed professional designers who had a repertoire of design situations.

I conducted focused interviews in two sub-studies: *Interpretation-* and *Ideation-approach* studies. By nature, a focused interview is conducted with a relatively open form so that there is an opportunity to permit points of view that had

not been anticipated to become part of the interview (Hopf, 2004, p. 205). Accordingly, the interview here included a set of predetermined open-ended questions in which the focus was on ideation and further follow-up questions emerged in the interview. Thus, the style in the interview was conversational and flexible. In addition, to support the conversation and recall, I asked interviewees to use their ideation process materials. Process materials were any concrete representations related to creative design or the construction process from sketches to portfolios and diaries (see Johansson, 2011; Sjöberg, 2009; Kosonen & Mäkelä, 2012). I videotaped the situations in order to capture the nature of the interactions during the interviews.

However, in their everyday work conditions, designers take part in several temporal and multifacted activities. These real-life contexts and the nature of design events are hard to capture with the interview method alone. Therefore, I also used event sampling together with a new data collecting method for capturing design events and actions in their social and cultural contexts.

Event sampling

The emerging contextual research on design ideation has emphasized physical and material settings of the design ideation. Nevertheless, there are still some methodological challenges for capturing the multifaceted nature of designers' work. New ways to capture design activity have been presented by the technology that has extended the role of observation with unobtrusive devices such as Internet camera systems or programmes for tracking the use of computers at work (Gershuny, 2001). Recently mobile technology has also been harnessed for research purposes (Mattelmäki, 2006).

Event sampling belongs to the family of diary methods. Traditionally, aggregated diary data has consisted of single reports in which participants retrospectively recall their experiences (Bolger, Davis & Rafaeli, 2003). Event sampling refers to the research strategy for studying ongoing daily experiences, events, emotions or social activities as they occur in the ebb and flow of everyday life (Reis & Gable, 2000; see also Christensen, Barrett, Bliss-Moreau, Lebo & Kaschub, 2003).

Event sampling methods consist of a repeated collection of real-time data on participants' specific momentary states in natural contexts (Stone, Shiffman, Atienza & Nebeling, 2007). These methods have been identified either with the experience sampling method (ESM) (Csikszentmihalyi & Larson, 1987; see also, Hulkko, Mattelmäki, Virtanen & Keinonen, 2004 for mobile probes) or with the ecological momentary assessment (EMA) method (Shiffman, 2000). ESM has focused on the sampling of experience at random intervals to capture flow experiences that occur in situations where the subjects are encountering challenges

and feeling competent to do so. The methods of EMA, in turn, broaden the scope of event sampling from subjective experiences to associated external events (Shiffman, 2000; Stone & Shiffman, 2002; Stone et al., 2007). These methods have been used to study a broad range of health-related issues. Event sampling is usually carried out by relying on four different sampling strategies: signal-contingent, interval-contingent, event-contingent and context-contingent sampling (Bolger et al., 2003; Feldman, Barrett & Barrett, 2001; Conner, Barrett, Tugade & Tennen, 2007; Reis & Gable, 2000).

The present study applied the ESM method with an event-contingent sampling strategy. I tested a research instrument called the Contextual Activity Sampling System (CASS). CASS has been developed by Kai Hakkarainen and his colleagues (Inkinen & al., 2014; Muukkonen, Hakkarainen, Inkinen, Lonka & Salmela-Aro, 2008); it uses a 3G mobile phone and Java application. CASS was used in educational (*Interpretation study*) and professional design contexts (*Design activity study*).

I tailored a specific query or set of questions for the purposes of studying design activities. Participants activated and answered the pre-determined query from a mobile phone whenever a design-related event emerged. Participants responded individually to the activated questions by writing a text, taking photos or making audio notes (an audio diary). CASS sent the data directly to the database and recorded the date and time of sampling.

In order to accomplish the research aims and provide answers to my research questions concerning design ideation, I drew upon the perspectives of both student teachers from textile teacher education and professional designers from different domains. In the following, I will elaborate on the data sets and the methods of collection and analysis.

5.2 Overview of research settings, data collection and data analysis

The data was collected by interviewing, applying event sampling and examining a virtual e-learning database. Table 2 presents an overview of the research setting. This study used textual data that was transcribed from the videotaped interviews. Other texts were essays, chat conversations, notes, work descriptions, portfolios and audio diaries. In each study, the verbal data was supported by the visual data. The visual data consisted of photographs or digital images of experiments, sketches, mind maps and sources of inspiration. In addition, I collected CASS related photos of the working environments, tools and materials. Qualitative content analysis was applied in each study (see Table 2).

Table 2. Overview of the research setting

	Inspiration study	Interpretation study	Ideation approach study	Design activity study
Participants	11 students	7 students	9 designers	6 designers
Methods of data collecting	E-Learning database	Focused interviews Event sampling	Focused interviews	Event sampling
Collected data	Conversations Visual material Chats Portfolios	Transcribed interviews CASS queries Process materials Essays Diaries (written and audio)	Transcribed interviews Process materials	CASS queries Audio diaries
Methods of data analysis	Qualitative content analysis	Qualitative content analysis	Qualitative content analysis	Qualitative content analysis

Qualitative content analysis was most useful for the purposes of this study because it is well suited for analysing meaningful matter varying from printed matter and visuals to websites (Krippendorf, 2013). In the present study analysis focus was on constructing the underlying meaning of the data where content emerged in the process of analysing a text in relation to a particular context (see Krippendorf, 2013). Thereby, this study has followed the interpretivist tradition and interpretative approach in the data analyses (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005).

By nature, qualitative content analysis involves three characteristics. Firstly, it requires close reading of texts; secondly, it involves interpretation of the data into new narratives accepted within particular scholarly communities and thirdly, it is the result of the analyst's work within hermeneutic circles that are participated in and influenced by his or her own understanding (Krippendorf, 2013). Accordingly, qualitative content analysis was a natural way to conduct analysis in which my experience of design, theoretical insights from the research literature and the data could iterate and lead to elucidations of ideation. In the following, I will briefly clarify each sub-study's setting, data collection and data analysis.

Inspiration study

Figure 2. Fabric collage made by a student. Photograph by Anu Kaukola.

In this study, the focus was on students' sources of inspiration and mental image generation in a fabric collage course. Participants were six voluntary students in textile teacher education at University of Helsinki and five students in class teacher education at the University of Turku. All participants were women. The present investigator was one of the participants in the course. When the course had been completed, there was an opportunity to study the produced process materials. Thereby, I engaged in to study ideation and also analysed my own process as a part of the data. The fabric collage course was part of the textiles teacher education optional studies that was conducted with the support of virtual material and interactions facilitated by the WebCT platform in the Internet. Fabric collage is usually made from materials that can be sewn on top of one another by machine or by hand. Fabric collage can be used to compose parts of a textile product or to create individual items of artwork (see Figure 2). WebCT is an e-learning platform that allows educational institutions to create and host courses in the Internet (see Goldberg, Salari & Swoboda, 1996; Naqvi, 2006). During the fabric collage course, the participating students produced many types of materials for the virtual learning environment. Thus, the learning environment was also an organized collection of data. The database stored both concurrent data in students' conversations as well as retrospective process descriptions.

Learning during the fabric collage course was organised to be asynchronous; students individually studied the learning materials from the platform and conducted the experiments with the fabric collage technique. However, they had an opportunity to contact the teacher and were required to send questions and to react others' writings in the shared online discussion room. Four synchronous chats or discussions were organised by the teacher. All messages and fabric collage experiment descriptions during the course were posted to each group's WebCT shared space and the activities were recorded by the system. The data consisted of students' written texts, discussions, chats, scanned process materials (inspiration sources, sketches, experiments, final designs) and design process portfolios. I analysed the verbal data qualitatively and the visual data supported the analysis.

The analysis had three phases that I have visualised in Figure 3. In the first phase, a goal was to discover how sources of inspiration were represented in the fabric collage course. I labelled 14 sources that were either abstract or concrete in nature. In the second phase, I analysed the relationship between the sources of inspiration and mental images. I organised sources of inspiration into higher-level mental image groups with type-analysis (see Eneroth, 1984). I identified four mental image groups or ideal types. I conducted the second phase with the help of a visual analysis tool, which represented the mental image-groups and related sources of inspiration. In the third and last phase of the analysis, I further analysed the mental images as part of the students' ideation process. The mental images appeared to have different dynamics in the ideation process; some were more processed than others. I presented these dynamics in visual form. The resulted visualisation of the dynamics of mental images in ideation will be explicated later in findigs section.

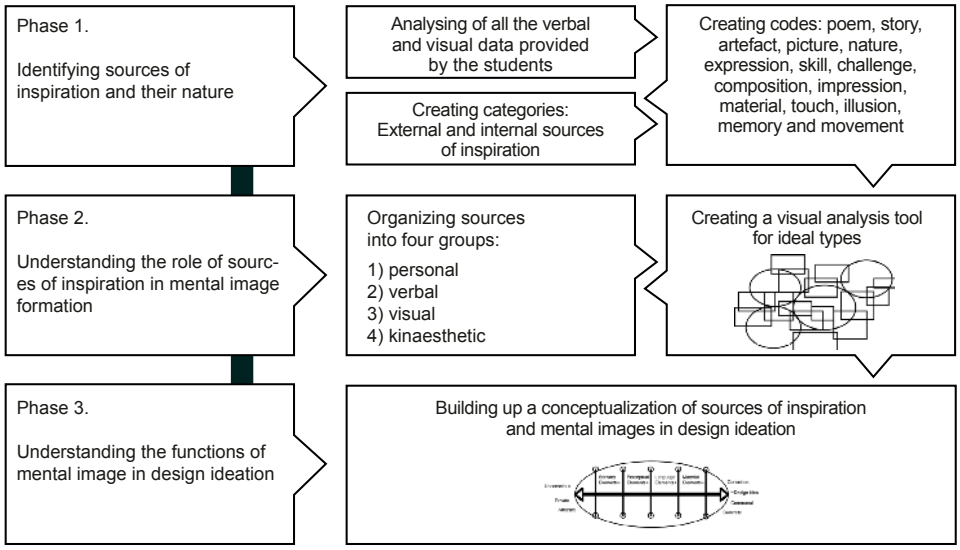

Figure 3. A visualisation of the analysis process in the *Inspiration study*

Interpretation study

Figure 4. Surface motifs made by a student. Photograph by Tarja-Kaarina Laamanen.

This study analysed students' processes and experiences related to an open-ended design assignment in the experiential textile design module. It was a com-

pulsory study module targeted for first-year students and it emphasised material experimentation during the ideation process. From this module, seven students in textile teacher education participated in the study; they were all women. During the module, the students were given an open-ended design assignment and five sub-tasks for ideation that encouraged reflective insights about individual and shared practices. Students executed all the sub-tasks three-dimensionally; drawing was not allowed (see Figure 4).

I interviewed the students at the end of the module with their design ideation process materials. The design process materials and CASS queries gave points of reference to the students' reports. I asked an individual student about her background and then she shared her general thoughts about designing. After that, the student clarified her design ideation processes and experiences in the experiential module.

In addition, students documented their experiences during the four course meetings (from the second to the fifth) with the CASS method. The teacher guided the sampling rhythm in the second meeting. For the rest of the time, the students activated individually the questionnaire every time the tool or material they worked with changed or if new thoughts about the design task appeared. The query had 22 questions consisting of open questions and Likert-type questions. All together students answered 54 queries and three of the students completed the audio diary. Accordingly, the data consisted of interviews, final essays, audio diaries and the photographs of experiments. The CASS query data was used for the purpose of data triangulation. I transcribed the verbal data and analysed it qualitatively.

The analysis had three phases as illustrated in Figure 5. I began the analysis by tracing students' reflections from the verbal data. I classified their reflections to *material* and *learning reflections* categories. In the second phase, I took text segments in the *material reflections* category for further analysis. I combined all data to an individual matrix for each student. I then applied the classification of Petre et al. (2006) for evaluating students' reinterpretations of inspiration sources and developed a table format for conducting the related analysis. In the third phase, I emphasised the nature of each student's process with blue bar(s).

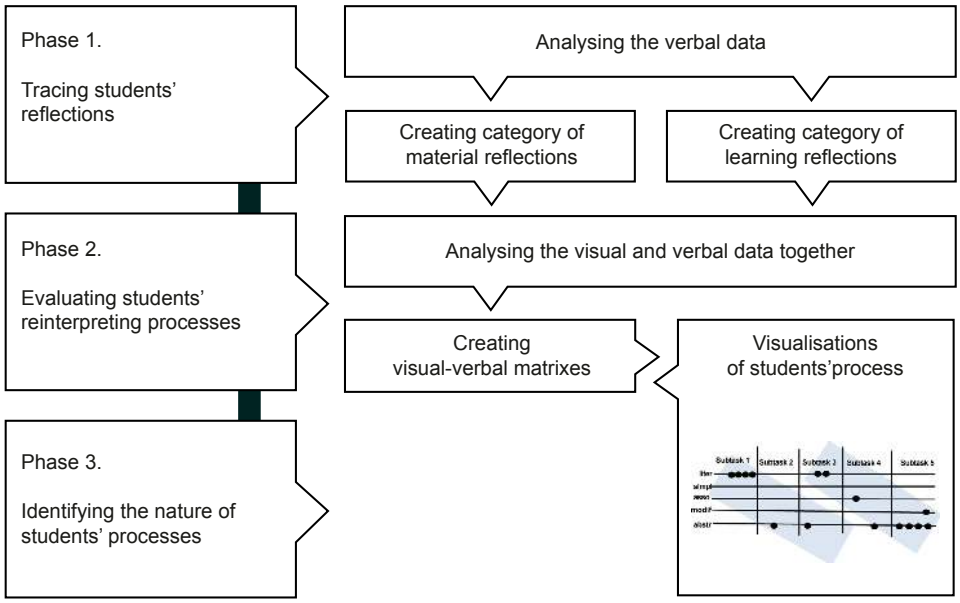

Figure 5. A visualisation of the analysis process in the *Interpretation study*.

Ideation approach study

Figure 6. Sources of inspiration presented by the designer in interview situation. Photograph by Tarja-Kaarina Laamanen.

This study focused on professional designers' practices for framing the idea space and their ideation approaches. I interviewed designers from the fields of interior, fashion and textile design. Seven of the interviewees were women and two were men. They had 2-20 years of experience in design. I conducted the semi-structured interviews with design process materials in the designers' own studios. One designer was interviewed in my office. The process materials consisted sources of inspiration collected by designers and their digital or manually-drawn sketches, mind maps or material experiments (see Figure 6). In the interview, the designer described his or her personal background. After that, the designer introduced freely-designed cases that he or she wished to discuss and I presented specific questions according to the ideation. Later, I transcribed the videotaped interviews and analysed them qualitatively.

The analysis had two phases visualised in Figure 7. In the first phase, I was interested in how designers begin to frame the design space in ideation. I conducted content analysis of the interview data. I determined two main categories: *supporting practices* and *triggers.* In the second phase, I analysed to which kind of ideation approaches designers' accounts referred. Based on the proportions of the statements related to the sub-categories, I conducted a cluster analysis. A K-means cluster analysis was used as a supporting method for typifying the designers' approaches and creating ideal types. As a result, typical approaches to ideation emerged that emphasized supporting practices and triggers in four different ways. I presented the proportions of the approaches in visual form.

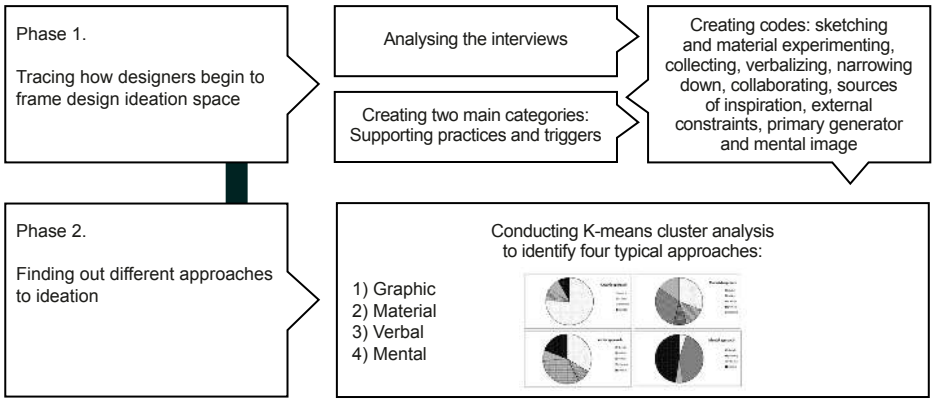

Figure 7. A visualisation of the analysis process in the *Ideation approach study*

Design activity study

Figure 8. Interior design materials: A photograph taken by the designer during CASS data collecting.

This study was related to the general nature of design work and activity; I examined its material and emotional dimensions, as well as the feasibility of the Contextual Activity Sampling System (CASS) method for collecting real time data. Designers photographed their daily activities as well as tools and materials as a part of the CASS query (see Figure 8). I reported this pilot study of testing CASS in Publication IV. In Publication V, I concentrated on the feasibility of CASS in accordance with the nature of the design activity. The data was collected from six professional designers' daily activities. They were all female freelance designers from the fields of interior, fashion and textile design and their ages varied between 32-49 years; they had a minimum of five years' experience in design.

The designers answered a CASS query about their ongoing design projects, emotions, and personal social networks. In addition, they recorded audio diaries on their mobile phones. I requested the designers to report the main design events and respond to the CASS query (i.e., set of questions) before moving to the next design event. They were given some examples of when to activate the query. The designers answered the queries during five working days. The query consisted of 20 questions that were either what, where, how and why questions or Likert-type structured questions. Of the six participants, three completed the

query for five days and three designers missed one day. Altogether, the designers responded to 67 queries. In addition, five of the designers completed an audio diary for each day.

The analysis had one phase (see Figure 9). I organised the data collected with CASS queries in separate individual designer's documents consisting of all CASS entries for each day. I classified the designers' activity into five categories for understanding their everyday activities and emotions. I then presented numerical data in visual workflow charts.

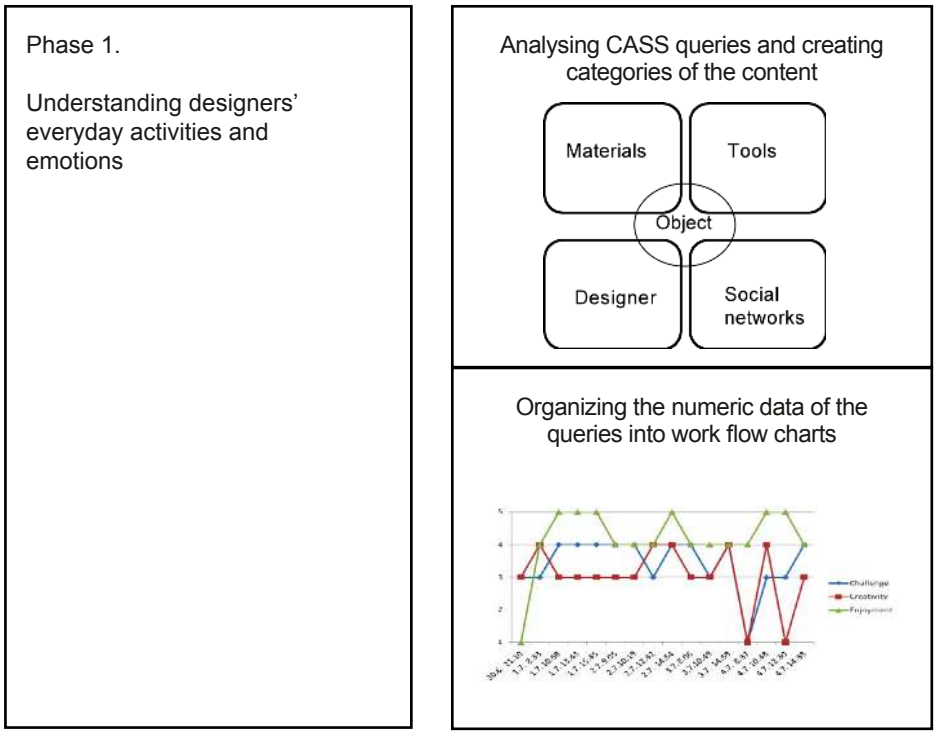

Figure 9. A visualisation of the analysis process in the *Design activity study*

6 Main findings of the study

In the following, I will explicate the main results published in the five articles. The original articles provide a more detailed description of the research results.

6.1 Sources of inspiration and mental image in textile design process (Publication I)

Publication I answered sub-question 1 of this dissertation study. It focused on the sources of inspiration, mental images and external representation that are in a dynamic relationship in the design process. Qualitative content analysis included students' written and visual representations that they posted on the virtual learning database during a voluntary fabric collage course held by the University of Helsinki.

During the fabric collage course, students faced open-ended design tasks. The results indicated that sources of inspiration and creating multiple mental images (i.e., abstract and concrete) provided a useful context for students to frame and revise their design ideas. The sources of inspiration gave multimodal starting points and suggested elements that could be incorporated into particular collages. The students pondered how they could express the nature of the sources with the materials and techniques. The students' conversations and descriptions captured not only the importance of touch, but also the desire for the expression of movements with line, rhythm and composition. Accordingly, these impression- and composition-related sources of inspiration were not only experienced visually, but were also related to bodily experiences and kinaesthetic sensations. In addition, verbalisations and narratives guided the students' ideation by developing rich associations.

The analysis of the multimodal nature of sources of inspiration resulted in four representative mental images (visual, verbal, kinaesthetic and personal mental images). The creation of mental images was dependent on and influenced by personal interpretation and experience. Therefore, the subsequent phase of the study focused on the appearance of dynamic interaction of multimodal sources of inspiration and mental images in students' ideation processes. Mental images had different qualities and different appearances. It became evident that multiple ways of processing mental images (thinking, writing, sketching and touching) provoked the design results. Different levels of processing also occurred; some mental images appeared instantly from the first source and some were the result of more thorough processing. Therefore, I created a visualisation of the dynamics between the spontaneous and more processed mental images (see Figure 10).

It illustrates the richness of mental images and their appearance with different temporal dynamics in ideation.

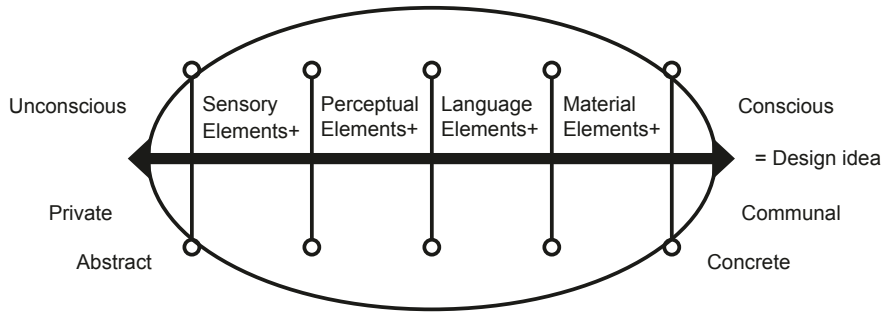

Figure 10. Description of the dynamics of mental images in design ideation

In Figure 10, the oval space represents a designer's mental imagery in which sensory, perceptual, language and material elements are situated between the vertical lines. The vertical lines represent spontaneous mental images. The dimensions of unconscious–conscious, private–communal and abstract–concrete at both ends of the horizontal arrow illuminate internal and external interaction in the mental imagery. The analysis exemplified that during ideation mental images were processed between these dimensions and concluded that planning design tasks that require use of multimodal sources of inspiration could evoke mental images that trigger diverse processing and thus enhance ideation.

In addition to the above-mentioned detailed analysis of the use of sources and creation of mental images, the analysis gave some insights of learning and motivation during the open-ended design task. Since students were provided only verbal instructions or images of the technique without actual demonstrations, learning a creative expression during the course were at first challenging. Students had to look for inspiration and ask for advice to generate ideas for designing. Interpreting sources of inspiration and using a sewing machine to make free forms were new activities for most of students. Many lacked the confidence for artistic expression. However, towards the end of the course, the results indicated that the virtual environment provided a collective repertoire of design possibilities for the fabric collage technique. It supported students' competence to find and use different types of sources of inspiration and utilize the surrounding materiality in more novel ways.

To conclude, Publication I captured the importance of multisensory sources of inspiration and mental images for creative design. The findings also indicated that manipulating and interpreting the original source was essential in idea generation. However, this was not addressed in detail. Accordingly, the following study concentrated on students' source interpretation in ideation.

6.2 Constraining an open-ended design task by interpreting sources of inspiration (Publication II)

Publication II answered sub-questions 1 and 2 of this dissertation study. It reported how students in textile teacher education interpreted the sources of inspiration and constrained the idea space in an open-ended design task during an experiential textile design module. Combining each student's visuals, the CASS queries and related descriptions in respective documents made it possible to trace students' individual interpretation processes from the first sources till the final surface motifs.

In the qualitative content analysis I applied categories defined by Petre et al. (2006) to evaluate students' reinterpretations. The analysis focused on how students utilized sources of inspiration and how primary generators contributed to constraining the design task. As a result, I grouped students according to their interpretation processes to three approaches. In the *Sequential steps and leaps* approach, interpretations proceeded with sequential steps (i.e., from a literal source of inspiration to a literal interpretation of that source); there were also leaps to interpreting the sources of inspiration more abstractly. In the *Changing path* approach, students proceeded mainly between literal and associative interpretations until the final surface motifs. The *Personal exploration* approach was distinct in that students reinterpreted sources of inspiration in more abstract ways in each subtask.

In students' processes a primary generator would either help to constrain certain lines of ideas (i.e., anchor the experiment to the source of inspiration) or generate different kinds of ideas that were not traceable to the original idea (as a key idea to produce a variety of reinterpretations). In general, both ways were useful, but when the anchoring effect of a primary generator became too strong, fixation occurred.

The fixation effect emerged for example when the initial source of inspiration was interpreted literally throughout the ideation process. Some of the students had aroused sources of inspiration for the experiential module beforehand. They had developed practical uses for their ideas and thereby prevented the free generating-transforming process from occurring during the module. There were also students that, due to their previous education in design, efficiently selected sources of inspiration to develop design concepts; thus, they omitted the more thorough processing of their initial ideas.

A primary generator as a key idea was used often in processes where students developed an abstract source of inspiration from the beginning. However, the continuous crafting with physical materials and getting support from the group and teacher during five subtasks could also lead students to interpret the literal sources of inspiration in more abstract ways. In the sub-tasks students were re-

quired to create three themes that stretched their imagination beyond the obvious.

It was apparent that ideation was more than the ability to interpret sources of inspiration in versatile and deep ways. Students approached designing from their own backgrounds and utilized their personal experiences. These would help to overcome design challenges or sometimes prevent the proper engagement.

This Publication also reported briefly the results of the students' learning experiences. The experiential textile design did not provide any specifics for the ideation despite the framework of the five subtasks. The goals were open and the beginning of the process caused anxious reactions in the students. Some students evaluated themselves as artistically incompetent for experimenting, whereas some considered experimenting simply useless, because they were unclear on the purpose of the activity. Students experienced uncertainty and managed the process with difficulty at the beginning. However, most of the students' perceptions changed during the module. Their insights covered both their personal design skills and their identity as design teachers. They reported adopting a more flexible approach to design ideation. Students identified material experimenting as one kind of alternative for sketching.

To conclude, this Publication highlighted students' interpretation processes when generating verbal, visual and material sources of inspiration and transforming them to material experiments. Practices of ideation were limited during the module to three-dimensional crafting. However, different types of design practices or approaches may support the ideation. After considering this process in the work of students, I then interviewed professional designers who have experienced countless design ideation processes.

6.3 Interview study of professional designers' ideation approaches (Publication III)

In order to answer sub-question 2 of how designers frame the idea space and what kind of approaches could be identified, Publication III reported an interview study on professional designers. The analysis showed that designers used supporting practices (collecting, sketching, material experimenting and verbalising) and triggers (sources of inspiration, mental images, primary generator and constraints) in framing the idea space.

Designers referred to triggers that were artefacts and more abstract entities, such as designer's personal memories. There were designs that inspired; solutions, general styles or design types that also acted as important tools in designers' thinking. In client-initiated cases, external constraints were important triggers, whereas in self-initiated cases internal constraints were naturally emphasised more. In general, designers used these as triggers to evoke atmospheres, stimulate thinking processes and feed the imagination.

Designers' ideation consisted of different types of practices for constraining ideas' space and finding interesting angles on the task. All designers used sketching as a supporting practice, although they used it in differing phases of the ideation process. Designers also collected sources of inspiration, made mood boards, observed surroundings in a focused manner, sketched, used different types of tools, read and wrote.

In order to illuminate these different ways of framing the idea space, I characterized supporting practices and triggers into four approaches. The *Graphic approach* included sketching, informal collecting and utilizing external constraints and mental images. The *Material approach* included collecting many materials, narrowing a primary generator and sketching to develop an idea. In the *Verbal approach* designers used different verbal means to frame the design space. The *Mental approach* had the strongest emphasis on the use of the mental image and a primary generator.

The primary generator appeared to be in very versatile use in a professional context. To frame and constrain the idea space, designers actively developed a certain background principle or specific theme relating to the abstract or concrete sources of inspiration. These triggers were often used as primary generators. They ranged from abstract background philosophy, memories and personal stories to concrete objects and artefacts. In any case, a primary generator captured essentials for the ongoing design case.

To conclude, this Publication showed the results of design ideation from the perspectives of designers themselves. However, the findings of the study also implied the layered and complex nature of design context that would have an effect on the tools and approaches used in ideation. Henceforth, I explored possibilities of capturing real-life designing with the CASS method. The following section will explicate a summary of the related pilot study findings.

6.4 Tracing design work through contextual activity sampling (Publication IV) & Materiality and emotions in making (Publication V)

Publications IV and V answered sub-question 3 of this dissertation study. They examined the everyday activity of professional designers regarding the material and emotional aspects of their work. These publications focused on reporting the analysis and research process of design activities, with slightly different emphases.

The purpose of the study was to explore the feasibility of collecting research data using mobile technology (i.e., a CASS query) and apply an event sampling method in the context of design work. In order to capture the general features of the designers' working practices, I asked the designers to assess in the context of each design event the support of the physical resources (the design tools, the

materials and the place) during one week. Depending on the design phase, the designers used different materials and tools in their work. Most of the designers reported using sketching tools such as design software, paper and a pen. They estimated that these tools supported their working very well in most cases.

During the data collecting, the designers used a variety of materials; such as idea materials, pictures, materials for sketching and designing (i.e., colour and fabric samples) as well as materials for experimenting, for example, when producing preliminary plans, sketches and prints. Designers considered that these materials supported working very well in one-third of the cases and moderately and quite well in the half of the cases.

The designers also assessed the emotional load of the work as a part of query which asked how challenging they experienced the situation to be, how well they were able to concentrate on the task, how creative they felt, and how much they enjoyed the work. Designers reported challenges related to design tasks that were demanding; however, they noted that they had enough resources to meet them. Designers considered that they were able to concentrate during their work well or very well in most of the cases. They also enjoyed their work a good deal or very much in half of the cases.

It appeared that the changeable nature of the design work was related to the multi-layered physical and social spaces of the work. Designer's work was a combination of physical, virtual and social settings. These settings were blended together and varied when a designer shifted from one event to another or from working sometimes physically alone and then with others, virtually or through face-to face contacts. However, the reported enjoyment of the events indicated that they were not disturbed by the changeable nature of the design work and found satisfaction in it.

To conclude, the CASS application aimed to provide data from actual contexts. The motivation for conducting this study was aroused by the current understanding of the design activity as a multi-layered phenomenon in which different variants affect each other (Dorst, 2008). While exploratory in nature, this study was a small first step towards capturing the main characteristics of design work in actual contexts. The data collection method provided one possibility to capture, at least partially, some features of designers' work and related emotional experiences.

6.5 Summary of the findings

In this study I have identified the nature of design ideation and the main elements of ideation, analysed the generation–transforming processes of representations and traced the approaches to ideation. Further, the present study tested a new data collecting method in design context. The focus of this study was on the open-ended design situations, which have a variety of approaches to begin de-

signing and multiple possible choices for the solution (Cross, 2011; Dorst, 2006). As mentioned earlier, these types of situations are challenging and often too complex for immediate solutions. They require creative processes such as the use of analogical thinking and abstraction in order to pursue novelty in idea generation. Therefore, the present study analysed the processes of creative idea development and aimed for finding some concrete methods to manage ideation.

The main question of this dissertation study was, ”How did designers and students generate ideas in their respective contexts?” The results confirmed that creative ideation requires the gradual development of ideas. The designers learn the specifics of the task and through exploration and creation of visual-material or verbal ideas, constrain situation and find initial ideas or a range of them (cf. Schön, 1983; Tan & Melles, 2010; Jonson, 2005). A design task was a basis for ideation processes in student and professional contexts. There was variation in the degree of openness between tasks, because of the designers' heterogeneous positions in the field and students differing tasks in the two respective courses. Nevertheless, the design situations in general required constraining the task in personally meaningful ways. This meant finding a motivating angle to the task and applying design thinking to frame the problem. At the heart of this endeavour were the efforts to both widen and constrain the design idea space. At first, the design situation was open, but was framed by generating and transforming representations. These intertwined efforts created the dynamic nature of ideation.

The key finding of this study was that design ideation is a multimaterial and modal process where representations and objects of the material world are important triggers for ideation that inspire and direct the ideation process. They are generated and transformed with the help of supporting practices such as collecting, sketching and experimenting. A prolonged ideation phase, together with reasonable constraints, reflection and material experimenting, provide fruitful multimodal support for generating and transforming representations in ideation. In this process the role of context is evident. Creative ideation is not only a within-mind cognitive process, but also a fruitful interaction with environment including tools and social interaction (cf. Hutchins, 1995; Orligowski, 2007; Vygotsky, 2004).

In order to deepen the main question, the following sections will answer three sub-questions. They will summarize how the different elements and practices facilitated divergent design thinking in students' and professionals' ideation processes. In addition, they will discuss the importance of social context in light of the results although systematic analysis was not in the scope of this study.

The first sub-question asked, "*What was the role of the sources of inspiration, mental images and external representations in participants' design ideation processes?"* Different sources of inspiration were facilitators in ideation through which associations emerged. The range of sources and ways of using them illustrated the domain specific knowledge and the role of experience in design situa-

tions. Designers apparently had the capability to utilize previous ideas and knowledge that suited very well to the situation and still transform them in purpose to find new angles to the task. The findings indicated that collecting activities that professional designers engaged in and students were encouraged to do increased the number of sources of inspiration that would widen the scope of the given task. In addition, finding and expressing multimodal ideas in material form became possible. The practice of browsing sources of inspiration in concrete ways as well as analysing them conceptually, engaged students and professionals in the "research phase" in ideation (cf. Tan & Melles, 2010). It encouraged them to seek informational cues and emergent properties of sources of inspiration that would suit the current situation. The exploratory process included manipulating representations and restructuring sources of inspiration in ways that would bring new information to a situation or allow a better understanding and insight on the task.

Sources of inspiration and materiality in general provided different opportunities for the interpretation process that importantly promoted idea generation. The selected sources influenced the way the design task was understood and approached (cf. Visser, 2006). Apparently, collecting and the exploration process could prevent the fixation effect commonly associated with familiar exemplars and utilization of initial ideas. The participants' engagement in these types of practices aided in finding the problem or meaning to the task instead of focusing solely towards developing a final product.

The findings indicated that external and internal representations interacted in the ideation processes (cf. Visser, 2006). Mental images were informed by different types of multimodal sources of inspiration, but the generated mental images were also used as sources of inspiration. In that role, these internal representations would develop towards a design idea in the designers' minds and were advanced iteratively further with different externalization methods. In dialogue with their original mental images or other visuals as sources of inspiration, designers would develop their ideas by drawing by hand or by computer and sometimes by experimenting. In the student context, material experimenting as an unstructured method facilitated the emergence of coincidences, failures and surprises necessary in the creative idea generation process that facilitates the dialogue between a sketch and an emerging idea (cf. Schön & Wiggins, 1992). The sketching-materialising process represented the dialogue kind of iteration with the emerging idea (cf. Schön, 1983; Goldschmidt, 1991).

Designers and students identified uniting categories among conceptual, material and visual sources. Thus, they can be seen to rely on the capacity to see structural similarities between sources and the design task requirements (Welling, 2007; Dunbar & Blanchette, 2001). Conceptual thinking and material means were used to transform sources into new conceptual or material ideas. In the student context idea generation occurred in the simplest form as organising and

connecting concepts and giving verbal or material form to them by identifying surface relations and similarities between sources (cf. Casakin & Goldschmidt, 1999). However, ideation also included creating a symbolic relationship between verbal and material sources or even creating a new perspective or insight with verbal and material sources. Creating a new perspective can be seen to refer to the mental process of abstraction that also results the product of abstraction. These types of products of abstraction or initial ideas were in this study material entities that defined the underlying relationship between sources of inspiration in concrete material ways. These materializations with abstraction would bring a completely new understanding (cf. Welling, 2007; Dunbar & Blanchette, 2001). Thus, the ideation process could be, beyond visual manipulation, a method for making deeper meanings or personal exploration that resulted in practice-led types of knowledge creation where research and learning are intertwined (cf. Mäkelä, 2007; Kosonen & Mäkelä, 2012). Especially students with previous experience in design could engage in reflection and dialogue with materials developing an explorative approach to ideation.

The second sub-question asked, "*How did participants frame the idea spaces explored and what kind of approaches on ideation can be identified?"* In the professional design context, designers deliberately utilized various internal, external, personal and social resources to be part of the ideation and used the different type of representations together with different supporting practices to frame the situation to meet their personal goals and the demands of the task. The four approaches to ideation—*graphic*, *material*, *verbal* and *mental*— illustrated these versatile processes.

In the student context, the teacher defined certain external constraints for the design tasks. However, students also had to find their own self-imposed constraints in order to manage their design ideation processes. When they did this successfully, they framed the situation in ways that resembled professional designers' practices. They used sources of inspiration, had prolonged idea generation and utilized primary generators (cf. Darke, 1979).

In both student and professional design contexts, a primary generator was a result of framing the idea space when selecting sources of inspiration, sketching or verbally analysing the current design task. Designers would also use their previous designs, design types, precedents and principles as primary generators.

In the student context, three types of ideation processes were found. *Sequential steps and leaps*, *Changing paths* and *Personal exploration* made visible the different type of interpretation processes involved when generating and transforming representations. In these processes, theprimary generator was the most important and it had two different roles in framing the idea space. The concepts of anchor and key idea referred to the specific role of the source of inspiration in idea generation. The creation of similar variations of representations referred to the use of an anchor idea. Interpretations that had more abstract connections to

the source of inspiration referred to the use of a key idea. Both of these idea types occurred in idea generation and had an important role in managing ideation.

The third sub-question asked, *"What kinds of tools and materials did designers use in their everyday design activity and what were the qualities of associated emotional experiences? "* Creating representations and working in general was dependent on different types of tools that were used as practical aids during the designing. These varied from the classical tools such as pen and paper to the advanced software applications. The designers' everyday work environment was a rich source of varied materials that could be used a source of information or inspiration, to communicate with stakeholders or to develo towards a design object. The findings suggested that design work often included distributing the attention into several tasks at the same time. Therefore, it was occasionally experienced as demanding, yet the designers also reported finding the work intriguing and satisfactory.

In general, there was an indication that students' and designers' individual processes were dependent on the contexts in their respective communities. The various communities that were domains in a professional design context and universities and peer groups in student design context provided the primary environments in which participants could ideate. These communities shared certain cultures and practices, but the participating designers and students also brought their prior experiences and personal resources to the community. The community provided specific frames and examples for ideation. The designers' community influenced their ways of working and utilizing representations.

In the student context, the participants had heterogeneous backgrounds and different types of experiences of design and craft. Some students had previous education in design, whereas others were novices. Personal history in different types of communities and traditions of making evidently influenced the way they approached the open-ended tasks. Therefore, the peers and learning environment in general had an important role in bringing versatile experiences to be shared and discussed. Learning ways of making from others provided a repertoire of examples and thus supported growth of individual student's creative capacity (cf. Vygotsky, 2004).

Considering the nature of ideation, this study concludes that holistic making-related learning in ideation is best constructed in concrete interaction with others, not as an individual and inside the mind process. Therefore, in education, creating and maintaining a learning environment that facilitates joint reflection including an exploratory approach for evolving ideas is crucial to successful ideation.

The conclusions highlight that internal memories and experiences provide potential resources for making unique combinations in interaction with external sources. Novices are capable of significantly transforming representations to-

wards analogies and abstraction when provided scaffolding, time and motivation.

7 General discussion

The present study analysed multiple cases from the student and professional design contexts in order to understand design ideation. The following three sections discuss the implications and methodological choices of this study.

7.1 Theoretical and empirical implications for studying craft and design ideation

This study investigated creative ideation processes, representations and practices to promote design ideation in professional and educational contexts. The design ideation was in this study formulated in the intersection of perspectives related to the conceptual side of ideation (creative thinking, embodied cognition) and the dialogical side of ideation, which concentrates to materiality, reflection and situation in design.

By nature, ideation is a process for creating new perspectives and meanings of existing sources; thus, it requires creative and cognitive efforts beyond the immediate context. Since the focus of this study was on analysing open-ended design tasks, the ideation phase was seen to provide a more constrained design situation as well as the initial design idea(s) to be further manipulated in design process. The findings showed that in order to constrain the situation and create novel ideas, design ideation benefits from a process for generating and transforming representations. It requires conceptual, practical and materially embodied activities. The process includes learning, sharing and communicating ideas to others. This conception was also supported by recent design research regarding ideation in design (Jonson, 2005; Petre et al., 2006; Ramdyny-Ellis et al., 2010, Tan & Melles, 2010).

The research on idea generation is still sparse in craft science and education. The iterative nature of manipulating representations as a core activity in designing has been well explicated in design research, but the potential for doing so in craft ideation practices is yet to be realized. The present investigation provides a deeper understanding regarding the nature of design and craft in the course of cases studied.

Previous research in craft science has been interested in the designing and making processes. Pirkko Anttila (1993; 1996) has provided a model in which initial mental images iteratively develop towards to a more rigorous plan for design activity and further to a final result. Pirita Seitamaa-Hakkarainen's (2000; Seitamaa-Hakkarainen & Hakkarainen, 2001) experimental study presents designing in the three-dimensional model that clarified the use and selection of visual elements through *composition space* and technical elements through *con-*

struction space. It also informed how designers approach the given design task by constructing and reconstructing the context, which defines and redefines the *constraints space* of a design situation. She concludes that designing is not only solving problems, but also structuring and framing the design context (Seitamaa-Hakkarainen, 2000).

There are also models for the purposes of education: the craft process model for elementary school (Lindfors, 1992) and a model for analysing user-centred design for holistic craft (Lindfors, 2010). All these mentioned models and related studies acknowledge ideation, but their focus is on the description of the whole conceptual design process. They are abstractions of the design process and as such have valid uses both for designing as well as studying design processes.

The design ideation presented in this study can be embedded in these process models presented in craft science. However, the findings of the present investigation deepen the existing knowledge focusing especially on ideation. This study provides a description of sources of inspiration, mental images, the role of triggers and their use as key or anchor ideas (see primary generators, Darke, 1979). These concepts have not been previously introduced in craft science research.

Figure 11 provides a description of the ideation, as presented in this study, using an hourglass analogue. The real hourglass is used for measuring time. It is a glass container that allows sand to trickle from the upper bulb through a narrow center to the lower bulb. Here, in the Figure 11 hourglass is a description of a designer's process. In the beginning, the designer studies the design task. The situation is more or less open and the task provides triggers (constraints, mental images, sources of inspiration) for ideation. The designer also intentionally searches for and creates new triggers in the generating and transforming process that is illustrated in the upper part of the hourglass. Thoughts are also often reflected upon and shared with someone. This process constrains the situation and results in the emergence of anchor and/ or key ideas. The anchor or key idea is in the narrow middle of the hourglass to represent a more constrained situation in the ideation process (see Figure 11). These (key or anchor) ideas are one kind of filter for the rest of the process giving it its nature and soul. The crystallization of anchor and/or key ideas also provides new, more constrained directions for ideation. Then, representations may be generated and transformed again to develop the initial ideas that are presented at the bottom of the Figure 11.

In a real hourglass, the sand trickles at a regulated rate. Sand may trickle down a few grains at a time or as an ongoing stream depending on the type of hourglass. As an anlogue to ideation, the hourglass emphasises the time needed in the idea generation process. Sometimes ideation requires a very long and thorough process; sometimes it may be quicker, depending on the task, situation and experience of the designer. The hourglass analogue also describes the continuous or never-ending process of idea generation. When the hourglass is turned

upside down, the initial ideas are revised or they are used as starting points for the following design task.

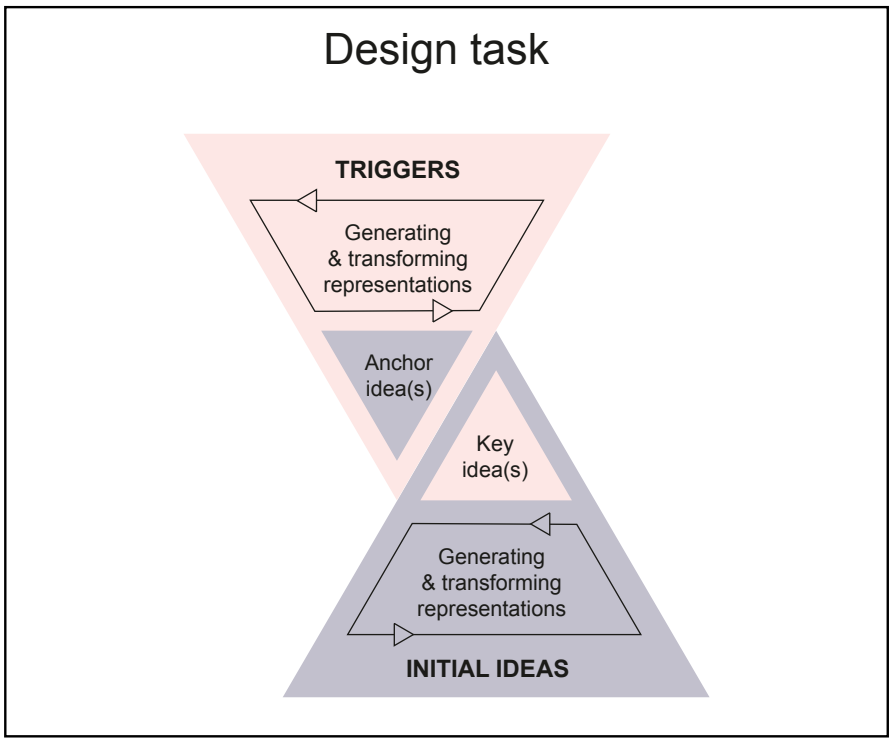

Figure 11. Description of design ideation

In the following, I will explicate the theoretical and empirical implications of this study concerning the four research streams presented in the literature review that were: 1) creativity in the generation of new perspectives; 2) materiality as a resource for inspiration, making and knowledge creation; 3) representations as internal and external aids for ideation, and 4) practices of ideation as ways of generating and transforming representations. In addition, the study provided implications for design learning that I will address later in the final section.

Creativity and materiality were considered in this study as necessary background conditions for design ideation to flourish. The topic of this dissertation 'generating and transforming representations' aimed to crystallize the creative conceptual thinking (the internal representations) and material, situational practices to manipulate and create external representations.

Ideation is sometimes presented as a mental process. In this study, the mind-centred conception was challenged. The design ideation process was presented as a materially embodied activity. This was supported by socio-cultural and practice theories that have emphasised the role of cultural knowledge, tools and practices in human thinking (Hutchins, 1995). Ideation was also discussed in

connection with a situated approach to designing as suggested by Donald Schön (1983). Materiality in the context of designing was seen as a multi-faceted concept involving the physical aspects from tool use to manipulation of materials, as well as reflection on sensory experiences.

In this study, the open-endedness of the design task was characteristic of the creative ideation and made it complex to tackle. Although there is often variation in the extent to which the problems encountered are ill-defined, design tasks always contain a part where the designer is able to choose to follow his or her own preferences, style and competence in design (Dorst, 2006). Accordingly, as the findings also suggest, it is not always evident how much freedom the task will offer, how definite the constraints will be and how much challenge is involved. In any case, designers operate between their own internal needs and the constraints of the current design case. The openness of the design situation provided the designer or student opportunities for personal expression and creativity, but also required goal oriented efforts and analytical thinking for successful solutions (Dorst, 2006). This study noted that while designers carefully considered the constraints of the situation, they also wanted to add personal goals to the given design brief. This kind of approach would give the resulting design its novel appearance and can be seen as an important characteristic of design thinking in design ideation (cf. Cross, 2006).

As the findings of this study suggest, designers' experience also influences how ideation and the design process proceeds. Expert designers appeared to have a vast repertoire of domain specific knowledge and the creative ability to extract, analyse and apply that knowledge (cf. Popovic, 2004). The applied knowledge apparently determined what kind of representation they formulated of the problem, which again influenced how they approached the problem (cf. Björklund, 2013). They had developed strategies of efficiently finding and using sources of inspiration as well as different type of representations for their current cases.

However, as a basis for the above-mentioned knowledge, design ideation was found to rely on certain cognitive capabilities in constructing representations (Visser, 2006; Boden, 2004). Developing a professional vision means competence in seeing a common underlying characteristic such as a pattern, a concept, a class membership, a rule, a process or causal relation as relevant (cf. Eisner; 1996; 1998). Designing is especially related to the development of visual competence that allows perceiving relationships. It is "seeing rather than looking" in multimodal ways and manipulating spatial relations in ways that are characteristic of design domain knowledge and practice. Therefore, creativity in ideation in this study was not only related to experience and materiality, but also to psychological processes that enhance visual capabilities related to analogical thinking or creation of novel associations.

When considering creative thinking, aspects that might hinder novel ideas are also important (cf. Smith, 1995). As reviewed briefly in the theoretical section, fixation has been documented in psychological research and also identified in design literature. In experimental design studies, the importance of representations as stimuli for design thinking is well documented. Source representation can be used to provide an alternative representation of the problem (Colado-Ruiz, & Ghorabi, 2010), impose a certain modality (Sarkar & Chakrabarti, 2008), emphasize a detail that inspires (Cardoso & Badge-Shaub, 2011) or encourage novelty in terms of a given design task (Perttula & Sipilä, 2007). The age and experience of the designer also affects the potential for fixation (Bonnardel & Marméche, 2004). However, there is evidence that fixation may appear in novices as well as practising designers' processes. In this study, evidence of fixation emerged only in the student context.

This study recognized that the creation of an anchor idea could cause fixation. Novices, who did not yet have mature design-thinking capabilities, anchored their process too early to a chosen source of inspiration. Accordingly, the conclusion was that novices could not readily learn to understand the dynamics of ideation without having had specific tuition in the process. The concept of anchoring and the process of literally interpreting sources of inspiration may help to identify and reflect on one's own orientation during ideation. Expert designers and advanced students may also find these "tools" helpful. During this dissertation project and in my own teaching, I have tested and tried design ideation practices and concepts with promising results.

However, with regard to this study, the findings do not explain fully how to prevent fixation in student work. Therefore, it emerges as an important topic for future studies in craft science. More studies are needed in both student and professional design contexts to understand how the ideation and creation of a primary generator is supported as a means to an end, as a design-thinking tool. This study will present some educational implications related to fixation that will support novices for using representations and primary generators to avoid fixation as is presented in a later section.

7.2 Methodological reflections of the study

Designing is a challenging topic to study as well as to teach. Design practices appear to be multidimensional, including interactions at both the individual and collective levels of experience. Designing and activities that support design practice are dependent on the context, constraints, community and physical resources. Thus, necessary knowledge is derived and created from different sources for the design process (Lawson, 2004a).

Designing also involves covert and tacit processes (use of intuition, routine practices, rules, values) not necessarily observable by a researcher. Communica-

tion is not only verbal, but is also embodied in making related aspects. Embodied aspects of cognition such as sensory and emotional experiences and associations may not be available for introspection. In addition, expert designers have developed routine practices that may not become easily articulated for research purposes or designing may be presented as more logical than it was in reality (Cross, 2011; Lawson, 2004a).

Keeping all these mentioned challenges in mind, this study focused on early phases of designing, which are considered the most internal and creative part of designing. In addition, the conceptions of the early phase of designing vary and are influenced by the diverse traditions and approaches presented in design research. The same phenomenon, idea generation, can be studied in terms of conceptual design and under the topic of ideation. In addition, idea generation is not easy to define and delimit as a separate phase in the design process. Consequently, there was a challenge in the research of how to capture elements involving ideation as well as frame the research topic of ideation so that it does not simplify the phenomena.

The present study focuses on the preliminary design phases conceptualized here as ideation, instead of the refining and detailing phases of design. In a preliminary design phase, alternatives are generated and explored until an initial idea emerges (cf. Goel, 1995). The study emphasised the practical and material emergence of ideation. This definition guided the data collecting and framed the analysis in three sub-studies. The fourth sub-study focused on the design context, addressing both the physical and emotional sides of designing. This type of study on design ideation is one of the first in the field of craft science. Therefore, I can suggest here the initial understanding of the very complex phenomenon of ideation where multiple creative processes and elements intersect.

The general appreciation of the need for a broader set of research approaches to capture designers' experience and practice informed this study. It was guided by several significant theoretical and methodological developments such as design thinking and design as a reflective and contextual practice (Schön, 1983). The main focus was on understanding design ideation from the aforementioned points of view; the study also involved experimenting with and developing a context-sensitive data collecting method and tool.

This study relied on multiple case studies so as to trace various aspects of design ideation within each setting and across settings (Baxter & Jack, 2008). It was aimed at examining converging and diverging aspects of design ideation across the cases (Stake, 2005). I expected the research design with qualitative multiple cases to promote the richness and depth of the data, while also supporting the design validity of this study. Accordingly, there was a range of sources of evidence of design ideation. The four separate sub-cases from student and professional design contexts were considered to provide relevant knowledge of open-ended creative tasks that are not yet everyday practice in the education of

crafts. The sub-studies had separate research questions, yet the cases and acquired data had complementary relations (Yin, 2003).

The database from a virtual course was considered ideal for examining the sources of inspiration, mental images and learning experiences in designing. It was a genuine design project and as such it provided naturally occurring data (see Silverman, 2006). All participants provided both verbal and visual data for each design task and took part equally in on-line discussions. There were, of course, individual differences in the length and detail of the descriptions and discussions between students. The portfolio data complemented the virtual database; thus, the data was rich and detailed enough for studying the research topic. In addition, as I was one of the participants in the course, I had an insider understanding of the database and context where it was generated.

The interview data was based on focused interviews, which were designed according to the main themes so that the topic was covered. At the same time, it was open enough for associations for the participants to reflect on their recent design process as well as bring out their own points of view on the subject matter (see Hopf, 2004). The interview data was collected from student and professional design contexts in two of the sub-studies. The process materials were seen as important for recalling and reflecting upon the design tasks in the interview situation (Flick, 2006). They also made the discussion of designing somewhat relaxed and fluent. All the interviews were long and in-depth as they covered the intended themes of ideation.

However, each professional designer was interviewed only once. Understanding the complex ideation phase and expert designing more fully would require several research cycles in terms of repeated interviews and longitudinal data collection methods (Reis & Gable, 2000). In addition, these methods (interviews and on-line database) alone did not fully provide information of the students' or designers' own environments, where they designed, the range of tools they used or their social relationships that influenced the design decisions or the temporal aspects of their designing. Accordingly, the analysis and findings were based on verbal data (supported by visual material data) of what participants themselves said about their own activity and their experiences related to designing. As such, they are retrospective generalizations regarding their past activities, rather than represented ongoing design processes (cf. Reis & Gable, 2000).

The Contextual Activity Sampling System (CASS) (cf. Inkinen et al., 2014; Vartiainen et al., 2007) that I used for data collecting in two of the sub-studies aimed to provide data from real-time design events, which meant acquiring information of ideation in the student context and features of design activity in the professional context. However, as this was the first attempt to pilot the CASS method in a design context, there were challenges that related to both the planning of the data collecting and the execution of the study. There was a variation in the intensity of responding to real-time queries. It appeared that professional

designers' work was even more mobile and multifaceted than what I had expected and the query answering interrupted the designer's activity to some extent. The questionnaire was also too burdensome. This type of sampling bias affected the data collected and may, to some extent, have influenced the results. This has to be taken into consideration when interpreting the results. In addition, it was difficult to plan query questions that would fit in a variety of design situations. Students were especially confused when the questions did not directly match their real-time experiences. They wished for an option of a totally open question, but at the same time were not willing to freely report their thoughts in the audio diary.

However, the CASS data collecting method appears to have potential for design research since the nature of ideation and designing is multifaceted and dispersed across time and space. CASS allows the collection of mobile and multimodal data. Regarding future research projects, I see that the value of event sampling for design research is in how it complements other methods. It is not very suitable for capturing everything a designer does; CASS is best when used as a part of the multi-methodological research plan or as an initiator in a research programme focusing on specific parts of the design activity.

In this study, as in qualitative research in general, insights and information from existing literature were used as context knowledge to contextualize statements and observations (Flick, 2006; Krippendorf, 2013). The qualitative content analyses that were conducted in sub-studies were iterative processes between data and the theoretical propositions to support or discard interpretations during the analyses. The processes were rigorous; the operationalized codes and categories of data analysis were presented as coding schemes that explicated the meaning of those constructs as well as their relation to the analysed texts as quotes. These interpretations were then woven into the design literature. In addition, procedures for combining both transcripts and frequencies in data analyses provided a better understanding of participants' approaches to ideation in general by making possible multifaceted analyses of different aspects of designing and associated experiences. Participants also had opportunities to comment on the interpretations and drafts of the sub-studies.

To sum up, qualitative multiple case studies with context-sensitive methods appeared to be suitable for capturing the richness, depth and complexity that is typical for designing. However, ethnographic, long term observations and practice-led points of view could have strengthened the chosen approach better addressing the tacit, embodied knowledge and contextual aspects involved in ideation. When considering the nature of ideation, it is essential to collect information from multiple events and with multiple methods to gain a full understanding.

7.3 Implications for design education

In the current society there is increasing dependency on innovative approaches and competences for solving open-ended problems related to economic, ethical, and ecological issues. Embedding an understanding of design ideation in professional education and on all the levels of general education provides one possibility to enhance needed skills for peoples' current and future lives. Design ideation where the focus is on seeing beyond the obvious and developing personal constraints to the situation has the potential to increase creativity in problem solving skills in general.

In this dissertation study, I have focused on the subject area of designing and provided implications for design practice and education. The skilled practice is often hard to describe or teach with words because it resides partly in learned routines and intuition (Dormer, 1991). This study, however, aimed to illuminate creative ideation that is manifested in practices and concrete activities of designing. The study also addressed analytical concepts related to ideation that could advance the daily work of design practitioners, students and teachers. The concepts, such as representations, triggers, key and anchor ideas and supporting practices provide the language and vocabulary with which to discuss ideation. Therefore, they enhance consistency in creating, developing and evaluating ideas in designing. In addition, creating meaningful processes by designing appears, according to the findings, to be connected to the identities of the practitioners and student teachers. Consequently, the implications of this study do not focus solely on the visualisation skills related to representations, but also address the value of students' personal experiences that initiate their own processes of inquiry and understanding.

As presented in the literature review, random processes seldom cause novel ideas. Previous research has reported on several creative thinking techniques that help inspiration to flourish (for an overview, see Lau, Ng & Lee, 2009). These techniques (brainstorming, mind maps, six thinking hats) may help in the initial stages, but do not alone assist in generating good ideas or guide the idea development process (Dorst, 2006). In addition, relying on techniques that require the development of creative ideas at the very beginning of a design project is difficult for novice students who may favour perceived standards due tradition, culture or other reasons (Law et al., 2013).

Regarding education, I suggest that ideation is learned through relevant and well-planned design tasks that provide prolonged ideation processes for novices so that they can understand the dynamics of ideation in practice. Design tasks should address two learning objectives for ideation: 1) deliberate practices for generating and transforming representations to develop visual ideas and 2) ways of generating meaning (for example, inquiry-based designing, personal or emotional engagement) for the process.

With regard to the first objective, many of the craft students in higher education already have a repertoire of craft techniques and can efficiently learn new ones. Some students may have engaged in crafts activities from their childhood. However, externalizing techniques for generating ideas is not necessarily habitual to them and needs to be practised more intensively. The findings suggest that students should be taught more explicitly how to use tools to facilitate the generation, not just the execution, of ideas (cf. Stones & Cassidy, 2010).

In order to cultivate ideation-related capabilities, students need to encounter several projects in which they become acquainted externalizing with different types of mediums. They need guidance in becoming aware of various aspects of the ideation process so they can learn to look at each mark for new interpretations (see Stones & Cassidy, 2010). Everyone has the cognitive capacity for analogical reasoning and guided practices regarding how to productively use sources of inspiration is likely to improve students' motivation (see Reading, 2009). Marian Petre's and her colleagues' (2006) categories (i.e., literal, simplification, association, modification, abstraction and deviation) provide examples of applying sources of inspiration in visual ways. These categories illustrate the difference between surface and deeper or more abstract relations between a source and the resulting ideas. As such, the categories can be used to explain how the processes of association and analogue are intertwined in creative ideation.

Drawing is often considered a most appropriate tool that expert designers use to externalize and manipulate representations. However, novices experience drawing as very challenging. It is indeed a demanding skill, since learning to use it sufficiently could take several years. Learning this type of skill would apparently take too much time in the curriculum in higher education. Therefore, if we hope that students will acquire more valid drawing skills, sketching as a natural part of craft studies ought to be introduced already in the elementary schools. However, teacher educators could also encourage students to develop their sketching skills as one of the capabilities that needs to be developed along with the specific crafting methods such as knitting or sewing.

In this study, the emphasis has been on different types of visualisation and verbalisation methods as a partial answer to the present challenge concerning sketching. I have noted that while drawing has an important role, material and verbal methods may similarly support the cyclical process of inspecting the representation and seeing unexpected relations that trigger new revisions and ideas. The different exploratory methods are important in general, but may have specific importance for novices to understand the dynamics of generating and transforming representations for ideation. There was also an indication that these methods bring new knowledge to the process and help develop creative imagination skills. The potential for material exploration for design education is revealed in studies reporting on the pedagogical implications of practice-led research in

which research and learning are intertwined (Kosonen & Mäkelä, 2012; Mäkelä & Löytönen, 2015). Nevertheless, there is a need for more profound research on the practice-led ways of working in textile teacher education, too.

Long-term goals in ideation can be addressed as meaningful making and finding reasons for the ideation process. Thereby, with regard to the second objective for teaching ideation presented before, meaning for the process is constructed by the teacher who embeds different goals to the design tasks, as well as by the student who finds reason for designing in the ebb and flow of conducting the ideation. Exploratory ideation could address several themes from cultural phenomena to interdisciplinary topics. This line of thinking is close to what the experiential learning theories applied in arts education say about learning (Räsänen, 1997; Sava, 1993). Such learning theories consider the teacher to be a facilitator and the emphasis is on the reflective process, where the teacher, peers, and a student together construct meanings regarding their joint learning experience (Räsänen, 1997).

Towards that end, I find it essential that tasks in craft teacher education, whether written or material, contain intellectual efforts that are directed towards a wider context than the final form, quality or a skilled performance. Otherwise, students will be unaware of the multiplicity of their subject and its potential for pedagogical purposes (see Collanus et al., 2012). These potential purposes of designing are not only in the realm of traditional academic learning, which is the theoretical basis of the subject, but also in the multimodal making that cultivates and supports the human abilities of imagination and empathy (Pallasmaa, 2009; Räsänen, 1997). Pallasmaa, who has emphasised embodied designing, suggests that the goals of artistic making may not directly reside in the different principles of making, but rather opening the personality of the student and his or her self-awareness and self-image in relation to the immensely rich traditions of art and the lived world at large (Pallasmaa, 2009, p. 21).

Although the best way to learn and understand is to experience the process as many times as possible in practice, the role of ideation and related practices ought to be also a target of reflection and research in teacher education. Questions such as why proper inquiry-based ideation will foster learning and how it is connected to the curriculum could be considered. Students should be helped to understand the relevance of ideation to their own work as prospective teachers. An open-ended process, even with balanced constraints, is complex, but at the same it provides an opportunity for growing students' own agency. Students may experience diverse emotions while developing their own ideas. Emotions are needed for the sensory experiences to be transformed from the material to the psychic level. According to Sava (1993), emotions ensure that the other forms of knowledge required for art learning (as well as for design learning) get their personal meaning and value (Sava, 1993).

Analysing and interpreting sources of inspiration that are the works of others and designs bridge the realm of social and personal knowledge where a learner derives personal meanings from cultural meanings (cf. Räsänen, 1997). Further, orientation towards process instead of product will better support the development of critical thinking and dealing with uncertainty. Externalizing skills enhances crystallizing and communicating ideas in visual and materially embodied ways. These skills are applicable to many contexts of life, but especially in the educational field, they can be considered necessary in the work as a practising teacher. In the context of textile teacher education, it is crucial that craft as a school subject is able to renew its tradition and future textile teachers are competent in providing methods for designing that are embedded in students' lives and engage them in the exploratory approach to learning as presented by the new Finnish National Core Curriculum (2014) for crafts.

The new curriculum challenges textile teachers' education and teachers' competencies. Students should take responsibility of the whole process including ideating, designing, making, documenting and evaluating the final outcome. Multimodal experiences and perceptions of the built and natural environment are presented as a basis for the creation of ideas. The textile curriculum supports the conclusion that knowledge accumulation and the development of the imagination rest on a large number of versatile experiences.

Students in textile teacher education should engage in design projects that activate their own knowledge creation in suitable learning environments that direct students' through processes and practices similar to those found in real design work settings (see e.g., Sawyer, 2012). An exploratory approach with a playful or artistic attitude is not yet common practice in craft teaching. What seems to be problematic in the field of crafts education is the product and utility centred approach, which may prevent invention (see Dougan, 2009).

Design projects challenge the traditional ways of learning. The exploratory process of designing requires that a student frames the design task and accordingly generates his or her own design ideas and proceeds to constructing the problem and solution together. This is not unproblematic to achieve; it is a balance between openness and the constraints of the task. Students need enough constraints and guidance to proceed beyond the familiar, but too many constraints will result in traditional outcomes. It is therefore important that teacher education support students' design ideation and multimaterial orientation towards the design process. These practices also support new curriculum demands for elementary and secondary education.

In crafts teaching, there is a great opportunity to engage in ideation and deep material explorations since there are no demands for a product-based approach or techniques to be learned. Many teachers are worried about the development of sufficient skills, which means that students might lack the capability to use certain techniques and tools. However, since we cannot know what kind of skills

students need in the future, it is more relevant to engage students in authentic design tasks that develop their overall competences in problem solving as well as their tactile and conceptual understanding of the material reality. This will definitely increase their skill set in holistic ways. In addition, authentic tasks are often interesting and if a student is motivated by the design task, the skill learning will happen automatically as can be seen in the various online craft and design communities. In authentic tasks students will gain experiences that are transferable to other situations as well as sense that they are competent to search for and use different resources in order to learn new skills.

The search for and use of representations and sources of inspirations for ideation as well as their manipulation is potentially supported by current digital, mobile and computer-based technologies and applications. Computer-based design tools, smart boards, mobile phones and virtual environments are already increasingly used in education. These tools enable collecting, storing, grouping as well as presenting, manipulating and discussing representations, design artefacts and ideas easily. Overall, students are proficient with digital technology and motivated to use it.

Teacher education as well as compulsory education would benefit from the increased documentation and use of multimodal representations in more concentrated ways in design teaching. Annika Wiklund-Engblom and her colleagues (2014) have recently introduced a mobile tool for documenting crafts processes. Called 'Talking Tools', the mobile learning management system for smart phones provides a variety of learning resources and transmedia affordances that complement each other. The TT tool allows the so-called microblogging of work processes using text, images and shorts videos that are saved in the individual blogs (Wiklund-Engblom, Hiltunen, Hartvik, Porko-Hudd & Johansson, 2014).

In educational use, the data-collecting tool tested in this study (CASS) indicated similar benefits as 'Talking Tools'. The CASS system was suitable for documenting sources of inspiration and sketching in multimodal ways and had the potential to store images of all the material aspects of ideation. It also could provide a tool for reflection at the moment of documentation. The Wiklund-Engblom et al. (2014) study clearly shows the value of concurrent process notes in the craft process. Accordingly, with these type of mobile tools, collected materials could be examined later in practice-led ways. The data collected allows a teacher a way to support and keep track of the students' processes; furthermore, it allows students to interact with each other in a virtual learning community of microbloggers as Wiklund-Engblom et al. (2014) report. Although there are also challenges (such as surface documentation instead of reflection or documentation), this type of new culture has already spread on the Internet. Education could use blogging for pedagogical purposes and perhaps combine with e-learning platforms.

To conclude, idea generation can be seen as a learning process and a one kind of pedagogical approach that is executable with variety of tools. It can be harnessed as a part of different types of design tasks. At its best there is possibility to promote open-ended problem solving skills, collaboration and understanding of the intertwined relationship between conceptual and material realities.

References

Ahsen, A. (1984). ISM-the triple code model for imagery and psychophysiology. *Journal of Mental Imagery, 8*(4), 15 –42.

Ahsen, A. (1986). The new structuralism: Images in dramatic interlock. *Journal of Mental Imagery, 10*(3), 1–92.

Akin, Ö. (1990). Necessary conditions for design expertise and creativity. *Design Studies, 11*(2), 107–113.

Akin, Ö. (2002). Case-based instruction strategies in architecture. *Design Studies, 23*(4), 407–431.

Anderson, C. (2012). *Makers. The new industrial revolution*. New York: Random House.

Anttila, P. (1993). *Käsityön ja muotoilun teoreettiset perusteet*. Porvoo: WSOY.

Anttila, P. (1996). *Tutkimisen taito ja tiedon hankinta*. Helsinki: Akatiimi.

Arnheim, R. (1969). *Visual Thinking*. Los Angeles: University of California Press.

Ashby, M. F., & Johnson, K. (2013). *Materials and design: The art and science of material selection in product design* (2nd ed.). Oxford: Butterworth-Heinemann.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544–559.

Baynes, K. (2009). Models of change: The impact of 'designerly thinking' on people's lives and the environment. *Seminar 1...modelling and intelligence*. Loughborough University.

Björklund, T.A. (2013). Initial mental representations of design problems: Differences between experts and novices. *Design Studies, 34*(2), 135–160.

Boden, M.A. (2004). *The creative mind: Myths and mechanisms*. London: Routledge.

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology, 54,* 579–616.

Bonnardel, N., & Marmèche, E. (2004). Evocation processes by novice and expert designers: Towards stimulating analogical thinking. *Creativity and Innovation Management, 13*(3), 176–186.

Brewer, J., & Hunter, A. (2006). *Foundations of multimethod research: Synthesizing styles* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Bucciarelli, L. L. (1988). An ethnographic perspective on engineering design. *Design Studies, 9*(3), 159–168.

Bucciarelli, L. L. (1994). *Designing engineers*. Cambridge MA: MIT press.

Bucciarelli, L. L. (2002). Between thought and object in engineering design. *Design Studies, 23*(3), 219–231.

Cardoso, C., & Badke-Schaub, P. (2011). The influence of different pictorial representations during idea generation. *The Journal of Creative Behavior, 45*(2), 130–146.

Casakin, H., & Goldschmidt, G. (1999). Expertise and the use of visual analogy: Implications for design education. *Design Studies, 20*(2), 153–175.

Cassim, F. (2013). Hands on, hearts on, minds on: Design thinking within an education context. *International Journal of Art and Design Education, 32*(2), 190–202.

Charlesworth, C. (2007). Student use of virtual and physical modelling in design development–an experiment in 3D design education. *The Design Journal, 10*(1), 35–45.

Christensen, T.C., Barrett, L. F., Bliss-Moreau, E., Lebo, K., & Kaschub, C. (2003). A practical guide to experience-sampling procedures. *Journal of Happiness Studies, 4*(1), 53–78.

Collado-Ruiz, D., & Ostad-Ahmad-Ghorabi, H. (2010). Influence of environmental information on creativity. *Design Studies, 31*(5), 479–498.

Collanus, M., Kairavuori, S., & Rusanen, S. (2012). The identities of an arts educator: Comparing discourses in three teacher education programmes in Finland. *International Journal of Education through Art, 8*(1), 7–21.

Conner, T.S., Barrett, L.F., Tugade, M.M., & Tennen, H. (2007). Idiographic personality: The theory and practice of experience sampling. In R.W. Robins, R.C. Fraley, & F.W. Krueger (Eds.), *Handbook of research methods in personalitypPsychology* (pp. 79–96). New York: Guilford Press.

Cross, N. (1997). Descriptive models of creative design: Application to an example. *Design Studies, 18*(4), 427–440.

Cross, N. (2001). Creativity in the design process: co-evolution of problem–solution. *Design Studies, 22*(5), 425–437.

Cross, N. (2006). *Designerly ways of knowing*. London: Springer.

Cross, N. (2011). *Design thinking: Understanding how designers think and work*. Oxford: Berg.

Cross, N. (2004). Expertise in design: An overview. *Design Studies, 25*(5), 427–441.

Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the experience-sampling method. *The Journal of Nervous and Mental Disease, 175*(9), 526–536.

Csikszentmihalyi, M., & Sawyer, K. (1995). The great-minds Approach. In J. Stenberg, & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 329–363). Cambridge, MA: MIT.

Darke, J. (1979). The primary generator and the design process. *Design Studies, 1*(1), 36–44.

Dazkir, S.S., Mower, J. M., Reddy-Best, K., & Pedersen, E. L. (2013). An exploration of design students' inspiration process. *College Student Journal, 47*(2), 394–404. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=88413470&site=ehost-live&scope=site

Dormer, P. (1991). *The art of the maker*. London: Thames & Hudson.

Dorst, K. (2006). *Understanding design*. Amsterdam: Bis Publishers.

Dorst, K. (2008). Design research: a revolution -waiting-to-happen. *Design Studies, 29*(1), 4–11.

Dorst, K. (2011). The core of 'design thinking'and its application. *Design Studies, 32*(6), 521–532.

Dougan, B. (2009). Craft-based design as a means to architecture. In L. K. Kaukinen (Ed.), *Proceedings of the crafticulation & education conference* (pp. 31–35). Techne Series: Research in sloyd and crafts science A: 14. Helsinki: Nordfo.

Drew, L. (2004). The experience of teaching creative practices: conceptions andapproaches to teaching in the community of practice dimensions. In A. Davies (Ed.), *Enhancing curricula: towards the scholarship of teaching in art, design and communication in Higher Education* (pp. 106–123) London: Centre for Learning and Teaching (CLTAD).

Drew, L., Bailey, S., & Shreeve, A. (2002). Fashion variations: Students approaches to learning in fashion design. Paper presented at CLTAD conference, *Enhancing Curricula*: *Exploring effective curricula practices in art, design and communication in higher education*. (pp.179–198). London: RIBA.

Dunbar, K., & Blanchette, I. (2001). The in vivo/in vitro approach to cognition: The case of analogy. *Trends in Cognitive Sciences, 5*(8), 334–339.

Duncker, K. (1926). A qualitative (experimental and theoretical) study of productive thinking (solving of comprehensible problems). *Journal of Genetic Psychology, 68*, 97–116.

Duncker, K. (1945). On problem solving. *Psychological Monographs, 58* (Whole No.270).

Eastman, C. (2001). New directions in design cognition: Studies of representation and recall. In C. Eastman, W. M. McCracken, & W. Newstetter (Eds.), *Design, knowing and learning: Cognition in design education* (pp. 147–198). Oxford: Elsevier.

Eckert, C., & Stacey, M. (1998). Fortune favours only the prepared mind: Why sources of inspiration are essential for continuing creativity. *Creativity and Innovation Management, 7*(1), 9–16.

Eckert, C., & Stacey, M. (2000). Sources of inspiration: A language of design. *Design Studies, 21*(5), 523–538.

Eckert, C., & Stacey, M. (2003). Adaptation of sources of inspiration in knitwear design. *Creativity Research Journal, 15*(4), 355–384.

Eckert, C., Stacey, M., & Clarkson, P. (2000). Algorithms and inspirations: Creative reuse of design experience. Paper presented at *the Greenwich 2000 International Symposium: Digital Creativity* (pp. 1–10). London: University of Greenwich.

Eisentraut, R., & Günther, J. (1997). Individual styles of problem solving and their relation to representations in the design process. *Design Studies, 18*(4), 369–383.

Eisner, E.W. (1996). Research on arts and crafts as cultural phenomena. In P. Seitamaa-Hakkarainen, & M. Uotila. *Product, Fenomen, Upplevelse. Proceedings of a Nordic Symposium* (pp. 64–72). Techne Series: Research in Sloyd and Crafts Science B no.3.

Eisner, E.W. (1998). *The enlightened eye. Qualitative inquiry and the enhancement of educational practice.* New Jersey: Prentice-Hall.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*(1), 107–115.

Eneroth, B. (1984). *Hur mäter man" vackert"? Grundbok i kvalitativ metod.* Stockholm: Akademilitteratur.

Ericsson, K. A. (2006). The influence of experience and deliberate practice on the development of superior expert performance. In K. A. Ericson, N. Charness, P. J. Feltovich, P. J., & Hoffman, R. R. (Eds.), *The cambridge handbook of expertise and expert performance* (pp. 683–704). New York: Cambridge University Press.

Ewenstein, B., & Whyte, J. (2009). Knowledge practices in design: The role of visual representations as epistemic objects. *Organization Studies, 30* (1), 7–30.

Ewenstein, B., & Whyte, J. (2007). Visual representations as 'artefacts of knowing'. *Building Research & Information 35*(1), 81–89.

Eysenck, M. W., & Keane, M. T. (2000). *Cognitive psychology: A student's handbook* (4th ed.). Philadelphia: Taylor & Francis.

Feldman Barrett, L., & Barrett, D.J. (2001). An introduction to computerized experience sampling in psychology. *Social Science Computer Review 19*(2), 175–185.

Fenwick, T., Nerland, M., & Jensen, K. (2012). Introduction. Sociomaterial approaches to conceptualizing professional learning. *Journal of Education and Work 25*(1), 1–13.

Ferguson, E.S. (1992). *Engineering and the mind's eye*. Cambridge MA: MIT Press.

Finnish National Board of Education (2014). *Basis for the national curriculum*. Retrieved from

http://www.oph.fi/english/curricula_and_qualifications/basic_education
Fletcher, K. (2008). *Sustainable fashion and textiles: Design journeys*. London: Earthscan.
Flick, U. (2006). *An Introduction to qualitative Research* (3rd ed.) Thousand Oaks: Sage.
Flick, U. (2008). *Designing qualitative Research*. New York: Sage.
Gershuny, J. (2011). *Time-use surveys and the measurement of national well-being*. Centre for Time-use Research.Department of Sociology. University of Oxford.
Goel, V. (1995). *Sketches of thought*. Cambridge MA: MIT Press.
Goldberg, M.W., Salari, S., & Swoboda, P. (1996). World Wide Web—Course tool: An environment for building WWW-based courses. *Computer Networks and ISDN Systems, 28*(7), 1219–1231.
Goldschmidt, G. (1991). The dialectics of sketching. *Creativity Research Journal, 4*(2), 123-143.
Goldschmidt, G. (1997). Capturing indeterminism: representation in the design problem space. *Design Studies, 18*(4), 441–455.
Goldschmidt, G. (2003). The backtalk of self-generated sketches. *Design Issues, 19*(1), 72–88.
Goldschmidt, G., & Sever, A.L. (2011). Inspiring design ideas with texts. *Design Studies, 32*(2), 139–155.
Goldschmidt, G., & Smolkov, M. (2006). Variances in the impact of visual stimuli on design problem solving performance. *Design Studies, 27*(5), 549–569.
Goldschmidt, G., & Tatsa, D. (2005). How good are good ideas? Correlates of design creativity. *Design Studies, 26*(6), 593–611.
Hacker, W. (1982). *Yleinen työpsykologia*. Espoo: Weiling+Göös.
Hakkarainen, K., Palonen, T., Paavola, S., & Lehtinen, E. (2004). *Communities of networked expertise: Educational and professional perspectives*. Amsterdam: Elsevier.
Hargreaves, A., & Shirley, D. (2009). *The fourth way. The inspiring future for educational change*. Thousands Oakes, CA: Corwin.
Heylighen, A., & Neuckermans, H. (2002). Are architects natural case-based designers? Experts speaking. *The Design Journal, 5*(2), 8–22.
Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.
Holyoak, K.J., Gentner, D., & Kokinov, B.N. (2001). Introduction: A place of analogy in cognition. In D. Gentner, K.J.Holyoak, & B.N Kokinov (Eds.), *The Analogical Mind: Perspectives from cognitive science*. Cambridge MA: The MIT Press

Holyoak, K.J., & Thagard, P. (1997). The analogical mind. *American Psychologist, 52*(1), 35–44.

Hopf, C. (2004). Qualitative interviews. An overview. In U. Flick, E. Kardoff, & I. Steinke (Eds.), *A companion to qualitative research* (pp. 203–209). London: Sage.

Howard, T.J., Culley, S. J., & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies, 29*(2), 160–180.

Hsieh, H.F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277–1288.

Hulkko, S., Mattelmäki, T., Virtanen, K., & Keinonen, T. (2004). "Mobile probes". In A. Hyrsykari (Ed.), *Proceedings of the third Nordic conference on human-computer interaction*, Tampere, Finland: ACM Press. 43–51.

Hutchins, E. (1995). *Cognition in the wild.* Cambridge MA: MIT press.

Inkinen, M., Lonka, K., Hakkarainen, K., Muukkonen, H., Litmanen, T., & Salmela-Aro, K. (2014). The interface between core affects and the challenge-skill relationship. *Journal of Happiness Studies, 15*(4), 891–913.

Jacucci, G., & Wagner, I. (2007). Performative roles of materiality for collective creativity. *Proceedings of the 6th ACM SIGCHI Conference on Creativity & Cognition*, Washington DC, USA, 73–82.

Johansson, M. (2011). Dagboksmetod – att beskriva slöjdarbete med elevers och lärares egna ord. [Diary method ‑ to describe sloyd work with pupils' and teachers' own words]. *Techne Journal, 18*(1), 79–93.

Jonson, B. (2005). Design ideation: The conceptual sketch in the digital age. *Design Studies, 26*(6), 613–624.

Kangas, K., Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2013a). Design thinking in elementary students' collaborative lamp designing process. *Design and Technology Education: An International Journal, 18*(1), 30–43.

Kangas, K., Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2013b). Figuring the world of designing: Expert participation in elementary classroom. *International Journal of Technology and Design Education, 23*(2), 425–442.

Keinonen, T. (2006). Introduction to concept design. In T. Keinonen, & R. Takala, *Product Concept Design* (pp. 1–13). London: Springer.

Keller, A.I., Pasman, G.J., & Stappers, P.J. (2006). Collections designers keep: Collecting visual material for inspiration and reference. *Codesign, 2*(1), 17–33.

Kirsh, D. (2010). Thinking with external representations. *Ai & Society, 25*(4), 441–454.

Kirsh, D. (2011). Creative cognition in choreography. In D. Ventura, P. Gervás, D.F. Harrel, M.L. Maher, A. Pease, & G. Wiggins (Eds.), *Proceedings of*

2nd International Conference on Computational Creativity, Mexico city. 141–146.

Knorr Cetina, K., (1999). *Epistemic cultures: The cultures of knowledge societies*. Cambridge, MA: Harvard University Press.

Knorr Cetina, K. (2001) Objectual practice. In T.R. Schatzki, K. Knorr Cetina, & E. von Savigny (Eds.), *The practice turn in contemporary theory* (pp. 175–188). London: Routledge.

Kojonkoski-Rännäli, S. (1995). *Ajatus käsissämme. Käsityön käsitteen merkityssisällön analyysi*. Turun yliopiston julkaisuja. Sarja C, n: o 109.

Kosonen, K., & Mäkelä, M. (2012). Designing platform for exploring and reflecting on creative process. *Procedia-Social and Behavioral Sciences, 45*, 227–238.

Kosslyn, S. M. (1973). Scanning visual images: Some structural implications. *Perception & Psychophysics, 14*(1), 90–94.

Kosslyn, S.M. (1980). *Image and mind*. Cambridge MA: Harvard University Press.

Köhler, W. (1927). The mentality of apes (2nd ed.). New York: Harcourt Brace.

Krippendorff, K. (2012). *Content analysis: An introduction to its methodology*. London: Sage.

Lau, K., Ng, M., & Lee, P. (2009). Rethinking the creativity training in design education: A study of creativethinking tools for facilitating creativity development of design students. *Art, Design & Communication in Higher Education, 8*(1), 71–84.

Law, D., Yip, J., Wong, C., & Cheung, M. (2013). Enhancing the process of idea generation in Hong Kong Chinese university students: The fashion visual merchandising experience. *Art, Design & Communication in Higher Education, 12*(1), 103–121.

Lawson, B. (1997). *Design in mind*. Oxford: Architectural press.

Lawson, B. (2004a). *What designers know?* Oxford: Elsevier.

Lawson, B. (2004b). Schemata, gambits and precedent: Some factors in design expertise. *Design Studies, 25*(5), 443–457.

Lawson, B. (2006). *How designers think: The design process demystified* (4th ed.). Oxford: Elsevier.

Lenau, T., & Boelskifte, P. (2004). Communication of semantic properties. *The 3rd Nordcode Seminar & Workshop*. Retrieved from http://nordcode.tkk.fi/lyngbypapers/nc3_lenau.pdf

Liddament, T. (2000). The myths of imagery. *Design Studies, 21*(6), 589–606.

Lindfors, E. (2010). Innovation and user-centred design in the pedagogical context. In J. Sjøvoll & K. Skogen (Eds.) *Creativity and innovation. Preconditions for entrepreneurial education* (pp.53–63). Trondheim: Tapir akademisk forlag.

Lindfors, L. (1991). *Slöjddidaktik. Inriktning på grundskolans textilslöjd*. [Craft didactic. Introduction to the textile craft education in basic education]. Helsinki: Finn Lectura Ab.

Lindfors, L. (1992). *Formgivning I slöjd. Ämnesteoretisk och slöjdpedagogisk orienterinsgrund med exempel från textilslöjdundervisning*.[Designing in sloyd. An orientation on a subject-theoretical and sloyd educational basis]. Rapporter från Pedagogiska fakultetet vid Åbo Akademi nr. 1. Vasa: Åbo Akademi.

Mattelmäki, T. (2006). *Design probes*. Vaajakoski: Gummerus.

McDonagh, D., & Storer, I. (2004). Mood boards as a design catalyst and resource: Researching an under-researched area. *The Design Journal, 7*(3), 16–31.

Mäkelä, M. & Löytönen, T. (2015). Enhancing material experimentation in design education. In R.V. Zande, E.Bohemia & I. Digranes (Eds.), *Proceedings of the 3rd International Conference for Design Education Researchers, Vol. 3,* Helsinki, Aalto University. 168–183.

Mäkelä, M. (2007). Knowing through making: The role of the artefact in practice-led research. *Knowledge, Technology & Policy, 20*(3), 157-163.

Muukkonen, H., Hakkarainen, K., Inkinen, M., Lonka, K., & Salmela-Aro, K. (2008). CASS-methods and tools for investigating higher education knowledge practices. P*roceedings of the 8th International Conference on International Conference for the Learning Sciences, Vol. 2*. 107–114.

Naqvi, S. (2006). Impact of WebCT on learning: Oman experience. *International Journal of Education and Development using ICT, 2*(4). Retrieved from http://ijedict.dec.uwi.edu/viewarticle.php?id=220&layout=html

Narvaéz, L.M.J. (2000). Design's own knowledge. *Design Issues, 16* (1), 36–52.

Newell, A., & Simon, H.A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Newstetter, W. C., & McCracken, W.M. (2001). Novice conceptions of design: implications for the design of learning environments. In C. Eastman, W.M. McCracken, & W. Newstetter (Eds.), *Design knowing and learning: Cognition in design education* (pp.63–78). Oxford: Elsevier.

Ng, E., & Bereiter, C. (1995). Three levels of goal orientation in learning. In A. Ram, & D. B. Leake (Eds.), *Goal –driven learning* (pp. 355–380). Cambridge MA: The MIT Press.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-creating Company: How Japanese create the dynamics of innovation*. Oxford University Press.

Nygren-Landgärds, C. (2000). *Educational and teaching ideologies in sloyd teacher education*. Åbo Akademi University Press.

O'Connor, K.P., & Aardema, F. (2005). The imagination: Cognitive, precognitive, and meta-cognitive aspects. *Consciousness and Cognition, 14*(2), 233–256.

Orlikowski, W.J. (2007). *Sociomaterial Practices: Exploring Technology at work. Organization Studies 28*(9), 1435–1448.
Oxman, R. (1990). Prior knowledge in design: A dynamic knowledge-based model of design and creativity. *Design Studies, 11*(1), 17–28.
Paavola, S. (2006). *On the origin of ideas: An abductivist approach to discovery*. University of Helsinki.
Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart and Winston.
Paivio, A. (1986). *Mental representations: A dual coding approach*. New York: Oxford University Press.
Paivio, A. (1991). *Images in mind: The evolution of a theory*. New York: Harvester Wheatsheaf.
Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Mahwah (NJ): Lawrence Erblaum Associates (LEA).
Pallasmaa, J. (2009). *The thinking hand*. United Kindom: John Wiley & Sons Ltd.
Patel, K. (2008). *Thinkers in the kitchen: Embodied thinking and learning in practice*. Harvard University.
Pei, E., Campbell, I.R., & Evans, M.A. (2010). Development of a tool for building shared representations among industrial designers and engineering designers. *Codesign, 6*(3), 139–166.
Perry, M., & Sanderson, D. (1998). Coordinating joint design work: The role of communication and artefacts. *Design Studies, 19*(3), 273–288.
Perttula, M., & Sipilä, P. (2007). The idea exposure paradigm in design idea generation. *Journal of Engineering Design, 18*(1), 93–102.
Petre, M., Sharp, H., & Johnson, J. (2006). Complexity through combination: An account of knitwear design. *Design Studies, 27*(2), 183–222.
Polanyi, M. (1966). *The tacit dimension*. NY: Doubleday.
Popovic, V. (2004). Expertise development in product design—strategic and domain-specific knowledge connections. *Design Studies, 25*(5), 527–545.
Pöllänen, S. (2009). Contextualising craft: Pedagogical models for craft education. *International Journal of Art & Design Education, 28*(3), 249–260.
Pöllänen, S.H. (2011). Beyond craft and art: A pedagogical model for craft as self-expression. *International Journal of Education through Art, 7*(2), 111–125.
Purcell, A.T., & Gero, J.S. (1996). Design and other types of fixation. *Design Studies, 17*(4), 363–383.
Purcell, A.T., & Gero, J.S. (1998). Drawings and the design process. *Design Studies, 19*(4), 389–430.
Ramduny-Ellis, D., Dix, A., Evans, M., Hare, J., & Gill, S. (2010). Physicality in design: An exploration. *The Design Journal, 13*(1), 48–76.

Reading, C. (2009). Sources of inspiration: How design students learn from museum collections and other sources of inspiration. *Art, Design & Communication in Higher Education, 8*(2), 109–121.

Reis, H. T., & Gable, S. L. (2000). Event sampling and other methods for studying everyday experience. In H.T. Reis, & C.M. Judd (Eds.), *Handbook of Research Methods in Social and Personality Psychology* (pp. 190–222). U.S.A: Cambridge University Press.

Rodgers, P., & Milton, A. (2001). What insipres undergraduate design students? *The Design Journal, 4*(2), 50–54.

Runco, M. A. (2014). *Creativity: Theories and themes: Research, development, and practice* (2nd ed.). London: Elsevier.

Räsänen, M. (1997). *Building bridges. Experiential art understanding: A work of art as a means of understanding and constructing*. Helsinki: University of Art and Design.

Sarkar, P., & Chakrabarti, A. (2008). The effect of representation of triggers on design outcomes. *Artificial Intelligence for Engineering, Design, Analysis and Manufacturing*, *22*(2), 101–116.

Sava, I. (1993). Taiteellinen oppimisprosessi. In I. Porna, & P. Väyrynen (Eds.), *Taiteen perusopetuksen käsikirja* (pp.15–43). Helsinki: Suomen kuntaliitto.

Sawyer, K. (2012). Learning how to create: Toward a learning science of art and design. In J.van aalst, K. Thompson, M.J. Jacobson & P. Reimann (Eds), *The Future of Learning: Proceedings of the 10th International Conference of the Learning Sciences (ICLS 2012), Vol. I, full papers* (pp. 33–36) Sydney NSW, Australia: International Society of Learning Sciences.

Scardamalia, M. (2002). Collective Cognitive Responsibility for the Advancement of Knowledge. In B. Smith (Ed.), Liberal Education in a Knowledge Society (pp.67–98). Chigago: Open Court.

Schatzki, T.R. (2001). Introduction: practice theory. In T.R Schatzki, K. Knorr-Cetina, & E. Von Savigny (Eds.), *The practice turn in contemporary theory* (pp.1–10). London: Routledge.

Schön, D.A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic books.

Schön, D.A. (1987). *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass.

Schön, D.A. (1988). Designing: Rules, types and worlds. *Design Studies, 9*(3), 181–190.

Schön, D.A. (1992). Designing as reflective conversation with the materials of a design situation. *Research in Engineering Design, 3*(3), 131–147.

Schön, D.A., & Wiggins, G. (1992). Kinds of seeing and their functions in designing. *Design Studies, 13*(2), 135–156.

Seitamaa-Hakkarainen, P. (2000). *The weaving-design process as a dual-spaces search*. University of Helsinki: Department of Home Economics and Craft Science. Research report 6.

Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2001). Composition and construction in experts' and novices' weaving design. *Design Studies, 22*(1), 44–66.

Sennett, R. (2008). *The Craftsman*. New Haven: Yale University Press

Shepard, A., & Metzler, J. (1971). Mental rotation of three-dimensional Objects. *Science, 191*, 701–703.

Shiffman, S. (2000). Real-time self-report of momentary states in the natural environment: Computerized ecological momentary assessment. In: A. Stone, J. Turkkan, J. Jobe et al. (Eds.). *The Science of Self-report: Implications for Research and Practice*, (pp. 277–296). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Shreeve, A., Sims, E., & Trowler, P. (2010). 'A kind of exchange': Learning from art and design teaching. *Higher Education Research & Development, 29*(2), 125–138.

Shumack, K. (2009). Learning as experience: A model for teaching the reflective exegesis for communication design practice. *Art, Design & Communication in Higher Education, 7*(2), 59–72.

Silverman, D. (2006). *Interpreting qualitative data: Methods for analyzing talk, text and interaction*. London: Sage.

Simon, H.A. (1969). *The sciences of the artificial.* Cambridge, MA: The MIT Press.

Sjöberg, B. (2009). Design theory and design practice within sloyd education. *International Journal of Art & Design Education, 28*(1), 71–81.

Smith, S.M. (1995). Getting into and out of Mental Ruts: A Theory of Fixation, Incubation, and Insight. In J. Stenberg, & J.E. Davidson (Eds.), *The nature of insight* (pp. 229–251). Cambridge MA: The MIT Press.

Stake, R.E. (2005). Qualitative case studies. In N.K. Denzin, & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (3rd ed., pp. 443–466). Thousand Oaks, CA: Sage.

Stacey, M., & Eckert, C. (2010). Reshaping the box: Creative designing as constraint management. *International Journal of Product Development, 11*(3–4), 241–255.

Sternberg, R.J., & Lubart, T.I. (1999). The concept of creativity: Prospects and paradigms. *Handbook of Creativity, 1*, 3–15.

Stones, C., & Cassidy, T. (2010). Seeing and discovering: How do student designers reinterpret sketches and digital marks during graphic design ideation? *Design Studies, 31*(5), 439–460.

Stone, A.A., & Shiffman, S. (2002). Capturing momentary, self-Report data: A proposal for reporting guidelines. *Annuals of Behavioral Medicine, 24*(2), 236–243.

Stone, A.A., Shiffman, S., Atienza, A.A., & Nebeling, L. (2007). Historical roots and rationale of ecological momentary Assessment (EMA). In: A.A. Stone, S. Shiffman, A.A. Atienza, L. Nebeling (Eds.). *The Science of Real-time Data Capture: Self-reports in Health Research*, (pp. 3–10). New York: Oxford University Press.

Suwa, M., & Tversky, B. (1997). What do architects and students perceive in their design sketches? A protocol analysis. *Design Studies, 18*(4), 385–403.

Syrjäläinen, E., & Seitamaa-Hakkarainen, P. (2014). The quality of design in 9th grade pupils' design-and-make assignments in craft education. *Design and Technology Education: An International Journal, 19*(2), 30–39.

Säljö, R. (2001). *Oppimiskäytännöt. Sosiokulttuurinen näkökulma*. Helsinki: WSOY.

Tan, S., & Melles, G. (2010). An activity theory focused case study of graphic designers' tool-mediated activities during the conceptual design phase. *Design Studies, 31*(5), 461–478.

Thomas, N.J. (2014). Mental imagery. In E.N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. Retrieved from http://plato.stanford.edu/entries/mental-imagery/bibliography-mental-imagery.html

Thomas, N.J. (1999). Are theories of imagery theories of imagination? An active perception approach to conscious mental content. *Cognitive Science, 23*(2), 207–245.

Thorndike, E.L. (1911). *Animal intelligence.* New York: Macmillan.

Van der Lugt, R. (2005). How sketching can affect the idea generation process in design group meetings. *Design Studies, 26*(2), 101–122.

Vartiainen, H. (2014). *Principles for design-oriented pedagogy for learning from and with museum objects.* Dissertations in Education, Humanities and Theology No 60. Joensuu: University of Eastern Finland.

Vartiainen, M., Hakonen, K., Koivisto, S., Mannonen, P., Nieminen, M. P., Ruohomäki, V., & Vartola, A. (2007). *Distributed and mobile work: Places, people, & technology*. Espoo: Otatieto; Helsinki: Gaudeamus.

Verstijnen, I. M., Hennessey, J. M., Van Leeuwen, C., Hamel, R., & Goldschmidt, G. (1998). Sketching and creative discovery. *Design Studies, 19*(4), 519–546.

Visser, W. (2006). *The cognitive artefacts of design*. Mahwah, NJ: Lawrence Erlbaum Associates.

Vygotsky, L. S. (1981). The instrumental method in psychology. In J. Wertch (Ed.), *The concept of activity in Soviet psychology* (pp. 134–143). Armonk, NY: ME Sharpe.

Vygotsky, L. S. (1978). *Mind in society: The development of higher mental process*. Cambridge MA: Harvard University Press

Vygotsky, L. S. (2004). Imagination and creativity in childhood. *Journal of Russian & East European Psychology, 42*(1), 7–97.

Wagner, I. (2000). Persuasive artefacts in architectural design and planning. In S. A. R. Scrivener, J. L. Ball, & A. Woodcock (Eds.), *Collaborative design: Proceedings of CoDesigning* (pp. 379-389).

Ward, T.B., & Sifonis, C. M. (1997). Task demands and generative thinking: What changes and what remains the same? *Journal of Creative Behavior, 31*(4), 245–249.

Ward, T.B. (1994). Structured imagination: The role of category structure in exemplar generation. *Cognitive Psychology, 27*(1), 1–40.

Ward, T.B., Patterson, M.J., & Sifonis, C.M. (2004). The role of specificity and abstraction in creative idea generation. *Creativity Research Journal, 16*(1), 1-9.

Ward, T.B., Patterson, M.J., Sifonis, C.M., Dodds, R.A., & Saunders, K.N. (2002). The role of graded category structure in imaginative thought. *Memory & Cognition, 30*(2), 199–216.

Welch, D., & Loy, J. (2013). A brave new creativity. *Art, Design & Communication in Higher Education, 12*(1), 91–102.

Welling, H. (2007). Four mental operations in creative cognition: The importance of abstraction. *Creativity Research Journal, 19(*2-3), 163–177.

Weisberg, R.W. (2006). Expertise and reason in creative thinking: Evidence from case Studies and the laboratory. In J.C Kaufman, & J. Baer (Eds.), *Creativity and reason in cognitive development* (pp.7–42). New York: Cambridge University Press.

Wertch, J. (1991). *Voices of the mind. A sociocultural approach to mediated action*. London: Harvester Wheatsheaf.

Wertheimer, M. (1954). *Productive thinking*. New York: Harper & Row.

Wiklund-Engblom, A., Hiltunen, K., Hartvik, J., Porko-Hudd, M., & Johansson, M. (2014). 'Talking tools': Sloyd processes become multimodal stories with smartphone documentation. *International Journal of Mobile and Blended Learning (IJMBL), 6*(2), 41–57.

Woodward, I. (2007). *Understanding material culture*. London: Sage.

Yin, R.K. (2003). *Case study research: Design and methods* (3rd ed.). London: Sage.

Yin, R.K. (2014). *Case study research: Design and methods* (5th ed.). London: Sage.

Yliverronen, V. (2014). From story to product: Pre-schoolers' designing and making processes in a holistic craft context. *Design and Technology Education: An International Journal, 19*(2), 8–16.

Youmans, R.J. (2011). The effects of physical prototyping and group work on the reduction of design fixation. *Design Studies*, *32*(2), 115–138.
Zhang, J. (2001). External representations in complex information processing tasks. In A. Kent (Ed.), *Encyclopedia of library and information science Vol.68*. (pp. 164–180). New York: Marcel Deccer, Inc.