INNOVATIONS
IN HANDS-ON SIMULATIONS FOR COMPETENCE DEVELOPMENT

Authenticity and ownership of learning and their effects on student learning in secondary and higher vocational education

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Anne E. Khaled

Thesis

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Contents

Chapter 1

General introduction

Introduction

Vocational curricula aim at new outcomes required by the workplace, such as dealing with a wide range of ill-structured problems and being creative, innovative and inquisitive: in combination referred to as professional competence (Mulder, 2014). To foster the development of these new learning outcomes, innovations in secondary and higher vocational education have been widely implemented across Europe and beyond (Argüelles & Gonczi, 2000; Brockmann, Clarke, Méhaut, & Winch, 2008; Mulder, 2012). Recent innovations in vocational education are characterised by an outcome-based approach to educational development (Young, 2009) in which outcomes of an educational path, formulated in collaboration with the labour market, are the starting point for the curriculum. Competence-based education is such an implemented example (Biemans, Nieuwenhuis, Poell, Mulder, & Wesselink, 2004; Sturing, Biemans, Mulder, & De Bruijn, 2011; Wesselink, de Jong, & Biemans, 2010). Competence-based education aims at developing new outcomes, next to the more traditional ones, by integrating the necessary knowledge, skills and attitudes in various (work-related) learning settings that are related to the profession. This situative perspective on learning originates from the idea that preparing students for their future requires confronting them with real-world problems and contexts (De Corte, 2003), including the social dynamics related to that practice (Brown, Collins, & Duguid, 1989).

Until recently, educationalists assumed that exposing students to the workplace via internships or apprenticeships automatically resulted in developing professional competence. Today, this assumption is disputed (Onstenk & Blokhuis, 2007; Poortman, Nelen, De Grip, Nieuwenhuis, & Kirschner, 2012) because learning activities in internships are focussed mainly on working processes and less on related theory or professional knowledge, and thus less on the professionally relevant outcomes for a certain educational trajectory (Nieuwenhuis, Poortman, & Reenalda, 2014). For example, interns frequently comment that they learn 'how to' apply knowledge and skills but do not learn 'why' they act in a certain manner during their internship (Akkerman & Bakker, 2011). Consequently, there is increased attention for creating meaningful work-related learning experiences with emphasis on pedagogies that connect professional theory and practice (Tynjälä, 2009), ranging from case-based learning and simulated learning to fulfilling a project with a real client. Simultaneously, empirical research emerges on how to design effective work-related learning environments in the context of innovative vocational education that aims at developing new outcomes such as professional competence (e.g. hybrid learning environments (Cremers, Wals, Wesselink, Nieveen, & Mulder, 2013; Zitter & Hoeve, 2012) and regional learning (Gulikers & Oonk, 2013)).

Hands-on simulations are also work-related learning environments in which vocational students participate during their education pathways. At the school site or in a simulation/training centre, work situations are replicated in order to stimulate competence development. Teachers in vocational education increasingly value hands-on simulations, the use of which is growing, especially at vocational schools (Jossberger, 2011). However, hands-on simulations have, up till now, been underexposed in empirical research about innovative vocational education and there is very little insight into how their learning environment characteristics relate to new outcomes such as competence development (Rush, Acton, Tolley, Marks-Maran, & Burke, 2010). The knowledge gap about whether hands-on simulations foster new outcomes makes it difficult for teachers to determine their role and function in a contemporary curriculum. Therefore, this dissertation generates understanding about student learning in hands-on simulations that are part of an innovative curriculum aiming at professional competence (competence-based education in this dissertation). This chapter will further elaborate on the concept of hands-on simulations, work towards a problem statement and aim, further explain the context of the hands-on simulations and outcomes, and close with the structure of the dissertation.

Hands-on simulations

A large proportion of students in secondary and higher vocational education will encounter simulated learning, especially in professions involving a risk of injuring or harming a patient or environment (e.g. medical, agricultural, police and aviation education). In educational simulations, the vocational context and tasks are replicated in either a virtual or live environment at school or at a training centre (Hertel & Millis, 2002). Novice or intermediate students, who are inexperienced in their professional field, will learn in a safe and controlled environment to perform professional tasks, from simple to complex. Benefits of simulation-based learning include standardisation and repetition of task, 'training' many students in a short time, learning in real-life contexts without consequences, pausing the session whenever felt necessary, and the ability to create a goal-oriented learning environment (Cunningham, 1984; Kneebone, 2003; Steadman et al., 2006). The simulations in this study are 'hands-on', which means that the students learn by performing one or more professional tasks 'live' in a learning setting that is a realistic replica of the workplace context, with tangible material and equipment (see page 14 and Chapter 2 for examples).

Problem statement and aim of this dissertation

In contrast to new work-related learning environments, such as hybrid learning environments and regional learning, hands-on simulations have been integrated in vocational curricula for a long time. Now that there are new requirements with respect to learning outcomes and processes in vocational education, teachers struggle with integrating hands-on simulations in the curriculum. The reasons underlying this problem concern theoretical as well as practical ambiguity for the use of hands-on simulations.

Firstly, pedagogical-didactic approaches in hands-on simulations are not well conceptualised from a learning theory perspective (Bradley & Postlethwaite, 2003; Rutherford-

Hemming, 2012; Schiavenato, 2009). Hands-on simulations have become more sophisticated due to technological developments and are increasingly used to teach more complex skills, such as problem-solving and investigating, instead of using them only for technical and procedural knowledge and skills development. However, the 'traditional' assumptions behind these simulations are based mainly on learning through instruction, learning by doing and learning from feedback to reinforce behavioural change (Cunningham, 1984). One might question whether this 'traditional' approach to hands-on simulations is appropriate for developing the outcomes desired these days, such as competence, or whether more *constructivist*, pedagogical-didactic approaches to teaching and student learning that align with innovative vocational education are desired (see Chapter 2). The idea behind more traditional learning (in the context of this study: behaviourist and early cognitivist learning) is that skills development occurs automatically through repetition and rehearsal, and that information is transmitted from one person to another in which the learner is more a passive recipient (Anderson, Magill, & Sekiya, 2001). The idea behind constructivist learning, however, is that the students' individual experiences in a situation and with others shape how they perceive information and learn. Therefore, in constructivist learning environments, students are responsible for learning and are active participants of learning (De Kock, Sleegers, & Voeten, 2004; Engeström, 1999; Jonassen, 1999; Simons, 1999). Specifically two aspects of active constructivist learning claim to foster competence development, that are 1) *authenticity*—realistic learning contexts and tasks and 2) *taking ownership of learning* (i.e. *self-directed learning*—students steer their learning by choosing learning content, and *self-regulated learning*—students control their learning during task performance) (De Bruijn & Leeman, 2011; Gulikers, Bastiaens, Kirschner, & Kester, 2006; Kicken, Brand-Gruwel, & van Merriënboer, 2008; Van Bommel, Kwakman, & Boshuizen, 2012). However, research on the effect of authentic design of hands-on simulations on competence development is ambiguous (Beaubien & Baker, 2004; Maran & Glavin, 2003; Van Merriënboer & Sweller, 2010) and research on taking ownership of learning in hands-on simulations is scarce (Jossberger, Brand-Gruwel, Boshuizen, & Van de Wiel, 2010).

Secondly, there are no straightforward guidelines for teachers about how to implement and use hands-on simulations in an innovative curriculum. There is little governmental supervision in hands-on simulations since they are not recognised as an official form of workplace learning. For example, in the Netherlands hands-on simulation is categorised as a 'special form of professional training' (Inspectie van het Onderwijs, 2012). Consequently, they officially do not count for work-related learning hours in a vocational education trajectory. Also, the implementation of hands-on simulation varies considerably across educational institutes, resulting in a wide variety of hands-on simulations depending on the vision and creativity of educational institutes.

Lastly, hands-on simulations are often associated with 'fun' and 'exciting', but empirical research on learning in hands-on simulation is scarce and not well communicated to practice (Jossberger et al., 2010). Therefore, policy makers and teachers do not exactly know for what purposes, other than developing technical and procedural knowledge and skills, hands-on simulations can be used.

These issues indicate that there is a need to conceptualise hands-on simulations in the light of the constructivist learning theory, which aligns with innovative vocational curricula and its desired outcomes, i.e. competence development, and investigating how specific constructivist learning environment characteristics, i.e. authenticity and ownership of learning, *are* and *can be* integrated in hands-on simulations and how they affect student learning.

To sum up, innovative vocational curricula increasingly integrate hands-on simulations to create meaningful, profession-related learning experiences. However, more insight is required about precisely what characteristics in hands-on simulations enhance outcomes that students need for their future profession, such as competence. Two constructivist learning environment characteristics (i.e. authenticity and ownership of learning) are argued to foster these outcomes (see Chapter 2 for the theoretical framework). This dissertation examines these learning environment characteristics in relation to secondary vocational and higher vocational education students' learning. The aim is to examine the value that hands-on simulations add to an innovative curriculum in which new outcomes, such as competence, are the intended learning outcomes. We do this by examining authenticity and ownership of learning (i.e. self-directed learning and self-regulated learning) in hands-on simulations and test how they affect students' competence development. In addition, students' perceptions regarding authenticity, self-directedness and self-regulated learning are examined because students' perceptions regarding the learning environment are claimed to be crucial in constructivist learning processes (Gijbels, Van de Watering, Dochy, & Van den Bossche, 2006).

Context of the study

Vocational life-science education

Data for this dissertation was collected in secondary and higher vocational life-science education in the Netherlands. There are two vocational pathways that students can follow in the Netherlands: secondary vocational education or higher vocational education (Van der Sanden, Smit, & Dashorst, 2012, see Figure 1.1). In context of the European Qualification Framework, the Dutch secondary vocational education pathway is practically oriented and equals EQF 1-4; higher vocational education is more theoretically challenging and equals EQF 6. In 2012, 29.000 secondary vocational education students and 9.500 higher vocational students participated in life-science programmes educating them for agricultural professions, such as dairy farming and greenhouse management, and other related professions, such as food technology, applied biology and floristry (Ministerie van Onderwijs, 2013).

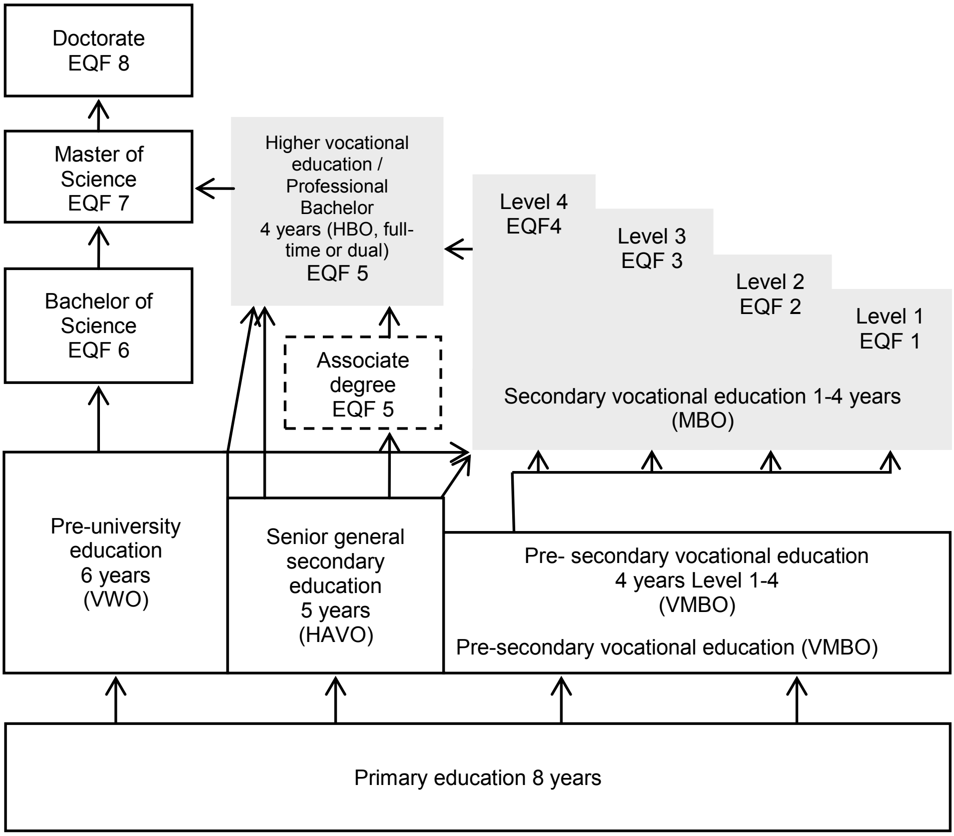

Figure 1.1 Dutch educational system. The grey shaded levels are included in this dissertation.

Competence development, competency development and the National Qualification Framework

Since 2010, the educational innovation *competence-based education* has been in force in Dutch secondary vocational education (Sturing et al., 2011). Competence-based education prepares students for a specific profession by stimulating competence development and professional identity through integrating theory and practice in the curriculum. According to Mulder (2014, p. 3), 'A professional is competent when he/she acts responsibly and effectively according to given *standards of performance*.' These standards of performances are formulated in National Qualification Frameworks with *competencies* and their performance indicators defining the outcomes of a vocational education trajectory. The concept of *competencies* is often perceived as ambiguous in terms of definitions and operationalization. Hence, we define competencies as *parts of professional competence*; they are a cluster of knowledge, skills and attitudes that one uses during job performances (Mulder, 2014). For example, a florist needs to have 1) broad knowledge about all the flowers he or she sells, about all innovations in the field and about how to do the bookkeeping, 2) he or she needs to have the skills to assemble flower bouquets and to dress the shop window and 3) he or she needs to be able to communicate in a friendly manner with (complaining) customers and in a professional manner with suppliers. This requires competencies such as problem solving, planning, innovating, coping with stress, communicating, showing empathy and craftsmanship. The Dutch Qualification Framework comprises 25 competencies (COLO, 2006). For the purpose of continuing learning pathways, these 25 competencies have been reformulated to apply to pre-vocational, secondary vocational, higher vocational and academic education (Groene Kennis Cooperatie, 2008). Therefore, these 25 competencies are applicable to both secondary vocational education and higher vocational education and used as the main outcome measures of this dissertation (also see Chapter 4).

Hands-on simulations in life-science education

Both secondary and higher vocational life-science education pathways in the Netherlands include learning in work-related settings for developing vocational expertise and competencies. In life-science education, students participate in a hands-on simulation in either a school setting or a training centre outside school. Data for this dissertation was collected in the latter context. These training centres are well-known institutions in life-science education, having been part of these educational pathways for a long time. After WWI, there was a need for more practical training, while training on farms and in agricultural enterprises had its limitations (Beijaard, 1985):

1) Specific materials were not available in all farms and agricultural enterprises.
2) Access to agricultural enterprises could not always be provided because of the risk of bringing diseases to the farm and its animals.
3) Tasks that could intervene with business operations could not be practised.
4) Teachers in agricultural schools and workplace supervisors lacked the capacity and skills to teach specific subjects.

As a result, training centres in which agricultural work situations are replicated for training purposes were established in collaboration with industry. These centres evolved into learning institutes for students, personnel and trainers from foreign (often Third World) countries. Today, the training centres do not focus only on agriculture but also specialise in most life-sciences domains. The learning situations included in this dissertation cover a broad range of life-science domains in hands-on simulations that are all characterised as follows:

1) They aim to *train* students for vocational-specific skills as well as for more generic competencies.
2) Students simulate tasks for their future profession.

3) The simulations are *practical* and hands-on, students work on tasks in a real-life setting with tangible material and equipment. Most of the learning contexts take place in replicas of the real workplace, but sometimes students practise parts of tasks in the real workplace (e.g. in a nature reserve or a farm).
4) The duration of the simulations varies. In our study, the minimum was two half days and the longest simulation lasted 38 half days.
5) Expert teachers guide learning.

Data was collected from four training centres across the Netherlands: 1) Rural Environmental Development & Animal Husbandry in Horst; 2) Horticulture and Engineering Technology in Ede; 3) Pigs, Poultry & Animal Feed in Barneveld; and 4) Dairy Farming & Milk Processing in Friesland. Figure 1.2 illustrates examples of simulation situations. The upper simulations are in engineering technology. Guided by a teacher, students work on technical problems in a real tractor provided by a tractor manufacturer. The lower situations relate to biology students who work on authentic professional tasks of an applied biologist by collecting data in the field and examining them in the laboratory.

Figure 1.2 Examples of hands-on simulations in life-science education.

Structure of the dissertation

A systematic literature review and four empirical studies are included in this dissertation, aiming at answering the question whether and under what conditions hands-on simulations have an added value for innovative vocational education. Figure 1.3 illustrates the structure of this dissertation.

Chapter 2 provides the theoretical framework of this dissertation. This chapter includes a conceptual discussion regarding hands-on simulations in innovative curricula. A systematic literature review aimed at positioning hands-on simulations in relation to other work-related contexts (i.e. internships and authentic projects), based on their learning environment characteristics and outcomes, was conducted. In combination with an additional in-depth analysis of literature focusing specifically on fundamental characteristics of constructivist vocational learning (i.e. authenticity and ownership of learning), this chapter concludes with concrete strategies for designing and implementing hands-on simulations with the aim of stimulating not only technical and procedural skills, but also competencies.

Chapter 3 describes the relationship between the authentic and–as part of ownership of learning–self-directed design characteristics of 23 hands-on simulations, the students' perceptions thereof and their effect on students' competency development. A survey study was conducted, with teachers and 514 students from secondary vocational and higher vocational education participating in a hands-on simulation. The questions guiding this chapter are:

1) To what extent do authenticity and self-directedness foster the development of conceptual and operational competencies for secondary and higher vocational education students in hands-on simulations?
2) Do students' perceived value, authenticity and choice explain additional variance in the relationship between authentic and self-directed design of the hands-on simulation and conceptual and operational competence development?

The experimental study (described in **Chapter 5**) examines the effect of adding authenticity and ownership of learning to hands-on simulations both on students' competency development and on the transfer of professional competence. To this end, we wanted to examine competency development in more detail (not only clusters of operational and conceptual competencies as done in Chapter 3) by using a competency self-report instrument, because competency self-reports have previously proven to be valid alternatives for measuring competency development (Braun, Woodley, Richardson, & Leidner, 2012). However, there was no valid self-report instrument that measures development of the competencies under the Dutch competence-based qualification framework. Therefore, we first designed a questionnaire. The validation and robustness of this instrument is discussed in **Chapter 4**. This chapter explores the face validity, construct validity and robustness of a competency self-report instrument that is aligned with contemporary competency theory and with current educational practice based on competence-based qualification frameworks. The research questions are:

1) What is the construct validity of a competency self-report instrument with distinguishing competencies and indicators?
2) Is a competency measurement with such a self-report instrument robust across educational levels?

Chapter 5 describes the experimental study with first-year Applied Biology students from higher vocational education. Concrete strategies for increasing authentic learning and ownership of learning to create innovative hands-on simulations (see Chapter 2) were added to a hands-on simulation. This innovative simulation was compared to a traditional hands-on simulation. The learning outcomes, i.e. competency development and transfer of professional competence, of students in the innovative hands-on simulation (*n* = 58) were compared to the students' learning outcomes in the traditional hands-on simulation (*n* = 65). In addition, we examined whether the students' perception regarding the learning environment mediated the relationship between the learning environment and the learning outcomes. Questions guiding this chapter are:

1) What is the influence of an authentic, self-directed and self- regulative hands-on simulation on higher vocational education students' competency development?
2) What is the influence of an authentic, self-directed and self-regulative hands-on simulation on higher vocational education students' near and far transfer of professional competence?
3) Is the effect of an authentic, self-directed and self-regulative hands-on simulation on student learning mediated by the students' perceptions regarding the learning environment?

Chapter 6 describes how students' ownership of learning is expressed in hands-on simulations. In hands-on simulations that promote ownership of learning, students are expected to be more motivated and engaged and, as a result, develop competencies. However, we do not know whether teachers stimulate students to use strategies for controlling their learning and whether students actually control their own learning in today's hands-on simulations. Therefore, teachers and students in eight hands-on simulations were structurally observed for two full days. To analyse the observation data we used the theoretical framework of Zimmerman (2001) and Schunk (2001) of self-regulated learning aiming at answering the following research questions:

1) To what extent do teachers show the various types of behaviour for promoting self-regulated learning in hands-on simulations?
2) To what extent do students show the various types of self-regulated learning behaviour in hands-on simulations?
3) What is the quality of the teachers' strategies that promote self-regulated learning and the students' self-regulated learning strategies in the three phases, and how do teachers' and students' self-regulated learning behaviours look in the three phases with lower, medium and higher quality?
4) What types of behaviour do teachers and students show in hands-on simulations with lower, medium and higher *overall* self-regulated learning quality?

Chapter 7 presents the main findings and limitations of this PhD research. It concludes with an integrated discussion answering the main question '*Do hands-on simulations* *add value in an innovative vocational curriculum?'* The question is discussed from a theoretical perspective (*'To what extent should we "innovate" hands-on simulations for competence development?'*) and a practical perspective *('What further steps do we need to take to integrate hands-on simulations into an innovative vocational curriculum?'*) and includes guidelines for practice and suggestions for future research.

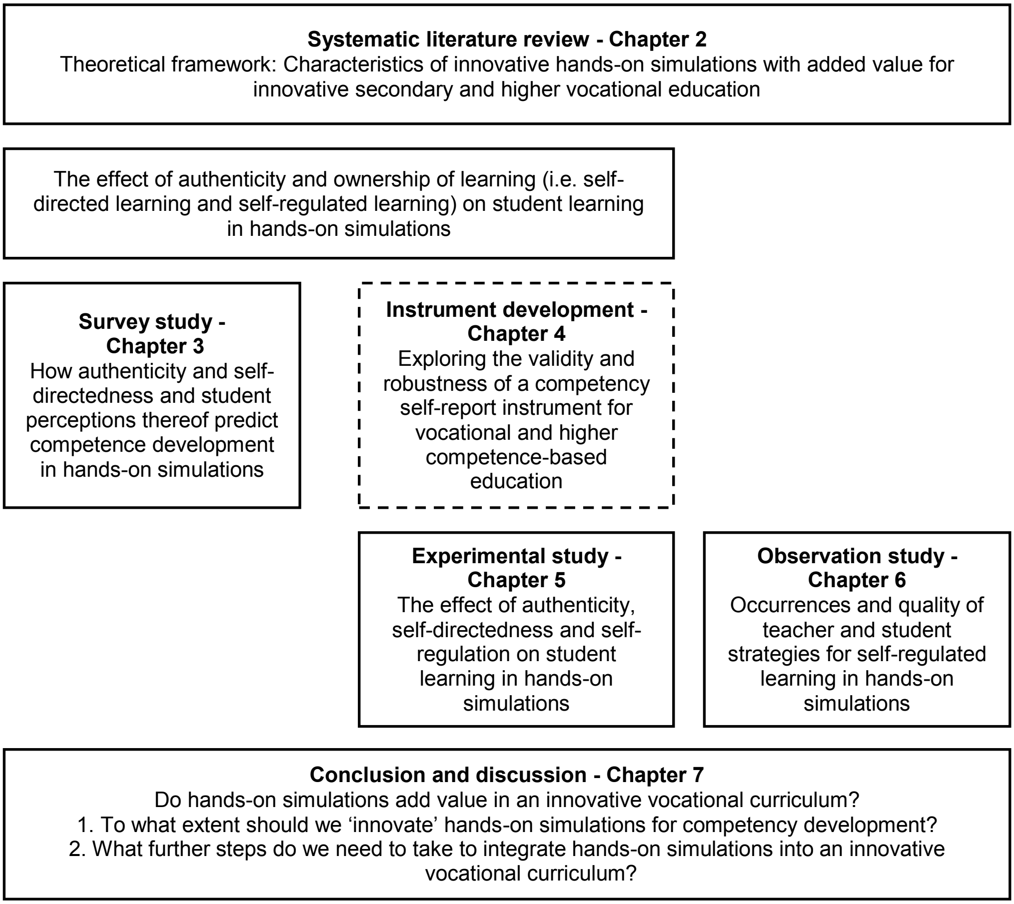

Figure 1.3 Structure of the dissertation.

Chapter 2

Characteristics of hands-on simulations with added value for innovative secondary and higher vocational education[1]

The intentions with which hands-on simulations are used in vocational education are not always clear. Also, pedagogical-didactic approaches in hands-on simulations are not well conceptualised from a learning theory perspective. This makes it difficult to pinpoint the added value that hands-on simulations can have in an innovative vocational curriculum that not only aims at developing technical and procedural skills, but also at developing professional competence. This chapter introduces a more explicit conceptual discussion regarding the opportunities for using hands-on simulations in innovative curricula. A systematic literature review aimed at positioning hands-on simulations in relation to other work-related contexts, based on their learning environment characteristics and outcomes, shows that certain constructivist characteristics and outcomes are underexposed in empirical research about simulations. The results of an additional in-depth analysis of literature specifically focusing on fundamental characteristics of constructivist vocational learning (i.e. authenticity and increasing students' ownership) propose ideas about how hands-on simulations can have added value to innovative curricula. This chapter concludes with concrete strategies for designing and implementing hands-on simulations from the constructive learning theory with the aim of stimulating not only technical and procedural knowledge and skills, but also competence development.

[1] This chapter is based on: Khaled, A., Gulikers, J., Biemans, H., Van der Wel, M., & Mulder, M. (2014). Characteristics of hands-on simulations with added value for innovative secondary and higher vocational education. *Journal of Vocational Education & Training*, Advance online publication. doi.org/10.1080/13636820.2014.917696

Introduction

Concerns about the limited applicability of educational learnt-outcomes to the workplace (Billett, 2003; Griffiths & Guile, 2003) have led to innovations in secondary and higher vocational education, such as the implementation of competence-based education (Biemans, Nieuwenhuis, Poell, Mulder, & Wesselink, 2004; Brockmann, Clarke, Méhaut, & Winch, 2008). In optimally functioning innovative vocational trajectories, lifelong learning is assured as '…competencies related to learning and (labour) identity development are integrated and reflection on the future careers of students has taken place' (Wesselink, Biemans, Mulder, & Van den Elsen, 2007, p. 47). Innovative vocational curricula attempt to realise this integration of lifelong learning, such as the development of professional competence, by building on constructivist learning principles (De Bruijn & Leeman, 2011), including collaborative, active, authentic or real-life learning and increasing students' ownership of learning (Loyens & Gijbels, 2008).

A direct consequence is that work-related learning contexts are increasingly used in vocational education as they are argued to be critical for stimulating competence development (Billett, 2012; Wesselink et al., 2007). Work-related learning contexts cover a wide range of learning environments that can be placed on a continuum of contextualised 'near work' exercises (e.g. cases and simulations) that take place at schools (i.e. non-work-based learning contexts) to learning experiences that completely take place at the workplace, such as internships (i.e. work-based learning contexts, see Figure 2.1).

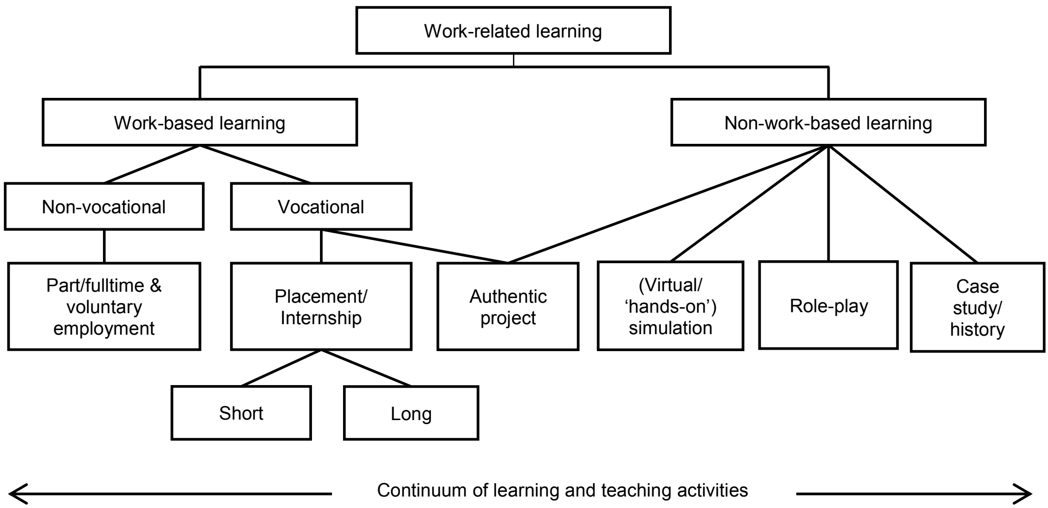

Figure 2.1 Diagram with activities on the continuum of work-related learning. Adapted from 'Bridging the gap between degree programme curricula and employability through implementation of work-related learning,' by J. Hills, G. Robertson, R. Walker, M. Adey, and I. Nixon, 2003, *Teaching in Higher Education, 8*(2), p. 226.

Simulated learning environments are one specific example of a work-related, but non-work-based learning context. In simulations, the vocational context and tasks are replicated in either a virtual or live environment at school or at a training centre (Hertel & Millis, 2002). The simulations that are subject in this study are live and 'hands-on', instead of virtual. They are frequently used for practising vocational skills before entering the completely work-based learning environment.

The problem with hands-on simulations—as part of the innovative vocational curriculum addressed in this chapter—is twofold: 1) the learning outcomes for which hands-on simulations are currently used are not always clear and 2) pedagogical-didactic approaches in hands-on simulations are not well conceptualised from a learning theory perspective. These two issues make it difficult to pinpoint the role and added value that hands-on simulations can have in an innovative vocational curriculum.

Firstly, over the past years, hands-on simulations have become more sophisticated due to technological developments and are increasingly used to stimulate more complex learning instead of only learning 'how to apply knowledge' and dealing with more complex situations. Hertel and Millis (2002, 1-2) state that 'during a simulation, students typically acquire broad discipline specific-knowledge, that they are able to later transfer into a professional practice. Simulations also "teach" much more, including the processes involved in the discipline; the organisations involved; and the interactions with other disciplines, people, and organisations'. But what 'more' Hertel and Millis (2002) actually mean remains unclear. Also Rush, Acton, Tolley, Marks-Maran, and Burke (2010) are unclear about the *exact* learning intentions of their hands-on simulation as they state that their simulation has the potential to better prepare students for placements as well as to enhance their performance when they get into the workplace. Thus, research about the relevance of hands-on simulations for stimulating competence development seems to be lacking.

Secondly, hands-on simulations have been used in various secondary and higher vocational education domains (e.g. medical, flight, military, agricultural and engineering) for many decades (Issenberg et al., 1999). A well-known problem with hands-on simulations is that they are not well conceptualised from the perspective of learning theories, resulting in teacher interventions and actions that are not always consistent with a learning theory (Bradley & Postlethwaite, 2003; Rutherford-Hemming, 2012; Schiavenato, 2009). Thereby, the 'traditional' assumptions behind simulations are mainly based on didactic-approaches, such as learning by doing and learning from feedback for procedural and technical skills development (Cunningham, 1984) within a completely teacher-provided structure (Maxwell, Mergendoller, & Bellisimo, 2004). One might question whether the 'traditional' approach to hands-on simulations is appropriate for developing professional competence or whether more constructive, pedagogical-didactic approaches to teaching and student learning that align with innovative vocational education are desired. This chapter will introduce a more explicit conceptual discussion regarding the opportunities for using hands-on simulations in innovative curricula that aim at developing competence development.

This chapter intends to discuss characteristics of hands-on simulations with added value for innovative vocational curricula. To start with, we provide a description of hands-on simulations in secondary and higher vocational education. Next, we present a systematic literature review conducted to position hands-on simulations in relation to other work-related contexts, based on their learning environment characteristics and learning outcomes. This did not result in indications about the added value of hands-on simulations in innovative curricula, because hands-on simulation research is barely embedded in learning theories underling innovative vocational curricula. Subsequently, we argue that, in order to accomplish the added value of hands-on simulations, educationalists should not be content with the way they are used these days, but need to design hands-on simulations more from the perspective of constructive learning. In secondary and higher vocational education, specifically two constructivist learning environment characteristics are argued to be important for competence development; that is *authentic learning* and giving students *ownership of learning* (De Bruijn & Leeman, 2011; Gulikers, Bastiaens, & Kirschner, 2006; Kicken, Brand-Gruwel, & Van Merriënboer, 2008; Van Bommel, Kwakman, & Boshuizen, 2012). Therefore, an additional *in-depth* analysis of specific literature about these characteristics in relation to hands-on simulations was performed and illustrates how hands-on simulations could have added value in an innovative curriculum. This results in concrete strategies for designing and implementing hands-on simulations from the constructive learning theory with the aim of stimulating professional competence.

Hands-on simulations in secondary and higher vocational education

As Hertel and Millis (2002, p. 16) point out, ‘Education simulations typically place students in true-to-life roles, and although the simulation activities are “real-world”, modification occurs for learning purposes’. In educational simulations: 1) the student sees cues and consequences very much like those in the real environment; 2) the student can be placed in complex situations; 3) the student acts as he or she would in the real environment; 4) the fidelity (exactness of duplication) of a simulation is never completely isomorphic with the reality because, for example, of the costs, engineering technology limits, avoidance of danger and time constraints and 5) simulations can take many forms (McGaghie, 1999). The simulations in this study are ‘hands-on’, which means that the students learn by performing one or more professional tasks ‘live’ in a learning setting that is a realistic replica of the workplace context, with tangible material and equipment. Hands-on simulations can go together with technology, such as human-patient simulators on which the students perform clinical skills. Two examples of hands-on simulations in vocational and higher education are:

- Engineering technology students, who follow a secondary vocational agricultural education trajectory, learn how to repair the transmission system of a tractor. A tractor company provided a real tractor with transmission problems. During a one-week training, (a small group of 3–4) students have to act as if they are mechanical engineers and analyse malfunctions in the transmission system of a tractor, adjust and repair it. All equipment and materials that the students work with are real. The teacher is an expert in engineering technology and gives students direct instruction about transmission systems but also lets student work on their own and gives help when needed.
- Junior nursing students participate four-hour human-patient scenario simulation sessions (Guhde, 2011). The students work on a complex scenario. The students are instructed how to play their role and the teacher plays the role of other health care providers. The patient is a manikin or lifelike model that, after computer programming, responds to the students as a real patient would. One scenario involves a gastric bypass patient who becomes hypovolemic (in shock) and has an asthma attack. Five students play the scenario and five students observe the scenario, focusing on specific areas, such as communication with and assessment of the patient. The students who play the scenario are provided with an equipment room with, for example medications, glucometer and intravenous solutions. Debriefing takes place after the scenario to discuss the medical problem and observers' comments.

From an educational perspective, simulation-based learning can be approached two ways (Van Emmerik, 2004). *The technical simulator design perspective* involves the more hardware and mathematical aspects that make simulators efficient for learning; this approach mainly concerns optimising the technical aspects of completely computer-based simulators (e.g. online business games) and simulators that combine real-world aspects with computer-based aspects (e.g. flight simulators). *The training perspective* concerns the pedagogical approaches and didactical methods, such as training strategies and instructional support that can be used in simulated settings to optimise learning—regardless of the technical specifications of the simulator. The present study approaches simulations from the training perspective by investigating the learning characteristics and outcomes in hands-on simulations.

Systematic literature review

In an effort to position hands-on simulations in an innovative vocational curriculum, insight needed to be generated into: 1) the learning environment characteristics of hands-on simulations compared to other work-related learning contexts (i.e. authentic projects and internships) and 2) the kinds of learning outcomes that can be fostered in hands-on simulations compared to other often used work-related learning contexts, that is, live or authentic projects and internships. This information could provide teachers with concrete ideas about how to use hands-on simulations for the development of specific outcomes, such as technical skills but also competencies. For this purpose, a systematic literature review was conducted of articles recently published in peer-reviewed journals to identify relevant current empirical studies about hands-on simulations, authentic projects and internships. An authentic project includes a realistic problem/task that is generated by a real client, is conducted in cooperation with the client, and delivers a real product (Boud & Costley, 2007; Helle, Tynjälä, Olkinuora, & Lonka, 2007). When a student fully participates in the working processes in a specific organisation for a pre-determined period of time, it was referred to as an internship (Onstenk & Blokhuis, 2007).

Search procedure, identification of literature and analysis

For the search, six sets of word combinations were generated. Three sets included terms referring to the work-related learning contexts: hands-on simulations (*simlat**, *re-creat**, *replicat** and *pretend**) extended with NOT '*computer*' and NOT '*virtual*', authentic projects ('*project-based learning*' and '*student projects*') and internships ('*internship*' and '*student placement*'). A fourth set of terms was carefully selected ('*field experience programme*', '*service learning project*' and '*real world*') as these terms are often used by educationalists when referring to work-related learning contexts. The fifth and the sixth set consisted of the learning outcomes ('*learning outcomes*', '*student learning*' and *effect**) and educational level ('*vocational education*', '*two-year college*', '*post-secondary education*' and '*higher education*'). Each term in sets 1, 2, 3 and 4 was combined with each term in sets 5 and 6 (e.g. *simulat** × *learning outcomes* × *higher education*), resulting in 148 word combinations. The word combinations were entered into Educational Resources Information Centre (ERIC) and Web of Science® databases with a period limitation between 2001 and 2011, which generated 1493 hits. Studies were only included in the review that focused on secondary vocational and/or higher vocational education students, reported a clear description of the learning environment characteristics and measured students' learning outcomes as a result of the intervention via a test, observations and/or student evaluations. Studies about completely virtual or computer-based simulations were excluded from the study.

These inclusion and exclusion criteria led to a total of 29 relevant studies, most investigated internships (n = 14), followed by hands-on simulations (n = 8) and authentic projects (n = 7). The learning environment characteristics were coded using the theoretical framework of De Bruijn & Leeman (2011). Their M*odel for Powerful Learning Environments* includes traditional design principles, such as direct instruction, as well as social constructivist learning principles, such as self-regulated learning. The learning outcomes of the three work-related learning contexts were coded as *knowledge* (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956), *technical skills* (Romiszowski, 1999), *attitudes* (Martin & Reigeluth, 1999), *competencies from* *the Dutch Qualification Framework* (COLO, 2006), *transfer* (Illeris, 2009) or *professional identity* (Savickas et al., 2009). To objectify the coding, nine publication (three simulations, three authentic projects, three internships) were coded by two researchers who met thrice for discussion after coding to establish the credibility of findings in the qualitative text analysis (Harris, Pryor, & Adams, 1997). During the discussion, the average percentage of agreement was sufficient for both the learning environment characteristic categories (76.1% with a lower bound of 61.5%) and the learning outcome categories (87.3% with a lower bound of 71.4%). Based on their experiences with the coding scheme, the two researchers formulated the final coding scheme and tested the reliability of coding with the final scheme by coding 81 fragments of another six, not yet coded, publications. Cohen's Kappa for the learning environment characteristic categories was .66 (70.2% agreement) and for the learning outcome categories .63 (70.6% agreement), which is good according to the criteria for Kappa (Strijbos & Stahl, 2007). Finally, the first author coded the remaining publications that had not been coded with the final coding scheme, allocated all coded fragments in one overview and summarised the learning environment characteristics and learning outcomes of hands-on simulations, authentic projects and internships. Characteristics and outcomes were ordered from most mentioned to least mentioned (see Appendices 2.1 and 2.2 for the full results).

Findings

Tables 2.1 and 2.2 summarise the results of the learning environment characteristics and learning outcomes of the hands-on simulations and the other two work-related contexts. Regarding the learning environment characteristics, the review showed that powerful didactic approaches that are specific for hands-on simulations are possibilities for providing the students with feedback, giving students rather intensive coaching, learning by doing, learning from observing others and learning by reflection-in-action (Table 2.1). Outcomes for hands-on simulations were metacognitive, conceptual, factual and procedural knowledge. However, the outcomes that were mentioned most for hands-on simulations (i.e. metacognitive knowledge and the competency 'applying expertise') were also mentioned in the authentic projects and/or internships research. Striking was that only literature about hands-on simulations reported technical skills development and the transfer of learning.

There were also learning outcomes and characteristics that were structurally underexposed in the hands-on simulations, compared to the research about the other work-related learning contexts. First, attitudes and competencies were not much examined as a learning outcome of hands-on simulations. Focusing on competencies as a learning outcome of innovative curricula, only the competencies 'deciding and initiating action', 'showing care and understanding', 'cooperating', 'applying expertise' and 'planning' were found as outcomes of hands-on simulations, while in authentic projects and internships a much wider array of competencies were studied (Table 2.2).

Table 2.1 Learning Environment Characteristics Identified in Empirical Research on Hands-on Simulations, Authentic Projects and Internships

Learning environment characteristics	Hands-on simulation	Authentic project	Internship
Program characteristic			
Authenticity	Partial authenticity: students perceive not all types of hands-on simulations as realistic. One or more professional roles assigned to students	Variety of learning in class and in profession. One or more professional roles assigned to student	Chance to act as a real professional, Adopting limited professional roles
Student learning			
Construction Individual	Repeating tasks Learning from observation and mistakes	Applying knowledge in practice	Integrating classroom and workplace activities Learning from observing mentor
Construction Cooperative	Working with peers regularly Structural peer and teacher feedback	Intensive cooperation with (interdisciplinary) peer and externals	Working with peers or with mentor
Reflection	Just-in-time reflection	Self-reflection and in-class reflection	Self-reflection and in-class reflection
Ownership of learning process	Teacher-structured: Little to none self-responsibility for learning process	High self-responsibility of students' success in learning process	Proactive attitude of student is expected
Teacher guidance			
Instruction and modelling	Instruction during sessions	Information provision by teacher Client is role model	Workplace supervisor/mentor is role model
Coaching	Rather intensive coaching before, during, and after sessions	Limited integrated tutorial support	Limited coaching
Stimulating self-regulated learning	No self-regulation stimulated	Reduced guidance during project	Guiding students in achieving learning goals

Note: The model of De Bruijn and Leeman (2011) focusses on characteristics for full educational trajectories. As the work-related contexts in this study were of shorter duration, the present study used characteristics that are directly related to the work-related contexts. Ordered from most to least mentioned characteristics of the work-related learning environments in the included studies.

Table 2.2 Identified Learning Outcomes in Empirical Research on Hands-on Simulations, Authentic Projects and Internships

Learning outcomes	**Hands-on simulation**	**Authentic Project**	**Internship**
Knowledge	- Metacognitive knowledge - Conceptual knowledge - Factual knowledge - Procedural knowledge	- Procedural knowledge - Conceptual knowledge - Metacognitive knowledge	- Metacognitive knowledge
Technical skills	- Quality of performing technical skills	xx	xx
Attitudes	- Self-confidence to function in the profession	- Self-confidence, inspiration, motivation - Interest in the core subject matter - Self-reliance - Diversity awareness - Professional demeanour	- Self-confidence - Sense of responsibility - Efficacy - Appreciation for diversity - Attitude towards the field - Self-motivation - Independence - Trust
Competencies (COLO 2006)	- Applying expertise - Deciding and initiating action - Showing care and understanding - Cooperating - Planning	- Planning - Cooperating - Showing care and understanding - Leading - Formulating and reporting - Researching - Analysing - Presenting - Relating and networking - Persuading and influencing - Creating and innovating - Decision and initiating action - Learning - Meeting customer expectations - Adapting and responding to change - Operating efficiently	- Applying expertise - Adhering to principles and values - Planning - Formulating and reporting - Cooperating - Learning - Following instructions and procedures - Showing care and understanding - Using materials - Analysing
Transfer	- Transfer from simulation to workplace	xx	xx

Chapter 2

Learning outcomes	Hands-on simulation	Authentic Project	Internship
Professional identity	- Professional development - Insight into developing professional role	- Insight into requirements of future profession - Insights into career choices	- Insight into requirements of future profession - Insight into career choices and prospects - Insight into problems in professional field - Insight into personal work habits - Willingness to perform the profession

Note. Ordered from most to least mentioned learning outcomes of the work-related learning environments in the included studies.

Furthermore, the results showed that important constructivist learning environment characteristics for developing competencies (i.e. authenticity and giving and stimulating students' to take ownership of the learning (De Bruijn & Leeman, 2011)) were typically not present in the studied simulations. Students did not often perceive the hands-on simulations as authentic learning environments and literature provided little information whether and how authenticity was taken into account in the design and how this relates to competency development. Also, the results showed that the students had almost no ownership over their learning processes. This includes having opportunities to control learning and having freedom to self-regulate the learning. Hands-on simulations were almost always teacher-driven, and the teachers did not, at least not explicitly, stimulate the students' self-regulative learning (see also Table 2.1).

In sum, the hands-on simulations in the included studies were powerful because of learning environment characteristics such as rehearsing, feedback, coaching and just-in-time reflection. Simulations were used for the development of knowledge, technical skills and transfer of learning. But based on these results, it is difficult to indicate the added value of hands-on simulations in innovative curricula in which new outcomes, such as professional competence and professional identity are also important outcomes. Characteristics from the constructivist learning theory that claim to stimulate these outcomes (*authenticity* and *students' ownership of learning*) are structurally underrepresented in the hands-on simulations in the literature review. Therefore, an additional study is needed about these characteristics in relation to hands-on simulations.

Research limitations

Although the authors carefully selected a set of search term and conducted a well thought-out search, issues related to the methods were inevitable.

Firstly, work-related learning contexts are in literature referred to with a wide array, interchangeably used, definitions and terms. Other terms used for work-related learning contexts (e.g. '*experiential learning*' and '*near work*' learning environments), hands-on simulations (e.g. '*laboratory*'), authentic projects (e.g. '*live project*') or internships (e.g. '*traineeship*') were left out the search, which could have excluded relevant studies.

Secondly, after many trail searches, a set of terms that cover secondary and higher vocational education was chosen. But because educational systems and the terms used for those systems differ significantly across countries in and outside Europe, other studies pertinent to ours could have been missed in the search.

Thirdly, our search was conducted in quality peer-reviewed journal and excluded all grey literature and non-scientific work about simulations. A more extensive literature search would be required to cover all related research terms, vocational education levels across countries and information sources about hands-on simulations.

The potential of authenticity and students' ownership in hands-on simulations

As literature suggests, authenticity and increasing students' ownership over learning are important characteristics of learning environments in innovative vocational education that aims at the development of professional competence (De Bruijn & Leeman, 2011; Gulikers et al., 2006; Kicken et al., 2008; Van Bommel et al., 2012). The review study identified that authenticity and increasing students' ownership over learning was underrepresented in the included studies about hands-on simulations, while in other constructivist learning environments authenticity and students' ownership over learning receive a lot of attention (e.g. in hybrid learning environments (Cremers, Wals, Wesselink, Nieveen, & Mulder, 2013; Zitter & Hoeve, 2012) and in problem-based learning (Blumberg, 2000)). This section zooms in on authenticity and students' ownership of learning and searches for their potentials in hands-on simulations. Additional literature was gathered via: 1) tracking down references in the initial literature review that included authenticity, fidelity, self-directed learning and/or self-regulated learning in the title and 2) a focused search strategy on *authenticity* and ownership (i.e. *self-directed learning* and *self-regulated learning*) in combination with hands-on simulations in vocational education contexts. This has led to a total of 11 additional relevant studies: seven about authenticity and four about ownership of learning in hands-on simulations. Based on these additional studies, we deduced strategies for fostering authenticity and ownership of learning in hands-on simulations for the purpose of stimulating competence development. This chapter concludes with a design framework for innovative hands-on simulations.

Hands-on simulations & authenticity

Several researchers state that simulations are not authentic because they do not touch upon the reality of social dynamics of the work community (Barab, Squire, & Dueber, 2000) and because students are not fully accountable for the outcomes of simulated learning (Cumming & Maxwell, 1999). Others do see hands-on simulations as authentic since students practise whole work-related tasks in a context directly derived from the professional practice (Dieckmann, Gaba, & Rall, 2007; Schiavenato, 2009). The tradition in examining hands-on simulation authenticity is to study the effect of exactness of reality duplication (i.e. realism or fidelity) on student learning. These studies repeatedly showed that highly authentic hands-on simulations indeed positively affect student performance because realistic environment and realistic equipment provoke accurate reproduction of movements and procedures (Beaubien & Baker, 2004; Maran & Glavin, 2003). Therefore, many researchers claim that simulation authenticity equals better learning (Alessi, 2000). However, these claims are somewhat too simplistic and nuances need to be made. First of all, very realistic simulations are especially beneficial for experienced workers as they are familiar with the working situation and thus can best be used for assessment purposes. Otherwise, simulations that represent the practice less exactly are more beneficial for novice students—for the purpose of not being overly complex— and are claimed to be more suitable for initial training (Alessi, 2000). Moreover, most of these studies examined simulation authenticity in relation to part tasks performance and isolated procedural and psychomotor skills development (see reviews of, for example, Issenberg et al., 2005).

How can hands-on simulations be authentic if they have to compromise realism when they are used for initial training? The key is to focus on the *primary goal of authenticity* in education. The danger of focusing too much on creating realistic learning contexts might distract from this goal, which is *authentic learning*; involving students in a problem and engaging them in situational meaningful thinking and interaction (De Bock, Verschaffel, Janssens, Van Dooren, & Claes, 2003). Fostering authentic learning in hands-on simulations can be achieved by confronting the student with *whole professional tasks* instead of part tasks. A whole task in which knowledge, skills and attitudes are integrated is an essential element of authentic learning, instead of learning separate pieces of a work task (Van Merriënboer, 1997). Herrington and Herrington (2006) and Gulikers, Bastiaens and Kirschner (2004) argue that authentic learning environments contain not only a *realistic physical context that resembles the future profession*, but also, and even more important, *activities that are representative of real-world professional tasks, ill-defined and have real-world relevance adapted to the level of the students*. It is a misconception that students automatically perceive learning environments, considered to be authentic by the teacher, as realistic. Authenticity involves subjectivity (Gulikers et al., 2006). According to Barab and colleagues (2000, p. 38), 'authenticity lies in the learner perceived relations between the practices they are carrying out and the use value of these practices'. This suggests that the degree to which the students *perceive* the learning environment to resemble the professional practice is at least as important for their learning, if not more important than, to which it *actually* resembles professional practice. In simulation literature, students' perceived authenticity of hands-on simulations increasingly receives attention. These studies all show that students' perceptions of authenticity determine their learning, instead of the 'objective' or teacher-created authenticity (Rystedt & Sjöblom, 2012). For instance, confronting first-year students with tasks representative of the complexity level of a starting professional is not realistic to the students; this may cause confusion, distraction and could even block learning due to cognitive overload (Van Merriënboer & Sweller, 2010). A strategy that teachers can use to overcome problems with authenticity is to *adapt the authenticity* of the physical learning context and the task to the level and perceptions of the student. Whole tasks should be representative of students' professional tasks at a certain point in their educational career (Gulikers et al., 2004). To be concrete, a task for a first-year animal care student could include feeding only cows, while a third-year student needs to feed a variety of animals. Or the physical learning context could consist of a mini glasshouse with only peppers in the beginning of the trajectory and a full-scale glasshouse with peppers, cucumbers and other vegetables at the end of the trajectory. This way, the learning context as well as the tasks are whole, realistic and have a higher chance to lead to meaningful learning experiences in which higher levels of learning are more likely to be expected. When authenticity is operationalised this way, hands-on simulations offer a lot of opportunities for creating authentic learning experiences for students at all stages of a vocational education trajectory. Thereby, hands-on simulations offer more opportunities for creating this 'authenticity at the student level' than internships that might be authentic but too complex for students, or too simple when supervisors do not challenge their interns with tasks at their level. Authentic projects that only address the authenticity of the task often without considering other important authenticity aspects (Gulikers et al., 2004).

Hands-on simulations & students' ownership of learning

It is no surprise that the students in the hands-on simulations from the literature review had not much ownership of their learning because hands-on simulations are traditionally characterised by a teacher-provided structure. This makes the organisation of student control in hands-on simulations a challenge (Maxwell, Mergendoller, & Bellisimo, 2004). In these more 'traditional', teacher-structured simulations, students enter the simulation to learn specific, pre-defined skills. Usually, the teacher is an expert who focuses his/her instruction and feedback, with great enthusiasm, on the content of that simulation. The main focus is efficient development of that specific skill with the consequence that giving students the freedom to control their learning is less relevant at that moment. The fact that hands-on simulations are teacher-structured can also be attributed to the costs; teachers wish to maximise learning during this costly short-term experience. Nonetheless, it does not mean that it is impossible to give students more ownership of their learning in hands-on simulations. In fact, hands-on simulations may be well suited for giving students their first experiences in directing and regulating their learning in a work-related learning context.

Self-directed learning

The two processes directly involved in students' ownership of learning are self-directed learning (SDL) and self-regulated learning (SRL). The concept of SDL originates from the adult learning theory and is defined as 'a process in which individuals take the initiative, with or without the help from others, in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate learning strategies and evaluating learning outcomes' (Knowles, 1975, p. 18). A main design feature of SDL is offering students a certain amount of *freedom of choice* to pursue their learning goals (Loyens, Magda, & Rikers, 2008) because giving students control over what they want to learn increases students' motivation to take part in learning activities (Corbalan, Kester, & Van Merriënboer, 2006). Brydges and colleagues were the first to examine the possibilities and effects of SDL in hands-on simulations. Brydges, Carnahan, Rose and Dubrowski (2010) showed that nursing students are capable of self-directing their learning in hands-on simulations, and that this can even lead to positive learning outcomes. The nursing students were indeed capable of directing their own learning in a self-directed simulation in which they had the freedom to choose whether or not to progress to another more complex simulation based on their self-monitored progress. The self-directed nurses had a higher overall performance and were able to maintain their skills acquisition. Brydges et al., (2010) attribute this positive effect in the self-directed simulation to the *self-monitoring process* of students before deciding to change to the next, more complex simulator. In another study, Brydges, Carnahan, Safir and Dubrowski (2009) showed that self-control over learning can lead to positive outcomes; however, only when the students work on *progress goals* (working towards accurate execution of the task) instead of outcome goals (working toward a product). Medical students who had clear process goals to work on were capable of self-guiding their access to instruction in hands-on simulations. This self-guidance had a positive effect on clinical performance compared to simulations in which the instruction was externally controlled.

Thus, with a clear purpose or goal to work toward, self-directed learning in hands-on simulations seems possible and positive for learning. This does not mean that hands-on simulations should be completely self-directed and that teachers do not play an important role in guiding students' learning in simulated learning. Providing guidance is even essential for novice and intermediate students as they are not naturally completely self-directed learners (Kirschner, Sweller, & Clark, 2006). We can make use of the fact that expert teachers guide hands-on simulations as they can play an important role in stimulating self-regulated learning.

Self-regulated learning

Where SDL concerns more long-term planning, SRL involves processes within task execution (Jossberger, Brand-Gruwel, Boshuizen, & Van de Wiel, 2010). According to Zimmerman (2001), SRL occurs when students are meta-cognitively, motivationally and behaviourally active participants in their learning. There are several teaching approaches that are typical for hands-on simulations and at the same time stimulate SRL. The teachers usually start the simulation by demonstrating or *modelling* desired behaviour in hands-on simulations. People are able to direct their own goals and regulate their learning but are also products of social systems (Schunk, 2001). Efforts to self-regulate are influenced by the students' social environment, which means that teachers and peers play an important role in the SRL. By observing their teacher, students feel more confident in applying skills on their own (Schunk, 2001). A teacher can also function as a model by *verbalising* process steps, problem-solving strategies and self-regulatory strategies. When teachers verbalise the actions that they take and the choices that go along with those actions, they influence self-regulatory strategies of the students (Lunenberg, Korthagen, & Swennen, 2007). During the simulations, teachers walk around, provide instruction and help students when needed. Hands-on simulations are mostly conducted in small groups. This gives teachers good opportunities to guide students in groups or individually. Activities teachers can perform for guiding students are helping individuals or groups while performing a task by giving hints and cues (*coaching*) and supporting them with help or additional materials or resources (*scaffolding*) (Collins, Brown, & Holum, 1991). Some hands-on simulations last for a longer period of time or are repeated during the educational trajectory. When this is the case, teachers can *fade their guidance* and increase the students' responsibility, which can lead to a self-regulated situation at the end of the hands-on simulation (Collins et al., 1991). Guiding moments can also be used for stimulating students to articulate their actions. *Self-verbalisation* has shown to be an effective strategy for self-regulating learning, especially for students in the early and intermediate phase of skills acquisition (Hattie, 2009). Probably the most important feature of hands-on simulation is the possibilities for providing appropriate and timely *feedback* (Issenberg et al., 2005). During a hands-on simulation, teachers give immediate feedback, sessions are paused to reflect, or debriefings take place to reflect on the whole task. With feedback on behaviour and progress, students can adapt strategies for better performance in the subsequent session. High-quality feedback has repeatedly shown to be an effective stimulant for SRL (e.g. Hattie & Timperley, 2007). Feedback on performance improves students' judgement about their performance, and the judgements that students make can influence their direct performance and their SRL process (Stone, 2000). Moreover, making students aware of the gap between current and desired performance helps them to increase motivation and self-esteem, which in turn improves self-regulation (Nicol & Macfarlane-Dick, 2006). The only study that—to our knowledge—empirically examined SRL in hands-on simulations shows that students are capable of self-regulating their learning in hands-on simulations; vocational students monitored their learning, made adjustments based on their mistakes by themselves and consulted the teachers when needed (Jossberger, 2011). However, the students hardly set explicit learning goals and did not always make a working plan. In a follow-up study, Jossberger (2011) showed that, when improving the teacher feedback, the students' motivation as well as their self-reflection skills improved, but the planning behaviour remained a point for improvement. These findings show that hands-on simulations have possibilities for SRL but that they require teachers and researchers to make better use of the opportunities that hands-on simulations provide to foster SRL.

How to create innovative hands-on simulations?

The findings of our first attempt to conceptualise hands-on simulations as a work-related learning context, by positioning their learning environment characteristics and outcomes in relation to authentic projects and internships, illustrated that a systematic literature review did not generate enough information for pinpointing the added value of hands-on simulations in innovative vocational curricula. Information about competency development and fundamental characteristics of constructive learning environments, i.e. authenticity and giving students' ownership of their learning, was lacking in the included studies. An analysis of additional literature specifically about those two characteristics allowed to identify opportunities that hands-on can offer for increasing authenticity and giving students ownership of their learning and as such contribute to developing professional competence. Based on this analysis, a framework with concrete strategies for designing and implementing innovative hands-on simulations was generated (Table 2.3), showing possibilities for increasing authenticity and students' ownership in hands-on simulations. The assumption is that a hands-on simulation that is designed and implemented according to the suggested strategies contribute to more competence development. In this way, hands-on simulations contribute to the learning intentions of work-related learning contexts and have an added value in innovative vocational education. However, this does not mean that hands-on simulations aiming at technical and procedural knowledge and skills cannot add value to an innovative curriculum. In contrast, we argue that if hands-on simulations are used with the intention to stimulate competencies and professional identity, next to technical skills, strategies for increasing authenticity and student ownership can be effective. Also, we acknowledge that implementing innovative principles is a challenge for teachers and students. They need to drastically change their teaching and learning approach. Students are used to the teacher-guided structure of hands-on simulation and they do not expect that they will have to self-regulate their learning during the simulation. To conclude, future studies should experiment more with authentic learning and giving students ownership of leaning in hands-on simulations, and relate those constructivist learning environment characteristics to more contemporary learning outcomes such as various competencies. Urgent questions are: What competencies can be developed in hands-on simulations?; Do hands-on simulations with more authenticity and self-regulated learning foster competence development? and What is the right balance of authenticity and ownership of learning in hands-on simulations? When these questions are answered, we could possibly state with more conviction what the position exactly is of hands-on simulations in an innovative vocational curriculum in which competence development an important learning outcome.

Table 2.3 Strategies for Adding Authentic Learning and Ownership of Learning to Create Innovative Hands-on Simulations

Stimulate authentic learning
- Work on whole tasks that integrate knowledge, skills and attitudes
- Adapt authenticity to the level of the student
- Include ill-defined problems in the tasks that require authentic cognitive processes
- Create a realistic physical context
- Take students' perceptions regarding authenticity into account

Give students more ownership of their learning

Self-directed learning
- Create moments of choice for students
- Let students choose what tasks to perform
- Let students choose how to perform the tasks
- Formulate progress goals (working towards accurate execution of the task) or let students formulate progress goals

Self-regulated learning

Teacher strategies for self-regulated learning
- *Model and verbalise*: model desired behaviour and verbalise process steps, problem solving strategies and self-regulatory strategies
- *Feedback*: provide immediate feedback and feedback on the whole task after the simulation
- *Coach:* give students hints and cues
- *Scaffold*: support students with help or additional materials or resources
- *Fade**: decrease guidance and increase students' responsibility over time

Student strategies for self-regulated learning
- Analyse observations and mistakes
- Self-verbalise actions and regulatory strategies
- Self-monitor performance and progress goals

* When time allows

Appendix 2.1 Overview of Learning Environment Characteristics for Hands-on Simulations, Authentic Projects and Internships Traced in Current Empirical Literature

Learning environment characteristic	Hands-on simulation	Authentic project	Internship
Program characteristic			
Authenticity	- Replicas of professional tasks and physical context (Alinier, Hunt, Gordon, & Harwood, 2006; McCaughey & Traynor, 2010; Wenk et al., 2009) varying from low fidelity to high fidelity simulations (Alinier et al., 2006; Grady et al., 2008; Levett-Jones, Lapkin, Hoffman, Arthur, & Roche, 2011; Wenk et al., 2009) - Integration of real clients in simulated learning environment (Zeng & Johnson, 2009) - One (Alinier et al., 2006) or more professional roles assigned to students (Zeng & Johnson, 2009) - Not all practical simulations are being perceived as realistic by students (McCaughey & Traynor, 2010) but high-fidelity simulations are perceived as more authentic (Grady et al., 2008)	- Physical context: partly in school, partly in profession with industry partners (Cooper, Bottomley, & Gordon, 2004; Curtis & Mahon, 2010; Govekar & Rishi, 2007; Lu & Lambright, 2010; Montgomery, 2004; Schäfer & Richards, 2007; Tschopp, 2004) - One (Schäfer & Richards, 2007) or more professional roles (Lu & Lambright, 2010) assigned to student - The authenticity of the physical context and the tasks stimulates student motivation (Cooper et al., 2004; Goto & Bianco-Simeral, 2009) and learning outcomes (Curtis & Mahon, 2010; Lu & Lambright, 2010) - Students benefit from variety of professional learning environments (Lu & Lambright, 2010) but need clear role description (Schäfer & Richards, 2007)	- Chance to act as a real professional (Freestone, Williams, Thompson, & Trembath, 2007; Hoifodt, Olstad, & Sexton, 2007) - Individual responsibilities and roles are negotiable (Grande, Burns, Schmidt, & Marable, 2009) - Limited learning experience in some internships due to many assistant and administrative tasks (Hoifodt et al., 2007; Jackson & Jackson, 2009; Pence & Macgillivray, 2008; Yang, 2011) - Rotation of roles stimulates student learning (Hoifodt et al., 2007)
Student learning			
Construction, individual	- Hands-on experience through practicing/repeating tasks (Alinier et al., 2006; Levett-Jones et al., 2011; Rush et al., 2010; Zeng & Johnson, 2009) - Learning from mistakes without	- Apply knowledge in practical, hands-on situations (Cooper et al., 2004; Schäfer & Richards, 2007) - Less valuable for students who prefer traditional instructional methods (Curtis & Mahon, 2010)	- Additional field assignments (Cannon, 2008; Mariani & Klinkner, 2009) - Observing mentor (Spooner, Flowers, Lambert, & Algozzine, 2008)

Learning environment characteristic	Hands-on simulation	Authentic project	Internship
	consequences (Rush, Acton, et al., 2010) - Observing peers (Alinier et al., 2006; Rush et al., 2010)		- Videotaped sessions (Cannon, 2008) - Discuss prepared dilemma's in-class (Cannon, 2008; Mariani & Klinkner, 2009) plans/concerns during the weekly seminars and through blackboard (Laframboise & Shea, 2009; Mariani & Klinkner, 2009) - Lack of opportunities to practice (Laframboise & Shea, 2009)
Construction, cooperative	– Working in groups of 2 to 6 students (Alinier et al., 2006; Levett-Jones et al., 2011; Rush et al., 2010; Zeng & Johnson, 2009) - Discussing performance in groups (Zeng & Johnson, 2009) - Giving peer feedback in debriefs (Alinier et al., 2006; Nestel & Kidd, 2003; Rush et al., 2010)	- Working in groups of 2 to 5 students (Goto & Bianco-Simeral, 2009; Govekar & Rishi, 2007; Montgomery, 2004) - Interdisciplinary groups (Cooper et al., 2004; Schäfer & Richards, 2007) - Tasks allocated according to each members strengths (Goto & Bianco-Simeral, 2009) - Joint responsibility of project success (Tschopp, 2004) - Meeting in own time (Cooper, 2004; Goto & Bianco-Simeral, 2009) - Students benefit from working in groups (Montgomery, 2004) and some students do not (Goto & Bianco-Simeral, 2009) but according to some students developing professional skills is inhibited compared to working individually (Lu & Lambright, 2010)	- Individual or in pairs (Sahin, 2008) - Cooperation with colleagues/workplace supervisor (Sahin, 2008) - Assistance provided by friends from school (Laframboise & Shea, 2009)
Reflection	- Stop simulation at any time and look back on performance or reflect on performance in debriefs (e.g. in group discussions). Formulate points of improvement and apply	- Reflection by reflective journals (Cooper et al., 2004; Govekar & Rishi, 2007) and in-class discussion on performance (Lu & Lambright, 2010; Montgomery, 2004)	- Reflection by assignments (Laframboise & Shea, 2009), reflective journals (Cannon, 2008; Helfeldt, Capraro, Capraro, Foster, & Carter, 2009; Pence &

Learning environment characteristic	Hands-on simulation	Authentic project	Internship
	points of improvement in next session or episode (Alinier et al., 2006; Nestel & Kidd, 2003; Rush et al., 2010; Zeng & Johnson, 2009) - Reflection by looking back on videotaped session(Nestel & Kidd, 2003) - Reflection by keeping reflective journals (Schlairet & Pollock, 2010)		Macgillivray, 2008; Yang, 2011)and discussions on blackboard (Laframboise & Shea, 2009) and in-class (Cannon, 2008; Grande et al., 2009)
Ownership of learning	- Students can request that the simulation stop at any point and be renewed so that the students can consider their previous actions/decisions and make different choices for care (Rush et al., 2010)	- Students choose content of assignment (Curtis & Mahon, 2010; Goto & Bianco-Simeral, 2009; Schäfer & Richards, 2007) - High self-responsibility of students success in learning process expected (Lu & Lambright, 2010; Schäfer & Richards, 2007)	- Proactive attitude of the student is expected. Students must initiate (challenging) activities or ask for feedback themselves (Helfeldt et al., 2009; Jackson & Jackson, 2009; Laframboise & Shea, 2009; Mihail, 2006; Sahin, 2008)
Teacher guidance			
Instruction and modelling	- Teacher instructs, gives cues and helps students during the simulation (Rush et al., 2010; Schlairet & Pollock, 2010; Wenk et al., 2009)	- Teacher gives lectures (Montgomery, 2004; Schäfer & Richards, 2007) - Teacher gives examples of good practices (Curtis & Mahon, 2010) - Skills are demonstrated by client (Cooper et al., 2004)	- Workplace supervisors function as a model (e.g., teaching techniques) (Helfeldt et al., 2009; Laframboise & Shea, 2009; Yang, 2011)
Coaching	- Teacher asks challenging questions (Rush et al., 2010) and gives feedback on performance before, during, and after the simulation (Alinier et al., 2006; Nestel & Kidd, 2003; Rush, et al., 2010; Wenk et al., 2009)	- Tutorial support is an integral element of the project (Cooper et al., 2004; Curtis & Mahon, 2010; Schäfer & Richards, 2007) - Sometimes lack of support and time for guidance by teachers and clients (Goto & Bianco-Simeral, 2009; Schäfer & Richards, 2007)	- Support and mostly oral feedback provided by teachers and workplace supervisors during internship (Cannon, 2008; Caprano, Caprano, & Helfeldt, 2010; Freestone et al., 2007; Helfeldt et al., 2009; Mihail, 2006; Pence & Macgillivray, 2008; Sahin, 2008; Spooner et al., 2008)

Learning environment characteristic	Hands-on simulation	Authentic project	Internship
			and after internship (Laframboise & Shea, 2009) - Teachers ask challenging questions (Cannon, 2008) - Teachers give written on feedback performance reflections (Cannon, 2008; Yang, 2011) - Often lack of feedback on workplace or only feedback provided when students ask questions (Hoifodt et al., 2007; Jackson & Jackson, 2009; Yang, 2011)
Stimulating self-regulated learning	xx	- Scaffolding by reducing guidance and dividing assignment in smaller proportions (Curtis & Mahon, 2010; Schäfer & Richards, 2007) - Reducing guidance can lead to difficulties (Schäfer & Richards, 2007)	- Teachers help with formulating learning goals for self-directedness (Jackson & Jackson, 2009) and gradually give students more responsibility (Sahin, 2008) depending on students capability (Freestone et al., 2007) - Students need help with perusing learning goals (Jackson & Jackson, 2009) - Not much autonomy given by workplace supervisors (Sahin, 2008)

Note. Ordered from most to least mentioned characteristics of the work-related learning environments in the included studies.

Appendix 2.2 Reported Learning Outcomes as a Result of Learning in Hands-on Simulations, Authentic Projects and Internships

Learning outcomes	Hands-on simulation	Authentic Project	Internship
Knowledge	- Metacognitive knowledge (McCaughey & Traynor, 2010; Nestel & Kidd, 2003; Rush, et al., 2010) - Conceptual knowledge (McCaughey & Traynor, 2010; Zeng & Johnson, 2009) - Factual knowledge (Zeng & Johnson, 2009) - Procedural knowledge (Zeng & Johnson, 2009)	- Procedural knowledge (Curtis & Mahon, 2010; Goto & Bianco-Simeral, 2009; Govekar & Rishi, 2007; Montgomery, 2004) - Conceptual knowledge (Govekar & Rishi, 2007; Montgomery, 2004) - Metacognitive knowledge (Curtis & Mahon, 2010; Govekar & Rishi, 2007)	- Metacognitive knowledge (Grande et al., 2009; Helfeldt et al., 2009; Sahin, 2008)
Technical skills	- Quality of nasogastric tube insertion and urinary catheter insertion (Grady et al., 2008)	xx	xx
Attitude	- Self-confidence to function in practice (McCaughey & Traynor, 2010; Wenk et al., 2009)	- Self-confidence, inspiration, motivation (Schäfer & Richards, 2007) - Interest in the core subject matter (Montgomery, 2004) - Self-reliance (Curtis & Mahon, 2010) - Diversity awareness (Govekar & Rishi, 2007) - Professional demeanour (Tschopp, 2004)	- Self-confidence (Freestone et al., 2007; Hoifodt et al., 2007; Laframboise & Shea, 2009; Pence & Macgillivray, 2008; Sahin, 2008) - Sense of responsibility (Mariani & Klinkner, 2009; Sahin, 2008) - Efficacy (Helfeldt et al., 2009; Mariani & Klinkner, 2009) - Appreciation for diversity (Pence & Macgillivray, 2008) - Attitude towards psychiatry (Hoifodt et al., 2007) - Self-motivation (Sahin, 2008) - Independency (Sahin, 2008) - Trust (Mariani & Klinkner, 2009)
Competencies (COLO, 2006)	- Applying expertise (Alinier et al., 2006; McCaughey & Traynor, 2010; Zeng & Johnson, 2009) - Deciding and initiating action (McCaughey & Traynor, 2010) - Showing care and understanding (Nestel & Kidd, 2003)	- Planning (T. C. Cooper, 2004; Govekar & Rishi, 2007; Schäfer & Richards, 2007; Tschopp, 2004) - Cooperating (S. Cooper et al., 2004; Govekar & Rishi, 2007; Lu & Lambright, 2010; Schäfer & Richards, 2007) - Showing care and understanding (S.	- Applying expertise (Caprano et al., 2010; Helfeldt et al., 2009; Hoifodt et al., 2007; Laframboise & Shea, 2009; Mihail, 2006; Spooner et al., 2008) - Adhering to principles and values (Cannon, 2008; Grande et al., 2009; Pence & Macgillivray, 2008; Sahin,

Learning outcomes	Hands-on simulation	Authentic Project	Internship
	- Cooperating (McCaughey & Traynor, 2010) - Planning (McCaughey & Traynor, 2010)	Cooper et al., 2004; Govekar & Rishi, 2007) - Leading (Govekar & Rishi, 2007; Lu & Lambright, 2010; Tschopp, 2004) - Formulating and reporting (Lu & Lambright, 2010; Schäfer & Richards, 2007; Tschopp, 2004) - Researching (Goto & Bianco-Simeral, 2009; Schäfer & Richards, 2007; Tschopp, 2004) - Analysing (Govekar & Rishi, 2007; Lu & Lambright, 2010; Schäfer & Richards, 2007; Tschopp, 2004) - Presenting (Govekar & Rishi, 2007; Tschopp, 2004) - Relating and networking (Govekar & Rishi, 2007) - Persuading and influencing (Govekar & Rishi, 2007) - Creating and innovating (Govekar & Rishi, 2007) - Decision and initiating action (Tschopp, 2004) - Learning (Govekar & Rishi, 2007) - Meeting customer expectations (Tschopp, 2004) - Adapting and responding to change (Govekar & Rishi, 2007) - Operating efficiently (Tschopp, 2004)	2008; Yang, 2011) - Planning (Caprano et al., 2010; Laframboise & Shea, 2009; Mihail, 2006) - Formulating and reporting (Freestone et al., 2007; Laframboise & Shea, 2009) - Cooperating (Freestone et al., 2007; Mihail, 2006) - Learning (Caprano et al., 2010; Pence & Macgillivray, 2008) - Following instructions and procedures (Jackson & Jackson, 2009; Spooner et al., 2008) - Showing care and understanding (Sahin, 2008) - Using materials (Sahin, 2008) - Analysing (Freestone et al., 2007)
Transfer	- Transfer to clinical practice according to students (McCaughey & Traynor, 2010; Rush et al., 2010; Wenk et al., 2009)	xx	xx
Professional identity	- Professional development (Rush, et al., 2010) - Insight in developing professional role (McCaughey & Traynor, 2010)	- Insight into requirements of future profession (Cooper, 2004; Curtis & Mahon, 2010) - Insights into career choices (Cooper, 2004)	- Insight into requirements of future profession (Jackson & Jackson, 2009; Laframboise & Shea, 2009) - Insight into career choices and prospects (Jackson & Jackson, 2009;

Learning outcomes	Hands-on simulation	Authentic Project	Internship
			Mihail, 2006) - Insight into problems in professional field (Jackson & Jackson, 2009) - Insight into personal work habits (Jackson & Jackson, 2009) - Willingness to teach (Grande et al., 2009)

Note. Ordered from most to least mentioned learning outcomes of the work-related learning environments in the included studies.

Chapter 3

How authenticity and self-directedness and student perceptions thereof predict competence development in hands-on simulations[2]

This chapter aims to examine in a wide range of hands-on simulations how constructivist pedagogical-didactic design principles affect secondary and higher vocational education students' development of competencies. For this purpose, 23 hands-on simulations were studied. Teachers rated the degree of authenticity and self-directedness of the hands-on simulations. Student perceptions (N = 516) of value, authenticity and self-directedness (operationalised as choice), as well as their competency development, were gathered using questionnaires. The results of the hierarchical regression analyses showed that: 1) authenticity and self-directedness did not automatically lead to more competency development and 2) student perceptions of perceived value, authenticity and choice of how to perform tasks were the main predictors of competency development in the simulations. Nonetheless, the additional mediation analyses suggest that it is still important for teachers to invest in learning activities that stimulate self-directedness as these activities indirectly predicted competency development, *through* student perceptions. Several reasons for the results are discussed; among them the mismatch between teachers and students of what was considered authentic, complexity of the simulations, the teacher's role as facilitator instead of activator and the lack of choice possibilities. Ideas for future research, as well as practical implications concerning designing and implementing hands-on simulations for fostering competency development, are suggested.

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[2] This chapter is based on Khaled, A., Gulikers, J., Biemans, H., & Mulder, M. (2014). How authenticity and self-directedness and student perceptions thereof predict competence development in hands-on simulations. *British Educational Research Journal.* Advance online publication. doi: 10.1002/berj.3138

The aim of this chapter is to examine how constructivist pedagogical-didactic approaches to vocational learning affect the development of competencies of students in secondary vocational education and higher vocational education in a wide range of hands-on simulations. We also examine how student perceptions of these learning environment characteristics contribute to their competency development. We begin by explaining the theoretical framework in which we introduce the concept of competencies, authenticity and self-directed learning in relation to hands-on simulation and work towards formulating hypotheses.

Conceptual and operational competencies

In today's vocational education, students need to develop profession-specific skills and more general competencies to prepare them for their future job, future education and life in society (Biemans et al., 2009). The concept of competencies is becoming increasingly important and at the same time creates a degree of fuzziness in terms of definitions and operationalization. In the present study, we define competencies as necessary knowledge, skills and attitudes to function in profession-related contexts (Mulder, 2014). Thus, we view competencies as integrative constructs that gain meaning in a certain professional context. Le Deist and Winterton (2005) unify dominant approaches of the concept of competence across countries in a model (Figure 3.1); they distinguish competencies to function in the *profession* and as a *person*. Competencies one needs in one's profession are *conceptual* (cognitive, knowing-that) and *operational* (functional, applying expertise/technical skills) of nature. But to function as a person, one also needs *conceptual* (metacognitive, knowing oneself) and *operational* (social/attitudinal) competencies. Cooperating is, for example, an operational competency in the personal dimension because it is needed for social interactions. Planning and organising demands cognitive insights and is, therefore, a conceptual competency in the professional dimension. Hands-on simulations aim at developing both conceptual and operational competencies. Hence, the study in this chapter differentiates between conceptual and operational competencies as dependent variables.

Effective learning

The kind of learning that is effective for developing competencies and preparing students for a professional life is learning through guided experience in work-related learning environments that are meaningful to students (Mulder, 2014).This situative perspective on learning originates from the idea that preparing students for their future requires confronting them with real world problems and contexts (De Corte, 2003), including the social dynamics related to that practice (Brown, Collins, & Duguid, 1989). Promoting authentic learning or learning in 'real-life contexts' is seen as a crucial aspect of effective vocational curricula, which has led to an increase in implementing learning activities and settings that resemble working contexts (Billett, 2012).

	Occupational	*Personal*
Conceptual	Cognitive competence	Meta competence
Operational	Functional competence	Social competence

Figure 3.1 Typology of competence. From 'What is competence?' by F.D. Le Deist and J. Winterton 2005, *Human Resource Development International, 8*(1), p. 39.

In the past decades, various situated learning environments have been created to prepare students for their future profession, e.g. problem-based learning (Dochy, Segers, Bossche, & Struyven, 2005) and virtual simulations (Kester, Kirschner, & Corbalan, 2007). Those situated learning environments are not always based on the same set of design principles. However, two principles are argued as crucial for learning in the context of vocational education (De Bruijn & Leeman, 2011), that is that the learning environment 1) should be authentic and 2) should stimulate students to direct their own learning process. We will begin by explaining authenticity and self-directedness and their effect on learning outcomes in hands-on simulations as shown in previous research. Because it has repeatedly been shown that student perceptions of a learning environment are essential for quality learning (see Könings, Brand-Gruwel, & Merriënboer, 2005; Ning & Downing, 2012), we will also elaborate on how student perceptions of these principles influence their learning.

Authenticity, self-directedness and competency development in hands-on simulations

Authenticity of a learning environment refers to the degree of resemblance of the learning environment to students' future professional practice (Gulikers, Bastiaens, & Kirschner, 2004). Authentic design of hands-on simulations has often been discussed. Several authors state that simulations do not touch upon the reality of social dynamics of the work community (Barab, Squire, & Dueber, 2000), and that students are not fully accountable for the outcomes of simulated learning (Cumming & Maxwell, 1999). Others argue in favour of the authenticity of hands-on simulations since they include whole work-related tasks in a context directly derived from professional practice (Dieckmann, Gaba, & Rall, 2007; Jossberger, Brand-Gruwel, Boshuizen, & Van de Wiel, 2010). Repeatedly shown is that hands-on simulations with an authentic physical context are effective for developing procedural- and psychomotor skills (see Jeffries, 2005; Nestel, Groom, Eikeland-Husebø, & O'Donnell, 2011). This is because real equipment and real materials provoke accurate reproduction of movements and procedures (Maran & Glavin, 2003), which implies that authentic hands-on simulations foster *operational* competency development. However, Herrington and Herrington (2006) and Gulikers et al. (2004) argue that, next to a physical context that resembles the future profession, authentic learning environments also contain learning tasks that are ill-defined, have real-world relevance and represent whole tasks. Whole tasks require the integration of knowledge, skills and attitudes, instead of tasks divided into separate parts, and are used for learning more complex cognitive skills, or *conceptual* competencies (Van Merriënboer, 1997). Hands-on simulations are instructional practices that are perfect for practising whole tasks; however, such highly authentic simulations can be overwhelming and distracting for students because they have to deal with several elements at the same time, which could hamper their cognitive skills development (Maran & Glavin, 2003; Van Merriënboer & Sweller, 2010). Therefore, increasing the authenticity of a hands-on simulation does not automatically stimulate *conceptual* competency development. Several studies have shown that simple simulations, such as case studies and role plays, can be very effective for developing cognitive skills and procedures (i.e. *conceptual* competencies) (Patrick, 1992), and for improving team work skills such as communicating and cooperating (i.e. *operational* competencies) (Beaubien & Baker, 2004). Thus, research on the effect of authentic design of hands-on simulations in developing *operational* and *conceptual* competencies is ambiguous.

Regarding self-directedness, learning environments that centre around the students' needs and facilitate moments to choose among various learning options are expected to stimulate students' motivation, engagement and the deep learning necessary for competence development (Baeten, Kyndt, Struyven, & Dochy, 2010). Though self-directed learning environments are typically student-oriented, teacher guidance is still important and more effective for novice and intermediate students (Kirschner, Sweller, & Clark, 2006). Coaching students' self-diagnosis, giving feedback and giving direct instruction when needed are examples of teacher activities that stimulate self-directed learning (Brookfield, 2009). In other words: the level of external guidance of students should be attuned to their capability to regulate their own learning. Hands-on simulations are traditionally characterised by a teacher-provided structure, making the organisation of self-directed learning in hand-on simulations a challenge (Maxwell, Mergendoller, & Bellisimo, 2004). Since self-directed learning heavily relies on *conceptual* competencies, such as metacognitive awareness, involving goal setting and making a plan to achieve these goals and decision-making (Loyens, Magda, & Rikers, 2008), teacher-centred learning environments are less likely to stimulate the development of these cognitive and metacognitive (i.e. *conceptual*) competencies (Boekaerts, 1999). This could explain why empirical research studying *conceptual* competency development in self-directed hands-on simulations is lacking. With respect to *operational* competencies, Brydges, Carnahan, Rose and Dubrowski (2010) recently examined self-directed learning for competence development in hands-on simulations. The results show that in the self-directed simulation, in which nursing students had the freedom to choose whether or not to progress to another more complex simulation based on their self-monitored progress, the nurses were indeed capable of directing their own learning. The self-directed method did not lead to a higher overall performance compared to the simulation in which the teacher directed the students progression based on their proficiency and the open-ended hands-on simulation in which the students were free to structure the learning setting with no teacher direction. However, the self-directed nurses were able to maintain their skills acquisition over a longer period of time compared to nurse students in the teacher-guided and the open-ended hands-on simulations.

Thus, in theory hands-on simulations that facilitate self-directed learning with monitoring could foster *conceptual* as well as *operational* competency development, but the tradition of teacher-structured hands-on simulation and limited amount of empirical evidence investigating the impact of self-directedness in hands-on simulation does not allow us to formulate a well substantiated hypothesis.

Student perceptions and competency development in hands-on simulations

According to Pridham, O'Mallon and Prain (2012), students learn through the interplay of mind, body, feelings and environment in work-related learning. Students' perceptions of the simulation learning environment, therefore, could have an important, but also a complex influence on their learning. In the context of this study, three student perceptions are important; perceived value, perceived authenticity and perceived choice.

First, the overarching goal of contemporary vocational curricula is to stimulate competence development by creating a learning experience that has personal meaning to the student (De Bruijn & Leeman, 2011). Researchers expect students to be more motivated and engaged in learning environments that they see the *usefulness* and *added value* of (Ryan & Deci, 2000; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). Learning environments that are related to current and future goals and interests, such as career goals, stimulate students to engage in a task (Wigfield et al., 2006). As such, simulations that students perceive as valuable for their future professional career seem a prerequisite for competence development.

Second, regarding authenticity, the main question is to whom *are* and to whom *should* learning environments be authentic (Gulikers, Bastiaens, Kirschner, & Kester, 2006)? According to Barab et al. (2000), the degree to which the students feel the learning environment, developed by teachers, resembles professional practice is at least as important as, if not more important than the degree to which it actually resembles professional practice or teachers see it as authentic. Students' perceived authenticity and its impact on the development of *operational* competencies (technical and psychomotor skills), but also *conceptual* competencies (e.g. Rudolph, Simon, & Raemer, 2007) increasingly receives attention. Gulikers et al. (2006) found that students' perceived authenticity of the task and the physical context was positively correlated with students' deep learning and development of generic skills like problem-solving. Rystedt and Sjöblom (2012) state that it is a prerequisite for students to understand *what the simulation is a simulation of*. Boersma, Ten Dam, Volman and Wardekker (2009) showed that senior vocational Care Assistant students' learning was hampered during a simulation, in which they had to simulate bathing a new-born baby, because the students did not perceive the object (a doll) nor the bathing assignment as realistic (i.e. no authentic context and no authentic task). *Perceived authenticity* can be maximized by offering students tasks and scenarios in which they can act and behave as they would in real professional situations. Authenticity of the physical context can be enhanced with technology and equipment, but if the tasks and scenarios are not perceived as authentic, what the students have learnt in the hands-on simulation has little application to the real working situation and competencies are less likely developed (Beaubien & Baker, 2004). In sum, we assume that perceived authenticity affects the development of both *operational* and *conceptual* competencies.

Third, how students perceive freedom of choice is expected to be a critical aspect of self-directed learning because students can only self-direct their learning when they are aware that there are options to choose from, and that alternative paths exist (Boekaerts, 1999). A student should perceive a certain degree of *freedom of choice* to select what activities to perform and how to do this. We know that self-directed learning activates metacognitive skills because students constantly have to think about what they want to learn next and how they are going to achieve that goal (Loyens et al., 2008). Baeten et al. (2010) show in their literature review that students who perceive a learning environment as student-centred (i.e. students' needs are the starting point of learning and more freedom of choice) show more deep learning approaches that are associated with *conceptual* competency development. On the other hand, students who perceive a learning environment as more teacher-structured show more surface approaches to learning which is more associated with automatic and reproductive learning. These findings combined suggest that perceiving freedom of choice stimulates students' *conceptual* competency development. However, to our knowledge there is little empirical evidence in hands-on simulation supporting this hypothesis. Moreover, several studies contradict the findings of Baeten and colleagues. Katz and Assor (2007) showed that too complex cognitive situations inhibited students from challenging themselves and caused them to choose simple tasks to compensate for their feeling of incompetence, resulting in less competence development. Thus, there might be an optimal degree of perceived freedom that is beneficial for competence development, also in hands-on simulation.

The present study explores the impact of authenticity and self-directedness and students' perceptions (i.e. value, authenticity and choice) of hands-on simulation on *conceptual* and *operational* competency development. The research questions are:

1) To what extent do authenticity and self-directedness foster the development of conceptual and operational competencies for secondary and higher vocational education students in hands-on simulations?
2) Do students' perceived value, authenticity and choice explain additional variance in the relationship between authentic and self-directed design of the hands-on simulation and conceptual and operational competency development?

We hypothesise that: 1) authenticity and self-directedness in hands-on simulations stimulate more competency development and 2) student perceptions of value, authenticity and choice in hands-on simulations explain additional variance in the relationship between the authentic and self-directed design of the hands-on simulation and competency development. Unfortunately, the limited amount of literature and the contradictory research findings did not allow us to formulate hypotheses regarding the differential impact of authentic and self-directed design and student perceptions thereof on *operational* or *conceptual* competencies.

This study adds insights to the literature on developing competencies in formal work-related learning environments in secondary vocational and higher vocational education. Moreover, the findings result in practical guidelines on how hands-on simulations could best be designed and used for competency development. This will help teachers, learning environment designers and policy-makers to consciously select and use formal work-based learning environments, such as hands-on simulations, for a vocational curriculum.

Method

Hands-on simulations

Data collection took place in 23 hands-on simulations in the domains of Animal Husbandry & Dairy Farming, Rural Environmental Development, Engineering Technology and Flower Retail. On average, a hands-on simulation course lasted 5.4 (SD = 2.5) half days. The hands-on simulations varied in their design regarding authenticity and self-directedness. The hands-on simulations differed in their use of real equipment versus fake equipment (e.g. replication of hydraulic motor system versus a real tractor motor) and classroom setups in the training centre versus task performance in the field (e.g. a pig farm set up by the training centre versus going to a real pig farm). Thus, the authentic context varied but students simulated professional tasks at all times. During all hands-on simulations, students worked on various individual and group activities, guided by an expert teacher, varying from completely teacher-structured to guidance-on-demand.

Participants

Data in our study were collected from a total of 516 life-science students (56% males, 43.8% females, 2% undefined). Two thirds (66.3%) of the students were at the secondary vocational education levels 2, 3 and 4, frequently combined in mixed groups (mean age = 18.5, *SD* = 1.8). In the final analysis, secondary vocational education students were combined because educational level was no significant predictor of the dependent variables. 33.7% of the students were at the higher vocational education level (mean age = 18.8, *SD* = 1.9). The students' year of education varied from Year 1 to 4 (1 = 47.9%, 2 = 45.7%, 3 = 5.2%, 4 = 1.2%).

Measures

Learning environment variables

Authenticity and self-directedness. To examine the relationship between the authenticity and self-directedness and competency development, teachers filled in a questionnaire based on the *Model of Powerful Vocational Learning Environments*, in which authenticity and self-direction play a central role. The questionnaire (De Bruijn & Leeman, 2011) operationalised authenticity by 'Authentic subject matter' and 'Authentic structure and scope', whereas 'SD learning activities' and 'SD guidance' represented self-directedness (see Table 3.1). These four scales were presented as two descriptions (A and B), one indicating the 'powerful' practice (A), and one indicating the 'less powerful' practice (B) (see Figure 3.2). After reading the descriptions of practice A and practice B, the teachers were instructed to reflect on their own simulation and score this on a four-point Likert-type scale 1 (*A*), 2 (*more A than B*), 3 (*more B than A*) or 4 (*B*).

Table 3.1 Learning Environment Characteristics Used in This Study (De Bruijn & Leeman, 2011)

Authentic subject matter	The emphasis is on functional and real life learning. The curriculum is organized around situations from the professional field. There is explicit attention to learning and problem solving.
Authentic structure and scope	Learning from complex professional situations and zooming into underlying (sub-) skills and knowledge. The learning process covers competence development.
Self-directed learning activities	Students acquire knowledge and skills by working independently in an active and explorative way on tasks. The main activity of the teacher is to stimulate students to independently seek for solutions. The emphasis is on reflective learning. In case of assessment, student portfolios play an important role.
Guidance that stimulates self-directedness	There are many modules from which students can make a choice. Autonomy and self-responsibility of the students is central to guidance from the beginning on. Teachers provide mostly guidance on call.

Note: The original model focusses on characteristics for full educational trajectories. As hands-on simulations are usually of shorter duration, in the present study we used characteristics that are directly related to hands-on simulations.

A	B
1. The curriculum is subdivided into separate units. 2. Vocational theory and general skills are mostly offered separately. 3. There is a lot of emphasis on training instrumental skills.	1. The emphasis is on functional and real life learning. 2. The curriculum-design is based on situations and skills from the occupational practice. 3. There is explicitly attention for learning and skills and for problem solving skills.

Figure 3.2 Illustration of the less powerful (A) and powerful (B) descriptions of the learning environment characteristic 'Authentic structure and scope' used in the questionnaire.

Student perceptions

Students' background variables. A closed-ended questionnaire gathered students' background information on gender, age, educational level and education year.

Perceived choice. Because self-directed learning in hands-on simulation was mainly operationalised by providing students with opportunities to choose for topics and tasks of interest, and because we were specifically interested in the amount of perceived choice during the task execution, two separate items were formulated, derived from the Intrinsic Motivation Inventory (IMI) (Ryan & Deci, 2000). One item was 'I felt I had some choice about *what* tasks I could perform during the training' and the other item was 'I had some choice about *how* to perform the tasks during the training'. Responses were made on a seven-point Likert scale, ranging from 1 (*not at all true*) to 7 (*very true*).

Perceived value. Perceived value of the simulation for students' future occupation was measured with the subscale value/usefulness of the Intrinsic Motivation Inventory (IMI)(Ryan & Deci, 2000). Four out of seven items from the original questionnaire that were most relevant to this study were selected and translated into Dutch. As required in this questionnaire, we adapted the context of the items to 'my future profession' or 'my future career'. A sample item was 'Doing this training is beneficial for my future career'. Responses were made on a seven-point Likert scale, ranging from 1 (*not at all true*) to 7 (*very true*). Cronbach's alpha for this scale was .90.

Perceived authenticity. Students' perceived authenticity was measured via six items of the Perceived Authenticity Questionnaire (Gulikers, 2006) on a five-point Likert-type scale of 1 (*strongly disagree*) to 5 (*strongly agree*). The questions covered the perceived authenticity regarding the physical context (e.g. 'The context of the simulation training reflected the professional practice I am learning for') and the tasks (e.g. 'The tasks of the simulation training resembled the tasks of the profession I am learning for'). Internal consistency of the scale was Cronbach's α = .76.

Outcome variables

Operational and conceptual competence development. The students' competence development was assessed using two scales derived from The Competence Development Meter (COM;

Chapter 4). The COM is a validated self-report questionnaire for robust cross-educational level evaluation of a broad range of competencies in vocational and higher educational settings through assessing multiple indicators per competency. For the purpose of this study, seven competencies commonly addressed in hands-on simulations were selected. A short description of each competency was given, including the most important indicators of the competency. The students were asked to estimate their competency gain as a result of the simulation. Each competency consisted of a nine-point Likert scale ranging from 1 (*not*) to 9 (*a lot*) (see Table 3.2). Two separate scales were constructed based on the theoretical division of Le Deist and Winterton (2005). The operational competency scale consisted of the items referring to the competencies 'applying expertise', 'using materials and products', 'following instructions and procedures' and 'cooperating' (Cronbach's $\alpha = .80$). The conceptual competency scale consisted of the items referring to the competencies 'planning and organising', 'deciding and initiating activities' and 'analysing' (Cronbach's $\alpha = .79$).

Table 3.2 Item Examples of a Procedural Competency ('Following Instructions and Procedures') and a Conceptual Competency ('Deciding and Initiating Activities') Used in the Self-report Questionnaire

How much did you gain in **following instructions and procedures** due to the training? - *following instructions* - *carrying out activities according to action plans* - *working according to safety regulations*	Not	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	A lot	O I have not worked on the competency
How much did you gain in **deciding and initiating activities** due to the training? - *picking up activities on your own initiative* - *carrying out activities with self-confidence* - *elaborating why you acted in a certain manner*	Not	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	A lot	O I have not worked on the competency

Procedure

The data were collected from September 2011 until March 2012. Immediately after each hands-on simulation, the first author or teacher introduced the questionnaire to the students to ensure their understanding of its content. After this, students anonymously filled in the questionnaire during 15 minutes.

The first author familiarised teachers with the authenticity and self-directedness questionnaire scales and asked teachers to score the simulations from student data collected. Teachers did this within one week after the end of the hands-on simulations to generate the characteristics as they actually took place instead of measuring the intended characteristics.

Analyses

The data analyses started with a scan of the correlations between the variables. Next, a hierarchical regression analysis was conducted on both dependent variables. In step 1, the student background variables were included as control variables. This was done because background factors can influence students' perceived authenticity (Gulikers et al., 2006; Lizzio & Wilson, 2004). In step 2, the authenticity and self-directedness were included as predictors of operational and conceptual competency development, and in step 3 the students' perceived value, authenticity, and choice were added to the equation. Effect sizes were calculated for step 2 and step 3 using Cohen's f^2. An effect size is either small at .02, medium at .15 or large at .35 (Cohen, 1988).

Results

Means, standard deviations and correlations of all variables are illustrated in Table 3.3. The correlations between the student background, authenticity, self-directedness, student perceptions and competency development variables were low to moderate, some significant. They were mostly in line with our expectations, except for 'Authentic subject matter' and 'Authentic structure and scope'. Those variables correlated negatively with operational and conceptual competency development. As expected, all four student perception variables had significant positive correlations with the competency development variables. To answer the research questions, however, hierarchical regression analyses were needed.

Hierarchical regression analyses

Operational competency development

Table 3.4 shows that, after including all predictors, the amount of explained variance was 28% (R^2 = .30) and the control variables became insignificant. The regression weights reported after step 3 showed a significant negative relationship between 'Authentic structure and scope' and operational competency development (β= - .12) and positive significant relationships between three out of four student perception variables, and operational competency development, i.e. perceived value (β = .28), perceived authenticity (β = .19) and perceived choice of *how* to perform tasks (β = .15). The learning environment variables explained 2% of the variance (R^2 = .02, p < .05 after step 2) and the effect size was small (f^2 = .02). However, when adding the student perception variables to the equation, the predicted variability increased from .04 to .28 (ΔR^2 = .25, p < .001).

Chapter 3

Table 3.3 Means, Standard deviations, and Zero-order correlations Between the Variables Included in this Chapter (N= 516)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Competence development														
1. OPCOM	-													
2. CONCOM	.78***	-												
LE characteristics														
3. ASM	-.03	-.09*	-											
4. ASS	-.16***	-.20***	-.03	-										
5. SDLA	.07	.11**	.22***	.12**	-									
6. SDG	.02	.06	.07	-.32***	.22***	-								
Student perceptions														
7. PAU	.39***	.36***	.05	-.05	.17***	.06	-							
8. PVAL	.44***	.38***	.04	.10*	.19***	-.10**	.59***	-						
9. PCHW	.28***	.31***	.04	-.18***	.19***	.11*	.17***	.31***	-					
10. PCHH	.34***	.34***	.01	-.10*	.17**	.07	.22***	.35***	.39***	-				
Control variables														
11. Gender [a]	-.10	-.05	-.08	.07	-.08	-.35***	-.05	.01	-.20***	-.11*	-			
12. Age	-.01	.03	-.11*	.01	.23***	.16***	.09*	.04	.04	-.09	-.12**	-		
13. Level [b]	-.17***	-.23***	.12***	.31***	-.10*	.11*	.02	-.08	-.37***	.20***	-.14**	.09*	-	
14. Educational year	.08	.16**	.02	-.30**	.35***	.29***	-.01	-.05	.32***	.16***	-.12**	.26***	-.52***	-
M	6.07	5.80	3.09	2.62	2.25	2.00	3.80	5.61	4.07	4.44	1.44	18.59	1.84	1.60
SD	1.33	1.54	0.67	0.87	0.94	0.75	0.60	1.11	1.76	1.54	0.50	1.83	0.90	0.64

Note: OPCOM= Operational Competency Development; CONCOM= Conceptual Competency Development; ASM=Authentic subject matter, ASS= Authentic structure and scope, SDLA= SD learning activities, SDG= SD guidance, PAU= Perceived authenticity, PVAL= Perceived value, PCHW= Perceived choice what tasks to perform, PCHH= Perceived choice how to perform a task, [a] Male =1, Female= 2, [b] secondary vocational education= 1, higher vocational education=2, * $p < .05$; ** $p < .01$; *** $p < .001$ (two tailed)

Table 3.4 Hierarchical Regression Analysis of LE Characteristics and Student Perceptions as Predictors of Operational Competency Development Controlled for Student Background Variables (N=516)

Predictors	Operational competency development								
	Step 1			Step 2			Step 3		
	B	***SE B***	β	***B***	***SE B***	β	***B***	***SE B***	β
Control variables									
Gender	- 0.15	0.13	- .06	- 0.13	0.13	- .05	0.02	0.12	.01
Age	0.02	0.04	.02	0.00	0.04	.00	- 0.01	0.03	- .01
Level	- 0.27	0.08	- .19**	- 0.21	0.09	- .14*	- 0.13	0.08	- .09
Year	- 0.01	0.11	- .01	- 0.12	0.12	- .06	- 0.03	0.11	- .02
LE characteristics									
Authentic subject matter				- 0.08	0.09	- .04	- 0.08	0.08	- .04
Authentic structure & scope				- 0.23	0.08	- .15**	- 0.19	0.07	- .12*
SD learning activities				0.18	0.07	.13*	- 0.01	0.07	- .01
SD guidance				- 0.06	0.10	- .04	0.01	0.08	.01
Student perceptions									
Perceived value							0.33	0.06	.28***
Perceived authenticity							0.42	0.11	.19***
Perceived choice, what							0.05	0.04	.07
Perceived choice, how							0.13	0.04	.15**
R^2			.03			.05			.30
Adjusted R^2			.02			.04			.28
ΔR^2						.02*			.25***
f^2						.02			.36

Note: $^*p < .05$; $^{**} p < .01$; $^{***}p < .001$.

Table 3.5 Hierarchical Regression Analysis with LE Characteristics and Student Perceptions as Predictors of Conceptual Competency Development Controlled for Student Background Variables (N = 516)

Predictors	Conceptual competency development								
	Step 1			Step 2			Step 3		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Control variables									
Gender	- 0.29	0.15	- .09	- 0.26	0.15	- .08	- 0.08	0.14	- .03
Age	0.04	0.04	.04	0.00	0.04	.00	- 0.01	0.04	- .01
Level	- 0.34	0.10	- .20***	- 0.23	0.11	- .13*	- 0.14	0.10	- .08
Year	0.15	0.13	.06	- 0.00	0.14	- .00	0.07	0.13	.03
LE characteristics									
Authentic subject matter				- 0.28	0.11	- .12**	- 0.28	0.01	- .12**
Authentic structure & scope				- 0.31	0.10	- .18**	- 0.26	0.09	- .15**
SD learning activities				0.28	0.09	.17**	0.08	0.08	.10
SD guidance				- 0.07	0.11	- .03	- 0.01	0.10	- .00
Student perceptions									
Perceived value							0.28	0.08	.20***
Perceived authenticity							0.49	0.13	.19***
Perceived choice, what							0.08	0.04	.09
Perceived choice, how							0.15	0.05	.15**
R^2			.05			.09			.29
Adjusted R^2			.05			.08			.27
ΔR^2						.04***			.20***
f^2						.04			.28

Note: *$p < .05$; ** $p < .01$; ***$p < .001$.

The effect size of student perceptions was large (f^2 = .36). Also, 'SD learning activities', which showed a significant positive relationship in model 2, became an insignificant predictor.

Conceptual competency development

Table 3.5 shows that, under control of students' background variables, 'Authentic subject matter' (β = - .12) and 'Authentic structure and scope' (β = - .15) predicted conceptual competency development negatively. In line with the findings on operational competency development, three out of four student perception variables significantly predicted conceptual competency development, i.e. perceived value (β = .20), perceived authenticity (β = .19) and perceived choice of *how* to perform tasks (β =.15). The learning environment characteristics explained 3% of the variance (ΔR^2 = .04, p < .001 after step 2) and had a small effect size (f^2 = .04) while adding the student perception variables to the equation, the total amount of explained variance increased to 27% (ΔR^2 = .20, p < .001 after step 3), meaning that 19% of the variance could be explained from the students' perceptions with a moderate effect size. Similar to the regression analysis for operational competency development, 'SD learning activities' became an insignificant predictor conceptual competency development after step 3. The impact of self-directed learning activities and self-directed guidance was not significant in both full regression models.

There is, however, one relationship that raised questions that we chose to unravel. The significant positive relationship between the 'SD learning activities' and operational and conceptual competency development became insignificant when adding students' perceptions to the equation. If a relationship between a predictor and an outcome variable becomes smaller or insignificant after another predictor appears in the equation, mediation effect may be present (Tabachnick & Fidell, 2007). For that reason, we chose to conduct additional mediation analyses.

Mediation analyses

We conducted additional mediation analyses using bootstrapping analyses with the PROCESS macros for SPSS according to Preacher, Rucker and Hayes (2007). The bootstrapping method is proven to give more accurate results than traditional mediation methods since it relies less on assumptions about the sampling distribution (Preacher & Hayes, 2004). Moreover, bootstrapping estimates the specific effect size of multiple mediators and gives pair wise contrasts to compare the mediated effect between variables. Significance of the mediated effect (i.e. *indirect effect*) is determined by the confidence intervals. When zero is not included in the lower and higher bound of the bias-corrected and accelerated confidence interval (BCa CI), the indirect effect is significant. The amounts of bootstrap were set to 5000 and the BCa CI was 95%. Complete mediation is present when the relationship between the independent variable and the dependent variable (i.e. *direct effect*) becomes insignificant when the mediators are included. In case of partial mediation, the direct effect, as well as the indirect effect, remain statistically significant (MacKinnon, Fairchild, & Fritz, 2007). The size of an indirect effect is either small at .01, medium at .09 or large at .25 (Kenney, 2012). First, we conducted a bootstrap analysis with operational competency development as the dependent variable, the 'SD learning activities' as the independent variable, and students' perceived value, authenticity and choice of *what* and choice of *how* as mediator variables. The same procedure was followed for the dependent variable conceptual competency development.

Table 3.6 Indirect Effects and Pairwise Contrasts Tested through the Bootstrapping Method

	Mean Indirect effect (SE)	Lower- and upper bound of the 95% BCa Confidence Interval
SD learning activities on operational competency development through student perceptions		
Total indirect effect	0.169 (0.041)	0.092, 0.250
Perceived value	0.061 (0.026)	0.019, 0.120
Perceived authenticity	0.049 (0.018)	0.021, 0.093
Perceived choice what	0.031 (0.014)	0.008, 0.067
Perceived choice how	0.027 (0.014)	0.007, 0.063
Contrasts		
Authenticity vs. value	-0.012 (0.041)	-0.074, 0.047
Authenticity vs. choice, what	0.018 (0.022)	-0.217, 0.064
Authenticity vs. choice, how	0.022 (0.020)	-0.016, 0.066
Value vs. choice what	0.030 (0.030)	-0.023, 0.093
Value vs. choice how	0.034 (0.028)	-0.017, 0.094
Choice how vs. choice what	0.005 (0.030)	-0.041, 0.042
SD Learning activities on conceptual competency development through student perceptions		
Total indirect effects	0.183 (0.044)	0.103, 0.273
Perceived value	0.043 (0.025)	0.004, 0.104
Perceived authenticity	0.058 (0.021)	0.025, 0.110
Perceived choice, what	0.049 (0.019)	0.019, 0.096
Perceived choice, how	0.034 (0.017)	0.009, 0.078
Contrasts		
Authenticity vs. value	0.015 (0.034)	-0.052, 0.083
Authenticity vs. choice, what	0.009 (0.026)	-0.041, 0.061
Authenticity vs. choice, how	0.024 (0.024)	-0.020, 0.075
Value vs. choice what	-0.006 (0.031)	-0.066, 0.059
Value vs. choice how	0.009 (0.030)	-0.048, 0.071
Choice how vs. choice what	0.015 (0.026)	-0.036, 0.066

Note: All indirect effects were significant at the $p < .05$ since no confidence intervals included zero and all contrasts were insignificant at the $p < .05$ since all confidence intervals included zero.

The bootstrap results indicated that all proposed mediators were statistically significant mediators in the relationship between 'SD learning activities' and both operational and conceptual competency development since no confidence intervals contained zero (Table 3.6). Moreover, the direct effect became insignificant for the relationship between 'SD learning activities' and operational competency development (-0.082, $p = .15$), as well as for the relationship between 'SD learning activities' and conceptual competency development (-0.009, $p = .91$), meaning that student perceptions completely mediated the relationship between 'SD learning activities' and competency development.

The total indirect effect of student perceptions was moderate for the relationship between 'SD learning activities' and operational competency development (0.169, 95% BCa CI between 0.092 and 0.250) and conceptual competency development (0.183, 95% BCa CI between 0.103 and 0.273). The specific indirect effects of both bootstrap analyses were estimated between 0.027 and 0.061, which indicated that the four individual indirect effects of the mediators were rather small, but significant. Furthermore, all confidence intervals for the pairwise contrasts included zero, meaning that the individual indirect effects did not differ significantly. In sum, the results imply that student perceptions of the hands-on simulation completely explain the effect of 'SD learning activities' on competency development. To be more concrete, simulations that facilitate self-directed learning activities have a positive effect on operational and conceptual competency development *because* they create positive student perception regarding powerful learning, i.e. value, authenticity and choice.

Conclusion and discussion

Since hands-on simulations are increasingly used in vocational curricula for developing outcomes that students need for their future profession, more insight needs to be generated about what exactly enhances these outcomes in hands-on simulations. This chapter aims to explore how authenticity and self-directedness are related to developing operational and conceptual competencies in hands-on simulations. We assumed that: 1) authenticity and self-directedness foster the development of conceptual and operational competencies for secondary and higher vocational education students in hands-on simulations and that 2) positive student perceptions regarding value, authenticity and choice of the hands-on simulation explain additional variance in the relationship between authenticity and self-directed learning and conceptual and operational competency development.

The results suggest that hands-on simulations that are designed to be more authentic and to stimulate more self-directedness did not automatically lead to more competency development, rejecting our first hypothesis. Authenticity even seemed to negatively influence student learning, whereas self-directed learning activities and guidance had no effect as suggested in the final regression model. The results also showed that student perceptions of perceived value, authenticity and choice of how to perform tasks are the main predictors of both operational and conceptual competency development, supporting the second hypothesis. Furthermore, the additional results of the mediation analyses showed that this does not mean that teachers' effort in optimising hands-on simulations design is meaningless, certainly when it comes to designing self-directed learning activities. There are several reasons that could explain our findings.

Regarding authenticity, it is possible that teachers' and students' differing images of the professional practice explain the unexpected finding regarding authenticity: teacher-rated authenticity was a small but significant *negative predictor* of competency development, while students' perceived authenticity was a significant *positive predictor* of competency development. Barab et al. (2000) argue that teachers' designs of profession-oriented simulations are not always authentic to students; this probably also holds for the simulations in the present chapter. Background factors, such as amount and type of work experience, have an effect on a person's perceptions of what the professional practice looks like. As such, teachers' perceptions of authenticity are likely to be different from students' perceptions thereof (Gulikers, Bastiaens, Kirschner, & Kester, 2008). The findings also suggest that teacher authenticity is somewhat more negatively related to conceptual competency development than to operational competency development (see Tables 3.4 and 3.5). It might be that teachers' view on the profession led them to develop hands-on simulations that were too complex for the young and inexperienced students in our study. Several simulations in our study involved a rather complex whole task using high-tech equipment. For instance, in one hands-on simulation, students had to fix a technical problem in a real tractor motor, requiring processing of multiple elements simultaneously such as tools, motor, information about the motor on the laptop and solving the problem. Since the majority of the students in our sample were in their first or second year, these hands-on simulations could have asked too much of students' metacognitive skills, leading to cognitive overload. As Maran and Glavin (2003) and Van Merriënboer and Sweller (2010) argued, this information processing overload could have hampered rather than stimulated students' conceptual competency development.

Regarding self-directedness, this study showed some challenging findings. Firstly, additional mediation analyses showed that the self-directed learning activities enhanced competence development via complete mediation of students' perceived value, authenticity and choice. This finding adds evidence to the idea that student perceptions and interpretations of a learning environment determine their learning (Doyle, 1977; Könings et al., 2005) and suggests that positive student perceptions of self-directed learning activities are a prerequisite for competence development. We would like to emphasize, however, that this means that purposefully designing self-directed learning activities *does* have an impact on learning in hands-on simulations, through students' perceptions. Another reason for the finding that self-directed learning environment characteristics did not directly affect students' competency development could be that the teachers in our study were not active enough in stimulating self-directed learning but took more the role of a facilitator on the periphery. Self-directed learning does not mean that the teacher has no role in guiding student learning. Hattie's (2009) extensive meta-analyses show that more active guidance strategies are more effective than just facilitating learning. In other words, if the teachers had engaged the students more actively in self-directed learning during the hands-on simulations, the self-directed guidance activities (and probably also the self-directed learning activities) might possibly have impacted competency development more positively. Thirdly, regarding the insignificant effect of students' perceived choice of *what* tasks to perform, it is possible that there were simply not enough opportunities for students to choose between different alternatives in order to sufficiently demonstrate their effect on competency development. Similar processes were found in a study by Jossberger et al. (2010), who examined how students perceived freedom of choice during a hands-on simulation. Results revealed that, although the simulation was designed to give students opportunities to choose, in reality choosing was not possible most of the time. For example, the task stated that the students could choose their own cooking recipe, but eventually that was not allowed because of costs and time limits. For this reason, more empirical evidence has to be collected demonstrating the effect of both actual and perceived choice in hands-on simulation.

Implications

When considering our results, what would be needed to develop a powerful hands-on simulation? The main message is twofold:

1) To *co-create* hands-on simulations with students that are, through their eyes, valuable for and authentic with respect to their future profession or career and offer options to choose how to perform a task.
2) To create and *actively* guide learning activities to stimulate students' self-directedness.

Our message is not that hands-on simulations should be totally adapted to the students' perceptions, but that their design requires collectively creating a realistic image of the professional tasks and environment (see also Gulikers et al., 2006). In the design phase, explicitly discussing with students what a professional practice looks like and how that could be translated into a realistic simulation is a strategy. Another strategy is helping students to accept and understand the 'as-if' factor (Dieckmann et al., 2007) by emphasising that the simulation does not always fit their idea of authenticity and by articulating what exactly makes the simulated scenarios or tasks authentic and valuable for their future profession. We also advise teachers to be more aware that authenticity involves complexity. When designing authentic learning environments, it is crucial to confront students with whole tasks representative of their future work (Van Merriënboer, 1997); however, confronting first year students with tasks representative of the complexity level of a starting professional is not realistic. Therefore, this whole task should be simplified to be representative of students' professional tasks at a certain point in their educational career (e.g. for example, feeding only cows for first year students, and feeding all animals at the farm for third year students) (Gulikers et al., 2004). Various instructional strategies are available for reducing a task's complexity without compromising the whole, authentic task approach (Van Merriënboer, 1997).

With respect to self-directed learning, teachers could experiment more explicitly with self-directedness, and explicitly discuss choice options and how the students can benefit from them. This way of incorporating freedom of choice in hands-on simulations is likely to result in more competence development.

Last, while teachers' effort to stimulate self-directedness by creating self-directed learning activities ('SD learning activities') positively affected competency development through the perceptions of the student (see Tables 3.4 and 3.5), their guidance activities ('SD guidance') did not. Teachers' learning activities and guidance might be more effective when teachers take the role of an activator instead of facilitator. Self-directed learning is often incorrectly associated with unguided learning. Teachers can contribute to self-directed learning by active guidance activities such as giving attributional and progress feedback, rewarding students, teaching students self-verbalisation, modelling and giving direct instruction when needed, and helping to set challenging goals (Hattie, 2009; Schunk, 2001).

Limitations

The present study has some limitations that should be taken into account. First, the hands-on simulations in our study and the students in our sample were all part of Dutch educational trajectories in the domain of life-sciences. Though we have collected data from four fields within this discipline, the findings may not be generalised to hands-on simulations and students in other countries and other disciplines. Second, competency development was measured via a self-report questionnaire. Students are very capable of estimating their own performance (Hattie, 2009) and self-reporting competencies is shown as a reliable way of assessing competencies for course evaluation (Braun, Woodley, Richardson, & Leidner, 2012); however, inconsistencies related to self-reporting competence are also found in students overrating and underrating their competence influenced by factors such as age, life experience, sex and purposes of the self-report method (Boud & Falchikov, 1989). Therefore, it would be valuable to use more integrated approaches of assessing competence that include self-reports as well as performance observation of complex skills in real-world situations (Shavelson, 2013) for future research related to the effects of hands-on simulations. Third, approximately a third of the variance in our regression analyses was explained by student background variables, authenticity, self-directedness and student perceptions. This means that there were other factors involved in competency development in simulations that we did not measure. Although we investigated *perceived choice* and *perceived value for the future profession* as factors that are likely to motivate students and stimulate deep learning approaches necessary for competence development, other factors such as goal orientation and autonomous motivation are also associated with motivation and deep learning (Baeten et al., 2010). Investigating these factors may have added explained variance to our results, yet our experience is that there could be many other factors in hands-on simulation that lead to engagement in learning that are hard to grasp. For example, the ‘the fun and enjoyment factor’, being in a different environment than the classroom, group dynamics and receiving instruction from an inspiring expert teacher.

In sum, our research showed that it is possible to develop competencies in hands-on simulations, and generated ideas on how to improve hands-on simulations in order to stimulate more competence development. It also showed that much more empirical research is needed to underpin how authentic and self-directed hands-on simulation design affects competency development.

Chapter 4

Exploring the validity and robustness of a competency self-report instrument for vocational and higher competence-based education[3]

Research on the effectiveness of competence-based education across educational contexts and levels requires a new evaluation measurement. This chapter explores the face validity, construct validity and robustness of a competency self-report instrument that is aligned with contemporary competence theory and with current educational practice based on Competence-based qualification frameworks. A pilot study showed face validity of the competency constructs and indicators according to students from various levels in vocational and higher education. The results of the principal components analyses and parallel analyses, using data from 351 secondary vocational education and academic students, show more construct validity and robustness for competency constructs that are concrete and easy to relate to specific situations (e.g. 'applying expertise') compared with the abstract competencies (e.g. 'deciding and initiating'). This chapter sets out implications for designing and administrating uniform competency self-reports across educational levels and discusses suggestions for subsequent research.

[3] This chapter is based on Khaled, A., Gulikers, J., Tobi, H., Biemans, H. ., Oonk, C., & Mulder, M. (2014). Exploring the validity and robustness of a competency self-report instrument for vocational and higher competence-based education. *Journal of Psychoeducational Assessment*. Advance online publication. doi: 10.1177/0734282914523913

Introduction

Within competence-based education (CB-education), there is a gradual paradigm shift from thinking in task-specific qualifications to more general competencies (Sturing, Biemans, Mulder, & De Bruijn, 2011). In the 1970s and 1980s, the CB-education movement led to formulating endless lists of detailed, narrowly formulated, task-specific performance criteria (Bowden & Masters, 1993; Grant et al., 1979) and ignored the importance of how to apply knowledge in various working situations (Argüelles & Gonczi, 2000). During the past two decades, several countries, including Germany, France and Austria, have developed a more comprehensive approach toward CB-education in which learning situations address essential knowledge, skills and attitudes in an integrated manner (Biemans et al., 2009). In a contemporary CB-curriculum, students are confronted with a variety of core problems that they may encounter in their professional lives, situated in meaningful and recognisable contexts, with the aim of developing competencies that are portable from one context to another (Wesselink, Biemans, Mulder, & Van den Elsen, 2007). These competencies are included in the qualification frameworks of many countries (e.g. the United Kingdom, Australia, Germany). This raises a number of questions: What specific learning settings and contexts are effective for developing competencies? What effects does CB-education have on vocational and higher education students' competency development? How can competencies best be assessed (e.g. Blömeke, Zlatkin-Troitschanskaia, Kuhn, & Fege, 2013; Schaap, Baartman, & De Bruijn, 2012)? Researchers who try to answer such questions need a competency measurement instrument that allows them to explain variation in the development of different competencies across educational settings and levels. Such an instrument also needs to be aligned with contemporary CB-education theory and practice. The aim of this study is to construct a competency measurement and to test its face validity, construct validity and robustness across educational settings and levels. This study argues that such a competency measurement consists of a) a variety of competencies from a qualification framework, b) incorporating, for each competency, several indicators that include relevant knowledge, skills and attitudes. Arguments for constructing the competency measure this way are the following:

First, competencies are the foundation of many countries' *qualification frameworks* (e.g. the U.K. National Vocational Qualifications Framework, Australian Standards Framework, European Qualifications Framework and the Bologna Qualifications Framework). These qualification frameworks consist of outcome standards for reaching a common approach to qualifications and assessments across disciplines. The idea behind qualification frameworks is *similarity*; all qualifications share core competencies that are generic across professional sectors and educational levels (Young, 2009). In formulating and working toward a common set of outcomes, the aim is to improve mobility of labour and transferability between educational systems (Brockmann, Clarke, Méhaut, & Winch, 2008). Competencies in a qualification framework include not only functional and behavioural requirements (e.g. applying expertise) but also more complex cognitive abilities for functioning in the profession (e.g. problem solving) as well as social abilities to function as a person (e.g. showing tolerance and caring for others; Le Deist & Winterton, 2005). The competencies in a qualification framework can be a guideline for teachers in designing their CB-learning context, adapted to the students' level (Young, 2009). It would be efficient to align competency effectiveness studies with a qualification framework and incorporate a set of competencies from a qualification framework in a competency measurement applicable to different educational programs and levels.

Second, competencies are coherent clusters of knowledge, skills and attitudes that can be utilised in real performance contexts (Mulder, 2014). Traditional CB-education aimed to enable students to acquire qualifications that led to competencies that basically consisted of a summing-up of fragmented knowledge, skills *or* attitudes related to a specific profession (Boyatzis & Royatzis, 1982). In contrast, the aim of contemporary CB-education is the development of competencies that students need in their future professional career and in society as a whole (Biemans et al., 2009). Therefore, an integration of knowledge, skills *and* attitudes in learning and assessment is necessary (Wesselink, De Jong, & Biemans, 2010).

Third, research argues that it is possible to measure different kinds of competencies via self-reports under certain conditions: a) The instrument should include *multiple indicators* per competency to address a competency in its full complexity; b) context should be given for the competencies and indicators and c) the indicators should concern concrete behaviour. Braun, Woodley, Richardson and Leidner (2012) review seven examples of competency self-reports frequently used in educational settings around the world. According to the authors, competency self-reports tend to include vague and abstract expressions, which increase the likelihood of personal interpretation and decreases the validity of the measurement. One example of abstract wording is the Cognitive Development Scale of the Cooperative Institutional Research Program (see http://www.heri.ucla.edu/abtcirp.php). Without further explanation of the concepts, this questionnaire instructs students to rate themselves on competencies such as 'my critical thinking skills' or 'my analytical and problem-solving skills'. Competencies are complex constructs; without context, they can be open to multiple interpretations (Hodkinson & Issitt, 1995). To avoid misinterpretation and to cover a given competency construct in its full complexity, self-reports should at least include multiple indicators that concern specific behaviour (Braun et al., 2012).

This study

The present study uses the competency framework used for vocational education programs as described in the Dutch Association for Vocational education expertise centre (COLO, 2006, see Table 4.1), which is based on the Uniform Competency Framework of SHL (Bartram, 2005). Our study is of an explorative nature and aims to investigate the possibility of constructing a competency self-report for vocational and higher education based on a generic

Table 4.1 Sample Competencies from the Dutch Competency Framework (COLO, 2006)

Initiating and taking actions
Leading
Showing tolerance and caring for others
Cooperating
Relating and networking
Persuading and influencing
Formulating and reporting
Appling expertise
Analysing
Creating and innovating
Learning
Planning and organising
Maintaining quality
Coping with pressure and setbacks
Demonstrating ambition
Entrepreneurial and commercial acting

competency framework. Because the concept of competencies is sensitive to personal interpretations, we a) have assured face validity with pilot groups from vocational and higher education level students and b) focus in the present chapter on examining the construct validity and robustness of the competency constructs. Robustness refers here to the possibility of using the instrument across educational levels. The educational field would benefit from a uniform competency self-report because it allows for comparing CB-learning context and thereby offers better insights into the effectiveness of specific CB-learning contexts. This allows for more targeted use of courses for training specific sets of competencies across various levels. The research questions guiding this study are as follows:

1) What is the construct validity of a competency self-report instrument with distinguishing competencies and indicators?
2) Is a competency measurement with such a self-report instrument robust across educational levels?

Method

Instrument development

Instrument development consisted of formulating the indicators for all 25 competencies from the theoretical qualification framework and testing the face validity with student groups.

Initially, the first two authors carefully compared indicators documented by various authors and organisations developing indicators for the theoretical qualification framework (e.g. Groene Kennis Coöperatie, 2008; Van den Herik & Winkler, 2008). The authors identified which indicators were mentioned most frequently per competency and formulated for each competency a comprehensive description of the competency and a set of indicators in the form of behaviour-related wording. Next, the descriptions of competencies and their underlying indicators were presented to independent researchers in the field of competencies for content validity, face validity, clarity and readability. Based on the reviews of the independent researchers, unclear indicators were reformulated and irrelevant indicators were eliminated. This resulted in a self-report with a Likert-type scale ranging from 1 (*not at all applicable to me*) to 10 (*completely applicable to me*) per indicator. The instrument was labelled Competentie Ontwikkelings Meter (COM)—or, in English, 'The Competency Development Meter.'

Second, the COM was pilot-tested in January and February 2011 with six student groups from secondary vocational education and higher education in the life-sciences, the latter consisting of the higher vocational level and the academic level. Students filled out the questionnaire individually; directly following, they took part in a 1½-hr group debriefing group interview per educational level to investigate face validity and readability of the competency indicators (Czaja & Blair, 2005). During interviews, the students were asked whether they a) understood the competency and the indicators, b) thought the indicators fit the competency, c) recognised the competency and indicators from their school and/or working situations, d) could name specific situations in which they worked on the competency and indicators and e) could specify how they worked on the competency and indicators. Last, each indicator was specifically discussed regarding its readability.

Students' reactions, interpretations and suggestions were ordered per competency and put in an overview. Reformulating indicators that the students found unclear and omitting those that none of the students recognised in practice ensured face validity. Finally, the indicators were corrected for readability by two independent researchers. This resulted in the last version of the COM consisting of 25 competencies from the theoretical qualification framework, with 5 to 9 indicators per competency.

Procedure

In 2011 and 2012, new groups of students from secondary vocational education and academic education were assigned to fill out the COM. Within the context of a certain educational module, students assessed themselves on a selection of the competencies that, according to the teaching staff, were relevant. For the purpose of the present study, only those competencies filled out by both groups were used in the analyses. The competencies 'deciding and initiating', 'cooperating', 'applying expertise' and 'planning and organising' and their related indicators, were included in the analyses. See Table 4.2 for all the indicators as translated from Dutch to English.

Participants

A total of 351 life-sciences students completed the COM (n = 195 for the secondary vocational education group and n = 146 for the academic education group, see Table 4.3). The secondary vocational education students were studying Animal Husbandry, Animal Care and Management, Horse Equipment and Commercial Entrepreneurship in a learning environment that intertwines school and workplace learning. The academic students were working in a project-based setting with multidisciplinary groups: Land use Planning; International Development Studies; Management, Economics & Consumer Studies; Forest & Nature Conservation; and Animal Science.

Table 4.2 Competencies and Indicators of the Competency Development Meter (COM) Included in this Chapter

Competency	Competency Indicator
Deciding and Initiating action	1. I take initiative to start tasks *
	2. When making a decision, I carefully weigh the advantages and disadvantages of the different options
	3. I am able to justify my choices
	4. I take responsibility for the choices I make
	5. I perform my tasks with confidence*
Cooperating	1. During group meetings I make valuable contributions to the final result *∇
	2. I contribute to the shared group result by performing my duties
	3. I do my best to achieve the best result possible together with my group
	4. I perform my duties and tasks as agreed
	5. I help my peers with their tasks
	6. I give feedback to members of my group
	7. I contribute to a good atmosphere in the group*
	8. I take actions to prevent conflicts between people
	9. I take actions to resolve conflicts between people
Applying expertise	1. I have broad expert knowledge
	2. I have a lot of expert skills
	3. I can easily perform standard operations in my area of expertise
	4. I have enough expertise to perform tasks properly in unexpected situations
	5. With my expertise, I help others to perform their tasks
Planning and Organising	1. During the preparation of an assignment I consider which results I want to achieve first
	2. During the preparation of an assignment I consider which tasks need to be executed
	3. I put the tasks to be performed in a logical order
	4. During the preparation of an assignment I draw up a time schedule
	5. I make note of the materials I need to perform the different tasks
	6. I regularly check if the job is running according to schedule
	7. I adjust my time schedule if needed

* Omitted from analysis for the vocational education group. ∇ Omitted from analysis for the academic group.

Table 4.3 Characteristics of the Participants

	Secondary Vocational Education Sample	Academic Education Sample
n	195	146
Gender (%) male	116 (59.5)	75 (51.4)
Age [mean (*SD*)]	19.03 (1.34)	21.0 (4.0)
Level (%)[a]	3 (3.1)	BSc 111 (76)
	4 (96.9)	MSc 35 (24)

[a] The Dutch secondary vocational educational system distinguishes levels 1, 2, 3, and 4. For more information about the Dutch educational system, refer to Wesselink et al., 2007.

Statistical analysis

Construct validity of the COM was explored in both groups by a principal components analysis (PCA) with orthogonal rotation (varimax). Prior to final component extraction, indicators with communalities below 0.5 were omitted. The suitability of the data was assessed with the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (> .5) and Barlett's Test of Sphericity (Field, 2009). With PCA, there are several debatable decision rules for component extraction, such as a low reliability of data interpretation and a high risk of over-factoring (O'Connor, 2000). Therefore, we performed a parallel analysis (PA) for each data set (O'Connor, 2000) to determine the number of components, as PA is currently the most accurate method for deciding on numbers of component extraction in PCA (Schmitt, 2011). Missing cases were excluded list-wise. The robustness of the components was explored by comparing component patterns of indicators across educational levels. All analyses were conducted in SPSS version 19.

Results

Secondary vocational education group

Four indicators had communalities under 0.5 and were therefore omitted from the analysis (Table 4.2). The KMO measure confirmed the sampling adequacy for the analysis with KMO = .81. Barlett's Test of Sphericity, $\chi 2(231) = 2{,}123.98$, $p > .001$, indicated that correlations between the indicators were sufficiently large for PCA. The analysis resulted in six components with an eigenvalue more than 1, which in combination explained 70.42% of the variance. The PA suggested four components (Table 4.4). Therefore, extraction was restricted to four components, explaining 54.38% of the total variance. Table 4.5 shows the factor loadings after varimax rotation.

Table 4.4 Parallel Analysis for the Principle Component Analysis of the Secondary Vocational Education Group Data

Component	PCA Eigenvalue	PA Eigenvalue [a]	Difference
1	5.563	1.764	3.800
2	3.776	1.617	2.159
3	2.260	1.522	0.738
4	1.590	1.440	0.150
5	1.288	1.364	-0.007
6	1.016	1.300	-0.284

[a] Random data eigenvalues for 100 replications over 22 indicators and 194 participants.

Table 4.5 Structure Matrix Obtained by PCA after the Varimax Rotation on Indicators for the Secondary Vocational Education Group (*n* = 194)

		Rotated Factor Loadings (Varimax)			
Competency	**Competency Indicator**	**Component 1 'Planning & organising'**	**Component 2 'Applying expertise'**	**Component 3 'Task-specific shared responsibility'**	**Component 4 'Peer collaboration'**
Planning & organising					
	6	**.851**			
	4	**.844**			
	5	**.817**			
	3	**.809**			
	7	**.764**			
Applying expertise					
	4		**.840**		
	2		**.800**		
	1		**.791**		
	3		**.765**		
	5		**.695**		.445
Cooperating					
	2			**.821**	
	4			**.809**	
	3			**.788**	
	5			**.582**	
	9				**.880**
	8				**.858**
	6				**.565**
Deciding &initiating					
	3				
	4				
	2	.442			
Eigenvalues		5.563	3.776	2.260	1.590
% of variance		25.29	17.16	10.27	7.22

Note: All loadings over .40 are depicted; factor loadings over .50 are bold.

Indicators of the competency 'planning and organising' had high factor loadings on Component 1, and 'applying expertise' had high factor loadings on Component 2. These two components were in line with the theoretical competency framework. The indicators for the theoretical competency 'cooperating' were divided between two components, a task-oriented component and a social-oriented component. Indicators 2, 3, 4 and 5 were mainly about helping others, performing duties, and contributing to the common result, and were labelled as Component 3—'task-specific shared responsibility'. Component 4 included Indicators 6, 8, and 9 of the theoretical competency 'cooperating' and represented only the social and interactive aspects of working together. Therefore, Component 4 was labelled as 'peer collaboration'. In the secondary vocational group, no component was found reflecting the competency and items of 'deciding and initiating'.

Academic group

Initial analysis showed one indicator with a communality below 0.5 and was omitted from further analysis. Refactoring showed sampling adequacy for the analysis (KMO = .81) and sufficiently large correlations between the indicators, Barlett's Test of Sphericity, $\chi 2(300) = 1{,}861.09$, $p < .001$. Seven components had eigenvalues greater than Kaiser's criterion of 1 and, in combination, explained 72.57% of the variance. The PA suggested extraction of only four components (Table 4.6). Therefore, four components explaining 59.52% of the total variance were extracted. Table 4.7 shows the structure matrix after varimax rotation. For the academic group, indicators for the competencies 'applying expertise' had high factor loadings on Component 1, whereas indicators for the competency 'planning and organising' had high loadings on Component 2. Components 1 and 2 were labelled as 'applying expertise' and 'planning and organising', consistent with the theoretical competency framework. Component 3 appeared to reflect the shared responsibility students have when performing a task together and was labelled as 'task-specific shared responsibility'. Component 4 consisted of three items of the theoretical competency 'deciding and initiating'. However, these items were not interpretable and we decided not to label this component.

Table 4.6 Parallel Analysis for the Principle Component Analysis of the Academic Group Data

Component	PCA Eigenvalue	PA Eigenvalue [a]	Difference
1	7.074	2.033	5.041
2	3.278	1.839	1.439
3	2.269	1.695	0.574
4	1.760	1.588	0.202
5	1.401	1.503	-0.102
6	1.338	1.432	-0.094
7	1.021	1.354	-0.333

[a] Random data eigenvalues for 100 replications over 24 variables and 135 participants.

Construct validity

The explorative analyses on the COM suggest construct validity of the theoretical competency constructs 'planning and organising' and 'applying expertise.' The analyses also suggest that the theoretical construct 'cooperating' actually is made up of two components: 'task-specific shared responsibility' and 'peer cooperation,' whereby 'task-specific shared responsibility' was found in both groups and 'peer collaboration' was only found in the secondary vocational education group. As the competency 'deciding and initiating' was not a meaningful construct in both analyses, this was not a valid construct.

Table 4.7 Structure Matrix Obtained by PCA after the Varimax Rotation on Indicators for the Academic Education Group (*n* =135)

		Rotated Factor Loadings (Varimax)			
Competency	**Competency indicator**	**Component 1 'Applying expertise'**	**Component 2 'Planning & organising'**	**Component 3 'Task-specific shared responsibility'**	**Component 4 *could not be labelled***
Applying expertise					
	2	**.900**			
	4	**.894**			
	3	**.867**			
	1	**.854**			
	5	**.844**			
Planning & organising					
	6		**.835**		
	4		**.832**		
	5		**.756**		
	3		**.722**		
	2		**.561**		
Cooperating					
	2			**.791**	
	4			**.788**	
	3			**.694**	
	5			**.628**	
Deciding & initiating					
	5				**.877**
	1				**.742**
	4				**.590**
Cooperating					
	6				
	9				
	8				
	7			.415	
Deciding & initiating					
	3				
	2				
Planning & organising					
	7		.468		
	1		.484		
Eigenvalues		7.074	3.278	2.269	1.760
% of variance		28.30	13.11	9.07	7.04

Note: All loadings over .40 are depicted; factor loadings over .50 are bold.

Chapter 4

Robustness

The results show robustness of some competency constructs from the original competency framework. The empirical patterns can be seen as signs of robustness across indicators on 'applying expertise' and 'planning and organising'. These indicators cover the same competency constructs on both educational levels. Indicators reflecting the 'shared responsibility' part of cooperating were extracted as a separate component in both groups, while the other indicators of the cooperating construct were only extracted as a separated component ('peer collaboration') in the vocational education group. Thus, 'task-specific shared responsibility' seems to be an additional robust construct. The theoretical competency construct 'deciding and initiating' could not be considered robust, as this was not an interpretable separate component in both groups.

Conclusion and discussion

This study explored the possibility of constructing a competency self-report aligned with the practice and theory of contemporary CB-education. The competency self-report instrument with multiple indicators per competency, COM, which has shown face validity according to vocational and higher educational students, was examined for its construct validity and robustness. The performance of the COM was mixed. Two constructs—'planning and organising' and 'applying expertise'—showed construct validity and robustness. The indicators loaded on the same extracted components in both groups. Construct validity of the theoretical competency 'cooperating' varied between groups, but an additional robust construct—'task-specific shared responsibility'—was found. No robust construct reflecting the competency 'deciding and initiating' could be found. These results show that, under certain circumstances, it is possible to construct a competency self-report instrument based on a qualification framework. The reasons for the mixed findings and the implications for assessing competencies using a self-report instrument can be found in *the formulation and context specificity of the indicators and the misalignment between selected competencies and their actual implementation*.

First, there is a possibility that the formulation of the indicators of the competencies 'deciding and initiating' and 'cooperating' was not specific enough for valid measurements. Schwarz (1999) advises self-assessment only for concrete and specific behaviours related to particular situations. Although we formulated the indicators of the COM as concrete as possible, it was also our goal to allow comparison and differentiation between educational situations and therefore to develop items that are generically applicable. Indicators such as those associated with the theoretical competency construct 'deciding and initiating', could have been more abstract in wording and consequently more ambiguous. Indicators such as 'I am able to justify my choices' may still have been too abstract for the students. In that respect, the present study underpins the statement of Braun et al. (2012) that concrete and straightforward wording is necessary when validly self-assessing competencies. Ackerman, Beier, and Bowen

(2002) state that self-assessment of capacity is markedly improved when using concrete items instead of broadly defined concepts. Because our study showed validity and robustness of competency measurements that are generally easier to relate to a specific context ('applying expertise' and 'planning and organising') than the more abstract ones are ('cooperating' and 'deciding and initiating'), there is a possibility that, for improving valid measurements, abstract competency constructs need more context-specific wording than concrete competency constructs do. Three questions remain from this study: To what extent should indicators of competency constructs be concretised for valid and robust measurements? How context-specific should competency measurements be? And can abstract competency constructs be evaluated with a self-report in a valid way across educational levels?

A second explanation may be the misalignment between selected competencies and their actual implementation. Benett (1993) attributes difficulties with standardised self-report instruments to the complexity and variety of learning situations students encounter in work-related learning. Benett (1993) claims that it is possible to use competency standards for comparisons between groups but only if the competencies and their associated indicators are representative of the situation to which the self-report instrument refers. A recent study on CB-assessment shows that the intended outcomes are often described in terms of competencies, but in practice, the competencies are not sufficiently addressed (Baartman, Gulikers, & Dijkstra, 2013). There is a possibility that the students in our study did not consciously work on the competency 'deciding and initiating actions', although the teachers selected relevant competencies prior to the learning situation. As a result, students may have found it hard to imagine indicators such as 'I take responsibility for the choices I make' because in reality they never had to deal with this consciously.

Implications

The present study demonstrated that there are possibilities for using a generic instrument to explain variation in the development of various competencies across educational setting and levels. However, two important conditions must be met for a valid measurement. First, formulations for indicators should be as concrete and straightforward as possible when designing a self-report; otherwise, interpretation problems are expected. Second, researchers have to critically overthink *which competencies* they want to assess and are advised to assess only competencies that are actually addressed in the learning context under study. Competencies that students do not specifically work on in their learning activities cause noise and ought to be excluded from self-reports. Such a self-report instrument is a valuable addition to the CB-education research and practice: It offers ample opportunities for examining and comparing the effectiveness of various CB-learning contexts in relation to qualification frameworks, and it offers opportunities for more evidence-based development and improvement of learning contexts with the aim of developing specific competencies of this framework. These insights can provide information for teachers to improve learning situations for developing certain competencies.

Limitations and future research

One limitation of the current study is the inclusion of only the secondary vocational and academic-level samples, although the COM was constructed for all tertiary educational levels (secondary vocational education, higher vocational education and academic education). Furthermore, this study used a relatively small sample size and was of a more explorative, rather than confirmatory, nature. Nonetheless, this study has taken the first step in establishing validity of a contemporary competency self-report instrument: We have found evidence of face validity and construct validity of the competency self-report. The next steps in the construct validation process of the COM would be a) examining its convergent and discriminant validity by comparing scores that *should* and *should not* be related to COM measurements, b) examining the predictive validity of the COM (e.g. do higher competency scores lead to higher performance during internships or other work experiences?) to add to the lacking evidence of predictive validity of self-assessed competency measurements (Braun et al., 2012), c) confirming construct validity by confirmatory factor analysis using a larger sample from all levels of tertiary education and d) then directly comparing the nature of the questionnaire responses between groups.

To further validate competency self-report instruments in general, it might also be interesting to test the other competencies and indicators from the Dutch Qualification framework included in the COM. In addition, we also suggest examining the construct validity and robustness of other existing competency self-reports used in different countries, from other qualification frameworks. It would be valuable to examine whether validation research on similar competency self-reports lead to the same findings.

Chapter 5

The effect of authenticity, self-directedness and self-regulation on student learning in a hands-on simulation[4]

Hands-on simulations have a longstanding history in their use for developing procedural and technical skills in higher vocational education. Now that they are increasingly used in vocational education for developing other learning outcomes such as professional competence, more constructivist pedagogical-didactic approaches are required. However, empirical evidence is needed to demonstrate the effectiveness of constructivist learning in hands-on simulations. We hypothesize that adding authenticity, self-directedness and self-regulation to hands-on simulations stimulates students to develop competencies and fosters near and far transfer of their professional competence, mediated by students' perceptions of the learning environment. A comparison of learning outcomes of 94 first-year Applied Biology students participating in an 'innovative' (authentic, self-directive and self-regulated) or a 'traditional' hands-on simulation showed a significant gain on four out of five competency scores. However, there were no differences between groups. Surprisingly, students in the traditional simulation scored higher on the far transfer test and their simulation was perceived as more authentic compared to the students innovative simulation. The discussion elaborates on possible explanations for the unexpected results.

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[4] This chapter is based on Khaled, A., Gulikers, J., Biemans, H., & Mulder, M. (2014). *The effect of authenticity, self-directedness, and self-regulation on student learning in a work related learning environment*. Under review.

Introduction

Students in higher vocational education trajectories are increasingly exposed to learning experiences that are closely related to their future profession to prepare them for their professional lives and to increase their employability (Billett, 2014; Tynjälä, Välimaa, & Sarja, 2003). Constructivist learning environments that are meaningful, situated in the working context, engage students in real-life problems and encourage students to take more initiative, plan and control their learning are receiving a great deal of attention across many disciplines (e.g. Cano, Lidon, Rebollar, Roman, & Saenz, 2006; Dochy, Segers, Bossche, & Struyven, 2005). A typical longstanding work-related learning environment is a hands-on simulation. Hands-on simulations involve active learning with guidance from an expert teacher through tasks and contexts designed to reflect real professional practice, including real materials and equipment (Bradley, 2006). At the demand of the student or the teacher, simulated events can be paused, followed by reflection-on-action (Maran & Glavin, 2003). Traditionally, hands-on simulations were developed to train specific, routine-based, procedural and technical knowledge and skills within a completely teacher-provided structure (Chapter 2; Issenberg et al., 1999; Kneebone, 2005). But for hands-simulations to have an added value to the innovative professional curriculum that aims at different outcomes, such as competencies and transferable skills, more constructivist pedagogical-didactic approaches might be appropriate (Chapter 2). Therefore, this chapter aims to illustrate how implementing an important set of constructivist learning strategies (i.e., authenticity, self-directed and self-regulated learning) in hands-on simulations affects higher vocational education students to develop competencies and foster transfer of professional competence.

Competencies

In today's education, students need to develop profession-specific skills and more general competencies to prepare them for their future job, future education and life in society (Biemans et al., 2009). We define a competency as an *integrative* construct that includes necessary knowledge, skills and attitudes to function in profession-related contexts (Mulder, 2014). An example of a competency is 'the ability to present'; for presenting a person needs to know how to structure the message, to able to use the PowerPoint-software and to feel confident when presenting his message. A competency construct should be operationalised in concrete behavioural indicators (Chapter 4).

Near and far transfer of professional competence

The ultimate aim of work-related learning is that the students are capable of applying what they have learnt at a later moment, in different working contexts. A long history of research into the effects of transfer of training, however, draws a mixed picture (e.g. Burke & Hutchins, 2007; Van Wijk, Jansen, & Lyles, 2008). Transfer consists of two dimensions; transfer can be seen as a generalisation and maintenance process of learning related to the *content*– what is transferred and the *context*– when and where learning is transferred from and to (Barnett & Ceci, 2002; Blume, Ford, Baldwin, & Huang, 2010). In the present study, the content of the transfer is professional competence (i.e. acting responsible and effective in a certain professional context, see Mulder, 2014) and the context of transfer is divided into *near transfer*– transfer between very similar contexts, and *far transfer*– transfer between contexts that differ from each other (Perkins & Salomon, 1992). Near and far transfer is specified in six domains: knowledge domain, physical context, temporal context, functional context, social context and modality (Barnett & Ceci, 2002). These domains are important for applying transfer and understanding the outcomes of transfer research; however, they are often ignored in transfer of learning research.

Innovative hands-on simulations: authentic, self-directed and self-regulative

Specifically three constructivist learning environment characteristics are argued to be important for developing competencies and transfer; that is authentic learning, self-directed learning (SDL) and self-regulated learning (SRL) (Chapter 2, De Bruijn & Leeman, 2011; Geurts & Meijers, 2009; Kicken, Brand-Gruwel, & van Merriënboer, 2008; Van Bommel, Kwakman, & Boshuizen, 2012).

Authenticity in hands-on simulations has often been discussed. Several authors state that social dynamics of the real work community are not reflected in simulations and that students are not fully accountable for the outcomes of simulated learning (Barab, Squire, & Dueber, 2000; Cumming & Maxwell, 1999). Others view hands-on simulations as authentic since they include whole work-related tasks in a context directly derived from professional practice (Dieckmann, Gaba, & Rall, 2007; Jossberger, Brand-Gruwel, Boshuizen, & Van de Wiel, 2010). Important elements that stimulate authentic learning include not only realistic physical contexts that resemble the future profession, but also whole tasks and activities that are ill-defined, representative of real world professional tasks, and have real world relevance adapted to the level of the students (Herrington & Oliver, 2000; Van Merriënboer, 1997).

Constructivist learning involves processes in which the student constructs or gives meaning to a specific experience, usually put in motion by the student's active engagement (De Corte, Verschaffel, Entwistle, & Van Merriënboer, 2003). This cannot only be achieved by situating students in meaningful or authentic contexts, but also by stimulating SDL and SRL. In SDL environments, an important feature is offering students a certain amount of freedom of choice to pursue their learning goals (Loyens, Magda, & Rikers, 2008). Giving students control over what they want to learn increases students' motivation to take part in learning activities (Corbalan, Kester, & Van Merriënboer, 2006). SRL is located on the level of task performance. SRL stresses the importance of using personal strategies, such as planning and self-monitoring for successful performance (Zimmerman, 2001) as well as contextual factors, such as teachers stimulating students indirectly via modelling and directly via reflection exercises (Paris & Paris, 2001).

Based on literature we have provided an overview of concrete strategies for adding authentic learning, SDL and SRL to create innovative hands-on simulations with the aim of stimulating the development of competencies and transfer of professional competence (Table 5.1, see also Chapter 2).

We hypothesize that a hands-on simulation with added authenticity, self-direction and self-regulation fosters the development of students' competencies as well as near and far transfer of professional competence. Because previous studies have shown that learning environment characteristics affect learning outcomes *through* students' perceptions regarding these characteristics (Chapter 3), we expect positive students perceptions to mediate the relationship between learning environment and outcomes. The research questions are:

1) What is the influence of an authentic, self-directed and self- regulative hands-on simulation on higher vocational education students' competency development?
2) What is the influence of an authentic, self-directed and self-regulative hands-on simulation on higher vocational education students' near and far transfer of professional competence?
3) Is the effect of an authentic, self-directed and self-regulative hands-on simulation on student learning mediated by the students' perceptions regarding the learning environment?

This study will contribute to insights into the effects of these three constructivist learning principles in a work-related environment (i.e. hands-on simulation) that has been used and is still mostly used for 'traditional' learning. This study will also generate ideas about how teachers can effectively use hands-on simulations in an innovative curriculum that aims at learning outcomes such as generic competencies.

Method

Design and participants

The present study is a randomised control-group pretest-posttest design including additional post-tests for measuring transfer. In spring 2011, first-year Applied Biology students (N=115) from a University of Applied Sciences in The Netherlands, participated in the hands-on simulations. The students were randomly assigned to the traditional simulation (control group) or the innovative simulation (experimental group). The final complete sample consisted of 49 students in the control group (mean age 19.8, *SD* = 2.42, 49% men) and 45 students in the experimental group (mean age 19.02, *SD* =1.83, 64.4% men) (Figure 5.1).

Table 5.1 Strategies for Adding Authentic Learning, Self-directed Learning and Self-regulated Learning to Create Innovative Hands-on Simulations (see Chapter 2)

Stimulate authentic learning
- Work on whole tasks that integrate knowledge, skills and attitudes
- Adapt authenticity to the level of the student
- Include ill-defined problems in the tasks that require authentic cognitive processes
- Create a realistic physical context
- Take students' perceptions regarding authenticity into account

Give students more ownership of their learning

Self-directed learning
  - Create moments of choice for students
  - Let students choose what tasks to perform
  - Let students choose how to perform the tasks
  - Formulate progress goals (working towards accurate execution of the task) or let students formulate progress goals

Self-regulated learning

Teacher strategies for self-regulated learning
  - *Model and verbalise*: model desired behaviour and verbalise process steps, problem solving strategies and self-regulatory strategies
  - *Feedback*: provide immediate feedback and feedback on the whole task after the simulation
  - *Coach:* give students hints and cues
  - *Scaffold*: support students with help or additional materials or resources
  - *Fade**: decrease guidance and increase students' responsibility over time

Student strategies for self-regulated learning
  - Analyse observations and mistakes
  - Self-verbalise actions and regulatory strategies
  - Self-monitor performance and progress goals

*When time allows

Intervention

The aim of both simulations was to learn to conduct applied biology research skills in nature, this is the main task of students' future profession.

The students in the *traditional simulation* followed isolated thematic (e.g. amphibians, butterflies) sessions for five days. During these sessions, students were placed in the role of researcher and applied various methods of conducting research in nature through standardised assignments, instruction and incidental coaching of an expert teacher. The content and sequence of the sessions were pre-determined by the teachers and contained no self-directed or self-regulative moments. In the design, tasks and physical environment lacked some authenticity; the traditional simulation did not fully resemble the real work of a biology researcher because the tasks did not include research tasks like planning, reporting and sharing information. The learning environment was also less authentic because the sessions took place in various nature reserves. For example, the amphibians-sessions took place at a site where there were many frogs, and butterfly-sessions took place in a nature reserve where many sorts of butterflies could be found. While in reality, biologists conduct research in *one* specific nature reserve to find relations between flora and fauna instead of in various nature reserves.

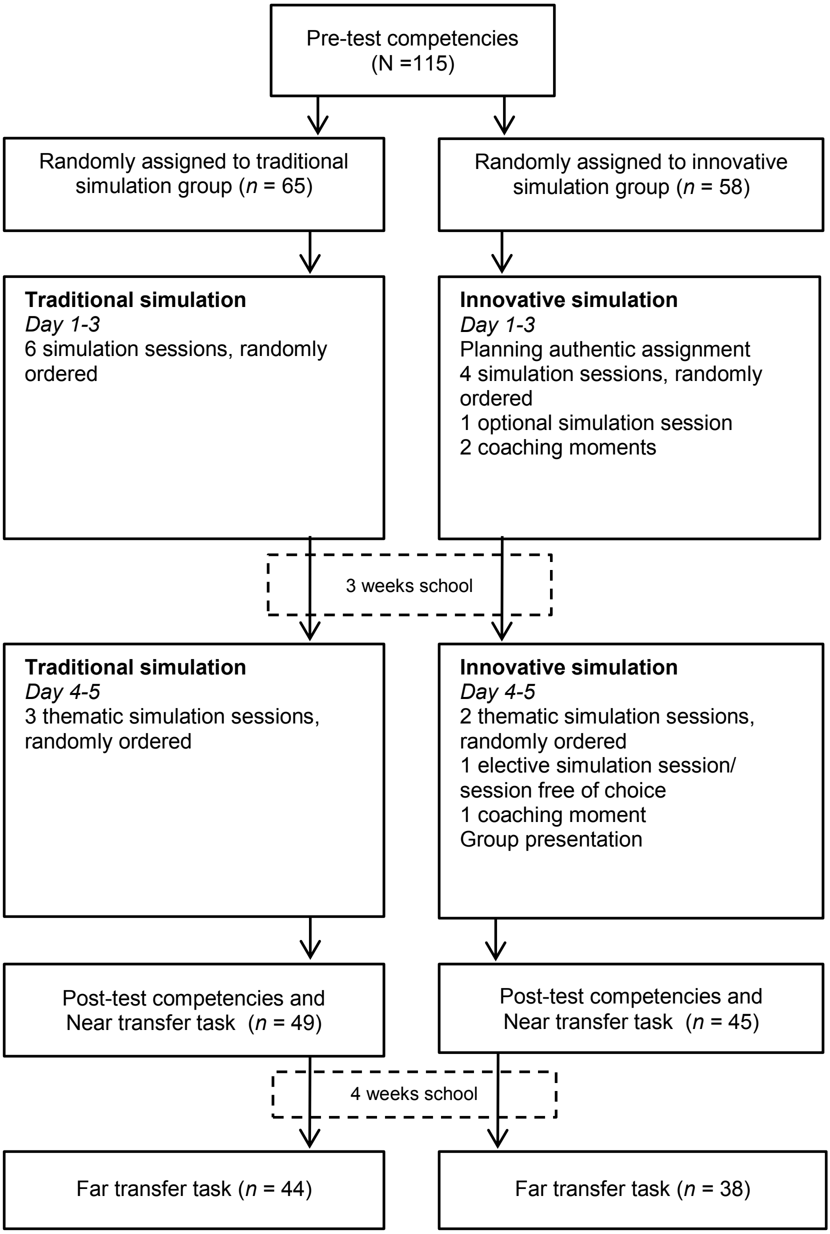

Figure 5.1 Study design.

An *innovative simulation* was designed by adding authenticity, SDL and SRL to the traditional simulation (Table 5.1). Authentic learning was added with a whole authentic task, which included ill-defined problem at the students' level and creating a realistic physical context (Gulikers, Bastiaens, & Kirschner, 2004; Van Merriënboer, 1997). The whole authentic task included answering a research question (e.g. What flora is present in the nature reserve and what is the impact on the wildlife?) in groups of four to five students by conducting research in a specific nature reserve. Thematic sessions were comparable to the traditional simulation, except that students had to apply their gained insights to their authentic assignment. The authentic assignment was completed with a presentation. With respect to SDL and SRL (Table 5.1), several moments of choice and coaching were planned: 1) students could choose the theme of the research; 2) during a number of thematic sessions, students were free to choose between two themes; 3) the first half of the fifth day was fully self-regulative (e.g. extra session, finishing authentic assignment) and 4) the design of the experimental simulation was characterised by structural coaching moments for stimulating SRL.

Data collection of learning outcomes

Competency measurement

Right before and immediately after the simulations, a self-report instrument measured a selection of six relevant competencies with multiple indicators for competencies (Competency Development Meter [COM]). The COM has shown appropriate face validity, construct validity, and robustness across vocational and higher education students under the circumstances that the competency constructs are concrete, such as 'applying expertise', and relevant to the specific learning situation (Chapter 4). Less concrete and less self-explanatory competencies, such as 'deciding and initiating', were not always valid and robust. To assure meaningful competency constructs, we conducted a Principle Component Analysis (PCA) with varimax rotation on the measured competency indicators before conducting the initial analysis.

Table 5.2 Parallel analysis (PA) for the Principle Component Analysis (PCA)

Component	PCA Eigenvalue	PA Eigenvalue*	Difference
1	11.04	2.19	8.85
2	3.02	1.97	1.05
3	2.21	1.85	0.36
4	1.85	1.73	0.12
5	1.71	1.62	0.09
6	1.21	1.52	-0.31

*Random data eigenvalues for 100 replications over 28 indicators and 94 participants.

For this study, competency development was estimated with 28 competency indicators from the COM that tap various competencies relevant for the simulation. Each indicator was rated by students on a 10-point scale (1-*not competent* to 10-*very competent*). The Kaiser-Meyer-Olkin measure confirmed the sampling adequacy for the analysis with KMO = .85. Barlett's test of sphericity $\mathcal{X}^2(351) = 2034.69$, $p > .001$, indicated that correlations between the 28 items were sufficiently large for PCA. The analysis resulted in six components with an eigenvalue over 1, which in combination explained 75.04% of the variance. The

Parallel Analysis (O'Connor, 2000) suggested five components (Table 5.2). Therefore, extraction was restricted to five components, explaining 68.71% of the total variance. The factor analysis resulted in the following five interpretable competency constructs: 'Applying expertise', 'Formulating & reporting', 'Presenting', 'Peer collaboration' and 'Using materials and equipment' (Table 5.3). Psychometric testing of the competency constructs resulted in high internal consistency (Cronbach's alpha values between .84 and .93).

Table 5.3 Structure Matrix Obtained by PCA After the Varimax Rotation on the 28 Competency Indicators (N= 94)

	Rotated Factor Loadings (Varimanx)				
Competency indicator	**Applying expertise**	**Peer collaboration**	**Formulating & reporting**	**Presenting**	**Using materials & equipment**
1. expertise skills	.877				
2. expertise knowledge	.827				
3. knowledge about equipment	.793				
4. choosing equipment	.776				
5. helping others with task	.749				
6. performing in unexpected situations	.733				
7. performing standard operations	.509				.440
8. preventing conflicts between others		.848			
9. helping peers with tasks		.766			
10. contributing to a good atmosphere		.748			
11. solving conflicts between others		.737			
12. contributing to group meetings		.726			
13. fulfilling tasks		.591			.497
14. giving others space to ask questions		.433			
15. formulating correct Dutch			.835		
16. formulating comprehensible			.795		
17. communicating message in a structured way			.702		
18. separating side issues from key issues			.634		
19. logical structure of message			.563	.458	
20. structured communication			.525		
21. fluent story telling				.883	
22. confident during presentation				.865	
23. lively story telling				.776	
24. maintaining equipment					.824
25. safe use of equipment					.817
26. having right materials available before starting	.476				.626
27. adapting style to recipient(s)				.482	
28. adapting formulation to recipient(s)			.547		

Note. All loadings > .40 are depicted; *Omitted from the analyses.

Near transfer measurement

Near transfer of professional competence of an applied biologist was tested with a final assignment, requiring students to describe a research setup for one out of four pre-determined research questions related to the simulation content (e.g. 'What factors affect the flora present in dead wood?') in a research report. For answering the research question, the students were required to use data collected during the simulation sessions. The transfer context of this test was *near* because it took place immediately after the simulation at the simulation centre, using data collected during this simulation; it was in the same knowledge domain as the simulation, and the same written format was used (Barnett & Ceci, 2002). Three teachers blindly corrected the assignments (score 1-10).

Far transfer measurement

The month after the simulations, the students finalised an authentic project. At school and together with a real client, the students conducted an applied research project. This transfer test was far on the domains of physical context (simulation vs working with a client at the workplace) and temporal context (weeks later) (Barnett & Ceci, 2002). The knowledge domain of the project was related to the simulation (biology), except that the theme of the project could differ (e.g. plants instead of butterflies). The functional, social and modality contexts did not significantly differ from the simulation context (Barnett & Ceci, 2002). The students' final research report was blindly corrected by a school teacher (score 1-10).

Data collection of perceived learning environment characteristics

Learning environment perceptions

Perceived authenticity and perceived choice were measured directly after the simulations.

Perceived authenticity. Students' perceived authenticity was measured via ten items of the Perceived Authenticity Questionnaire (Gulikers, 2006) on a five-point Likert-type scale of 1 (*strongly disagree*) to 5 (*strongly agree*). The questions covered perceived authenticity regarding physical context, tasks and social context of the simulation (e.g. 'The context of the simulation training reflected the professional practice of an applied biologist' and 'The tasks of the simulation training resembled the tasks of an applied biologist'). Internal consistency of the scale was Cronbach's $\alpha = .74$.

Perceived choice. We measured perceived freedom of choice with five items of the Perceived choice scale of the Intrinsic Motivation Inventory (e.g. 'I had little choice about what tasks I could perform', 1- *not true at all* to 7-*very true*) (Ryan & Deci, 2000). Cronbach's alpha for this scale was .71.

Observations

To examine whether the intervention was implemented as intended, two researchers performed non-participant observations on *the first and the last day* of both simulations. SDL and SRL were structurally observed using schemes based on the *Model of Powerful Learning Environments* (De Bruijn & Leeman, 2011). These schemes are designed to observe to what extent teachers use strategies for stimulating SDL and SRL and students use of SDL and SRL strategies. The observation scheme also includes observation categories about the extent to which teachers use traditional guidance activities (e.g. decontextualized learning, direct instruction) and students show traditional learning behaviour (e.g. memorising).

For each simulation, four session units were observed during two full days (see Chapter 6 for a detailed description of the observations process and reliability and validity of the research process). The behaviours were observed as an *event* (Winne & Perry, 2000), meaning that SDL, SRL or traditional behaviour was ticked off in the observation scheme when it occurred. Also, notes regarding the duration of the behaviours and examples of behaviours were written down. During the observations, one researcher observed the teacher and the other observed a group of students that was representative of the whole group.

At the end of each day and after both simulations, the researchers had peer-debriefing meetings that took approximately one hour to discuss all observed teacher and student behaviours extensively to decrease subjectivity of the observations. Also, the researchers critically discussed whether the authentic task was implemented as intended to check the authentic design of the intervention. The observation data for both hands-on simulations were placed in an Excel sheet.

Analyses

A repeated measure MANOVA was conducted to examine whether the two groups differed on their competency development. MANOVAs were performed to test whether the groups differed on their near and far transfer scores and on their perceptions regarding the learning environment. For the analyses, we used SPSS version 19 and a significance level of .05. The mediation analyses to answer the third question was conducted using bootstrapping analyses with the PROCESS macros for SPSS according to Preacher, Rucker and Hayes (2007). Significance of the mediated effect (i.e. *indirect effect*) was determined by accelerated confidence intervals (BCa CI). When zero was not included in the lower and higher bound of the bias-corrected and BCa CI, the indirect effect was significant. The amounts of bootstrap were 5000, and BCa CI was 95%.

Analysis of observation data focused on what and how much behaviour teachers and students showed that was related to the SDL, SRL and traditional behaviours. Presence or absence of behaviours was counted across session units per simulation. Based on these occurrence ratings, proportions of observed teacher and student behaviour were calculated (%

occurrence of the behaviours across session units of each simulation), placed in an overview and compared. Notes regarding SDL and SRL behaviours were collected and selected by the first author to provide a description of concrete SDL and SRL behaviours in both simulations.

Results

RQ 1: What is the influence of an authentic, self-directed and self- regulative hands-on simulation on higher vocational education students' competency development?

The repeated measures MANOVA results showed that the students scored significantly higher on the post-test compared to the pre-test $F(5,88)= 13.33$, $p <.001$, $\eta^2= .43$. Univariate tests also indicated that there was an effect of time on the competencies 'applying expertise' $F(1,92) = 47.8$, $p <.001$, $\eta^2= .34$, 'Formulating & reporting', $F(1,92) = 24.21$, $p <.001$, $\eta^2= .21$, 'Presenting' $F(1,92) = 20.61$, $p < .001$, $\eta^2= .18$ and 'Using materials and equipment' $F(1,92) = 11.16$, $p < .01$, $\eta^2= .11$. However, time did not affect 'Peer collaboration' significantly $F(1,92) = 2.99$, $p = .09$, $\eta^2= .01$ (see Table 5.4 for descriptive statistics).

There was no time-by-intervention interaction for the competency measures, meaning that statistically, both groups equally gained competencies over time, $F(5,88)= 0.47$, $p = .78$, $\eta^2= .03$.

Table 5.4 Descriptive Statistics

	Traditional simulation group				Innovative simulation group			
	Pre-test		Post-test		Pre-test		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Competency								
Applying expertise	6.27	1.22	7.06	0.97	6.16	1.01	6.85	0.80
Peer collaboration	7.32	1.13	7.40	1.02	7.12	1.05	7.34	1.21
Formulating & reporting	6.64	1.02	6.94	0.95	6.42	.96	6.85	0.78
Presenting	6.29	1.37	6.61	1.62	6.20	1.49	6.78	1.22
Using materials & equipment	7.14	1.29	7.71	0.91	7.09	1.13	7.33	0.88
Near transfer test			6.98	0.93			6.98	0.88
Far transfer test			7.09	0.72			6.65	0.76
Perceived learning environment								
Perceived authenticity			3.78	0.33			3.61	0.41
Perceived choice			4.16	0.85			4.23	0.87

RQ 2: What is the influence of an authentic, self-directed and self-regulative hands-on simulation on higher vocational education students' near and far transfer of professional competence?

Using Hotelling's trace statistic, the MANOVA test showed that there was a significant effect of intervention on the transfer outcomes, $T= 0.9$, $F(2, 79)= 3.56$, $p < .05$, $\eta^2= .08$. Separate univariate ANOVAs on the transfer measurements, however, revealed a non-significant intervention effect on the near transfer test $F(1, 80)= 0.06$, $p = .81$, $\eta^2= .001$, and a significant intervention effect on the far transfer test $F(1, 80)= 7.12$, $p < .01$, $\eta^2= .08$ with a lower score for the innovative simulation group (*M* = 6.65, *SD* = 0.76) compared to the traditional simulation group (*M*= 7.09, *SD* = 0.72).

RQ 3: Is the effect of an authentic, self-directed and self-regulative hands-on simulation on student learning mediated by the students' perceptions regarding the learning environment?

Using Hotelling's trace statistic, the MANOVA test showed that there was a significant difference between the groups in the way they perceived the simulations, T= 0.7, $F(2, 91)$= 3.12, $p < .05$, η^2= .06. Separate univariate ANOVAs on the perceived learning environment variables showed a significant intervention effect on Perceived authenticity $F(1, 92)$= 5.23, $p <$ .05, η^2= .05, with a lower score for the innovative simulation group (*M* = 3.61, *SD* = 0.41) compared to the traditional simulation group (*M*= 3.78, *SD* = 0.33). Perceived choice did not significantly differ between groups $F(1, 92)$= 0.13, p = .72, η^2= .001.

Because competency development scores, the near transfer scores and perceived choice did not differ between groups, only the mediation effect of perceived authenticity was tested for the relationship between intervention and the far transfer scores.

Combining the direct and indirect effects; the *total effect* of intervention on perceived authenticity and far transfer was -0.436 ($p < .01$). The *direct effect* for the relationship between intervention and far transfer remained significant after including perceived authenticity as a mediator (-0.474, $p < .01$). The bootstrap results indicated that there was no statistically significant *indirect effect* (effect size 0.038, 95% BCa CI between -0.015 and 0.160), meaning that perceived authenticity was not a mediator in the relationship between intervention and far transfer since the confidence intervals contained zero.

Observations

As shown in the observations, the implementation of the innovative simulation (i.e. adding authenticity, SDL and SRL) was successful to some extent.

The researchers agreed that the innovative simulation was more authentic regarding the task and the physical context than the traditional simulation. The thematic sessions (e.g. simulating conducting research about flora, amphibians and insects) that were offered in both simulations were related to the professional tasks of an applied biologist. Students in the innovative simulation also worked on an integrated research project related to the professional tasks of an applied biologist and collected data in one specific nature reserve, in line with the real work context of an applied biologist. Therefore, the innovative simulation was more authentic compared to the traditional simulation in which the students only participated in isolated thematic sessions and collected data in various nature reserves.

Table 5.5 shows that there was slightly more SDL and SRL behaviour observed in the innovative simulation: the teacher offered students more choices by including elective sessions and letting students choose the theme of their authentic task, and the students set goals by planning their authentic assignment. In the traditional simulation, there was one moment when the teacher gave the students freedom to choose how to perform the task but this was not a planned action and did not include setting learning goals for the students. A closer look at the teachers' guidance strategies to stimulate SRL and SRL strategies used by the students reveals that the innovative simulation was not entirely implemented as planned. Table 5 shows that the teachers' powerful guidance strategies for SRL 'verbalisation', 'coaching', 'scaffolding' and 'progress feedback' were offered to the same extent in both simulations, while the innovative simulation was designed to include more of these guiding strategies than the traditional simulation. Mainly during the moments of choice and the coaching moments in the innovative simulation, the teachers had the tendency to distance themselves from the students instead of using techniques to stimulate SRL, such as scaffolding and coaching.

Table 5.5 Results of Observation Regarding Learning Strategies Used by Teachers and Students in the Traditional and the Innovative Simulation Group.

		Traditional simulation	Innovative simulation
SDL			
Teacher guidance	Offering choices	25% (1/4)	50% (2/4)
Student learning	Goal setting	0% (0/4)	25% (1/4)
SRL			
Teacher guidance	Modelling	75% (3/4)	25% (1/4)
	Verbalisation	50% (2/4)	50% (2/4)
	Attributional feedback	0% (0/4)	25% (1/4)
	Coaching	50% (2/4)	50% (2/4)
	Scaffolding	50% (2/4)	50% (2/4)
	Progress feedback	25% (1/4)	25% (1/4)
	Evaluation	25% (1/4)	50% (2/4)
Student learning	Proposing methods for task completion	25% (1/4)	75% (3/4)
	Asking for feedback	0% (0/4)	0% (0/4)
	Self-verbalisation	0% (0/4)	0% (0/4)
	Help seeking	100% (4/4)	75% (1/4)
Traditional learning			
Teacher guidance	Instruction	100% (4/4)	75% (3/4)
	Memorising	100% (4/4)	25% (1/4)
Student learning	Rehearsing	100% (4/4)	50% (2/4)

Note. Proportion of SDL and SRL behaviour (%) was calculated using occurrences of observed behaviour across session units for each simulation (between brackets).

Also, there was no marked difference in SRL strategies used by the students. The amount of asking for feedback, self-verbalisation and help-seeking behaviour was almost the same for both groups. The only clear difference between the two simulations was that students in the innovative simulation were more active in proposing methods for fulfilling the task; they more actively planned out how to complete the task and what sources they needed for completion. The observations also showed that the students in the traditional simulation received more traditional guidance in the form of instruction, such as PowerPoint presentations or one-to-one instruction during task performance. During these instruction moments, the teacher asked the students many questions, which made the students memorise the subject matter. Also, the students in the traditional simulation more often rehearsed tasks such as rehearsing techniques that are not easy to master.

In sum, regarding authenticity the implementation was as intended. There were not many differences between the simulations regarding the teachers' guiding strategies for SDL and SRL and the observed SRL student behaviour. Both groups received almost the same amount of guidance for SRL, while the students in the control group received more traditional guidance, and thus more guidance in general.

Conclusions and discussion

The results of this study show that higher vocational education students gained competencies (except for peer collaboration) through participating in a hands-on simulation. Contrary to our expectations, adding authenticity, self-directed learning and self-regulation did not lead to more competency development in the innovative simulation group compared to the traditional simulation group. More surprisingly, the students scored equally on the near transfer test, but students in the traditional simulation scored higher on the far transfer task and perceived the simulation to be more authentic than students in the innovative simulation. Several explanations are suggested for the findings.

Students' perception scores and observations show that the implementation of the innovation was not entirely executed as planned. Students in the innovative simulation did not perceive more free choice than students in the traditional simulation, although free choice moments were explicitly planned and observations show that SRL components on both the teacher and the student side were lacking. Students in the traditional simulation received more instruction and guidance from the teacher than students in the innovative simulation. The effect of guidance should not be underestimated because the absence of appropriate teacher guidance in a SDL and SRL environments can lead to less motivation and student learning (Katz & Assor, 2007). This directly relates to the debate about the right balance between instruction and unguided-learning (Kirschner, Sweller, & Clark, 2006).

Several researchers claim that direct instruction leads to passive learning and that decreasing guidance leads to meaningful learning and transfer (e.g. Schwartz, Chase, Oppezzo, & Chin, 2011); others have demonstrated that explicit instruction fosters performance as well as transfer (e.g. Lorch Jr et al., 2010). In case of hands-on simulations, including more direct instruction in the sessions is not necessarily a disadvantage. Also, when introducing SDL and SRL, a change in study approach by students is essential. Previous research has shown that innovative learning environments do not automatically lead to a change in study strategies, such as monitoring and effort management, necessary for developing more generic competencies and professional competence (Baeten, Struyven, & Dochy, 2013). Gradually implementing forms of innovative learning in higher vocational education is therefore preferred (Taks, 2003). In our study, the students were in their first year of their higher vocational education programme and might not have been familiar with study approaches for SDL and SRL.

An explanation for the finding that the intervention did not affect near transfer while it did (negatively) affect far transfer can be found in the transfer measurements of professional competence. Professional competence is more than showing different kinds of isolated competencies; it is the ability to think, feel and act like a professional (Epstein & Hundert, 2002). Because of practical and time limitations, the near transfer test was a written case task, whereas the students in the far transfer test actually had to perform the task in practice. Although written assessment formats can capture 'know-how' and can be quite good predictors of professional competence (Van der Vleuten, Schuwirth, Scheele, Driessen, & Hodges, 2010), there is a possibility that the far transfer task, in which the student actually 'showed-how', better captured the professional competence of an applied biologist.

Unlike expected, the innovative simulation was perceived as less authentic than the traditional simulation. There was clearly a mismatch between students', teachers' and researchers' ideas about what an authentic whole task and authentic physical context should look like. The innovative simulation was less authentic to the students, probably because they had another vision of their future profession. The students visualise the profession of an applied biologist as exciting (e.g. frequently finding extraordinary species) and varied all the time (e.g. moving from one nature reserve to another), corresponding with what happened in the traditional simulation. They did not take into account that some aspects of the innovative simulation, such as planning and presenting research, are also important aspects of the profession. This discrepancy may have caused (parts of) the implementation to be interpreted or used in a different way than intended (Könings, Seidel, & van Merriënboer, 2014). The framework for designing innovative simulations includes integrating student perceptions regarding authenticity in the design process of the simulation (See Chapter 2, 3, and Table 5.1). Apparently, this design feature is crucial and when students' perceptions are not well integrated in the design, this is reflected in students' perceived authenticity.

We also hypothesized that students' perceived authenticity mediates the relationship between the learning environment and learning outcome, but we were not able to confirm this hypothesis. There is a reasonable explanation for this finding. Because far transfer was the only learning outcome that differed between groups, we were restricted to only use the far transfer scores in the mediation analysis. However, the far transfer test was the direct result of an authentic project, which had its own authenticity. It is likely that the students' perceived authenticity of the project overruled the mediation effect of perceptions regarding the simulation.

To conclude, innovative education based on the constructivist learning theory emphasizes the importance of authenticity, SDL and SRL. The present study has shown that implementing these learning environment characteristics is not automatically successful. For learning in a work-related environment that is self-directed and requires students use strategies for self-regulating their learning, teachers as well as students do not yet have the right skills and tools. And when the teachers wish to expand the authenticity of the simulation, a prerequisite is that they engage students in the design process. At the moment that these aspects are realised, more (quasi) - experimental research can further investigate the effect of innovative work-related learning environments, such as hands-on simulations, on students' perceptions, competency development and professional competence development.

Chapter 6

Occurrences and quality of teacher and student strategies for self-regulated learning in hands-on simulations[5]

The aim of chapter is to examine how ownership of learning, an important constructivist learning environment characteristic, is expressed in hands-on simulations. The three phases of self-regulated learning (SRL) of Zimmerman (2001) and Schunk (2001) functioned as the theoretical framework. Via structured observations of teachers' promoting SRL strategies and students' SRL strategies in eight hands-on simulations, this study is the first to expose whether students and teachers use SRL in hands-on simulations, what these strategies look like and what their quality is. The results show that both students and teachers demonstrate SRL behaviour in the forethought, performance and reflection phase to some extent, but that they vary considerably in their occurrences, form and quality. For instance, teacher strategies 'modelling' and 'scaffolding' were often used, while 'giving attribution feedback' and 'evaluation' were lacking. The student strategy 'proposing methods for task performance' was used regularly, while 'goal-setting' and 'self-monitoring' were often absent. This chapter concludes with an overview showing exemplary teacher and student behaviour in the *SRL phases* with lower, medium and higher quality and an overview with exemplary teacher and student behaviour in simulations with lower, medium and higher *overall* quality.

[5] This chapter is based on: Khaled. A., Gulikers, J. Biemans, H, & Mulder, M. (2014). Occurrences and quality of teacher and student strategies for self-regulated learning in hands-on simulations. *Studies in Continuing Education.* Accepted with minor revisions.

Constructivist learning and ownership of learning

The ultimate aim of vocational education is to develop profession-specific skills and more general competencies to prepare students for their role as professionals capable of performing their job, continue to develop their competencies and are able to anticipate future developments in their professional field (Biemans et al., 2009). This requires practice and professional experience, learning how to deal with complex situations; moreover, it requires students to become independent and self-directed thinkers (Beckett & Hager, 2013; Candy, Crebert, & O'leary, 1994; Van Merriënboer, Kirschner, Paas, Sloep, & Caniëls, 2009). Many innovations in vocational education introduce constructivist learning environments to foster new learning outcomes, such as competencies or improved transfer of learning to the workplace (De Bruijn & Leeman, 2011). They stimulate active participation of students towards deeper learning necessary for competence development (Baeten, Struyven, & Dochy, 2013) and for building relationships between pieces of knowledge, skills and attitudes necessary for transferring classroom learning to the workplace (Baartman & De Bruijn, 2011). Active learning requires students to take agency or ownership of their own learning (Boekaerts, 1999; Zimmerman, 1990). In active learning, students can take control over their own learning by planning, monitoring and managing their learning (Pintrich, 1995; Winne & Hadwin, 1998; Zimmerman, 2001). This can occur in the forms of self-controlling how long a student wants to work on a task, choosing whether or not to restudy a task, choosing what information to study or choosing what task to work on (Kostons, Van Gog, & Paas, 2012).

This chapter examines whether and how hands-on simulations indeed promote the use of strategies for taking ownership of learning, based on the idea that if hand-on simulations actually succeed in promoting these strategies, they in turn foster competence development and transfer from training to job. Since students often encounter workplace contexts for the first time in a hands-on simulation, these learning environments are the perfect place to experiment with guiding their own learning as required in the real work place.

Up till now, most empirical studies on ownership of learning have been conducted in primary, secondary and academic educational contexts, and very little research on this topic has been conducted in vocational education contexts (Berger, 2012), especially not in hands-on simulations. Very little has been reported about how teachers give students opportunities to gain ownership of their learning and weather students show behaviour that shows that they are taking control of their learning. More insight into these processes is required before we can study whether and how taking ownership of learning affects performance in hands-on simulations and helps to foster competence development (Jossberger, Brand-Gruwel, Boshuizen, & Van de Wiel, 2010). Yet some studies regarding ownership of learning in hands-on simulations were found.

Ownership of learning in hands-on simulations

The main challenge for teachers is to create a balance between teacher guidance and students' self-control in hands-on simulations. Jossberger, Boshuizen and Brand-Gruwel (2011) found that students feel the need for teachers to be constantly present during hands-on simulations and guide their learning closely. At the same time, teachers feel that it is difficult to be constantly around since students do not always work in one room during the simulation. Jossberger et al. (2011) also found that important activities for gaining ownership of learning, such as choosing what task to perform, planning and reflection, were poorly integrated in various hands-on simulations across different vocational educational programmes, while one of the most important requirements of the simulations in their study was self-regulated performance of professional tasks.

In clinical education, a first step in empirical research on students' ownership of learning in hands-on simulations has been taken. The studies by Brydges et al. (2009; 2010) show that hands-on simulations can be appropriate learning settings for self-controlling one's learning with the aim of improving clinical technical skills, but also show that teacher guidance is needed to some extent. Brydges et al. (2009; 2010) examined clinical simulations in which they compared teacher-structured simulations to simulations in which students have more ownership of learning. Brydges showed that the latter resulted in better clinical performance, but only when the students worked on progress goals and when their learning was being monitored. Medical students who had clear progress goals to work on were capable of self-guiding their access to instruction in hands-on simulations (Brydges 2009). This self-guidance had a positive effect on learning compared to hands-on simulations in which the instruction was externally controlled.

However, the studies described took place in more controlled research settings and mainly in the medical and nursing domains. No empirical studies on ownership of learning in hands-on simulations in other domains and related to other learning outcomes, such as more general competencies, were found. The present study uses structured and theoretically grounded observations to examine whether and how teachers promote ownership of learning and whether and how students use strategies that show they are taking ownership of their own learning in hands-on simulations across various domains in the life-sciences that all aim at competence development.

Theoretical framework

As described in Chapter 2, ownership of learning involves two processes: self-directed learning and self-regulated learning. Though both concepts include similar learning processes, such as active engagement, goal directed behaviour and self-reflection; self-directed and self-regulated learning are not completely identical to each other. The main difference between both is that in a self-directed learning environment the students—and not the teacher—define the learning tasks, while during the process of self-regulated learning also the teacher *can* determine the learning content as the students show self-regulated learning strategies, such as planning and monitoring, to control their learning processes during task performance (Loyens, Magda, & Rikers, 2008). Hence, self-directed learning may include self-regulated learning but self-regulated learning does not have to go together with self-directed learning. We chose to examine both concepts in simulations; after all, we do not know whether students are able to define their tasks in today's hands-on simulations. The theoretical framework of Zimmermann (2001) and Schunk (2001) was used for this study. This framework describes sub-processes in three phases: forethought, performance control and self-reflection. Both students and teachers should conduct certain strategies to facilitate these three phases. This framework is initially embedded in the self-regulated learning theory; however, the first (forethought) phase can theoretically be seen as a phase for self-directed learning as long as the students choose their own learning task during that phase. For readability of the text we will refer to the processes of self-regulated learning (SRL) from now on.

Forethought

A main feature of SRL is that the learning environments offer students a certain amount of *freedom of choice* to pursue their learning goals (Loyens et al., 2008), because giving students control over what they want to learn increases students' motivation to take part in learning activities (Corbalan, Kester, & Van Merriënboer, 2006). In the forethought phase, therefore, teachers give students an amount of freedom to choose and students decide on fulfilling the upcoming tasks while teachers help students to direct their learning. Typical activities that activate SRL in the forethought phase are *goal setting* and *social modelling* (Schunk, 2001). Students create realistic goals, plan how they are going to achieve these goals and what resources they need for successful completion. When students set goals for themselves, an increase of motivation, effort, persistence, as well as better performance is more likely (Hattie, 2009; Pintrich, 2000). In this phase, teachers can motivate students by acting as a model, for example during instruction, so that students can observe desired behaviour. When students know how they can succeed, they feel more motivated to proceed (Schunk, 2001).

Performance control

During the performance phase, students are actively involved in executing the learning task and may ask themselves questions such as: 'Am I following my plan correctly?', 'Am I being distracted?' and 'What strategies can I use to help me keep working?' (Moos & Ringdal, 2012). A strategy for self-regulated students in this phase is *help-seeking* and *asking for feedback*; self-regulated students know when and how to find the appropriate resources for help or further instruction (Brookfield, 2009; Hattie, 2009; Pintrich, 2000). Explicitly verbalising steps in problem-solving and how to proceed (*self-verbalisation)* has shown to be an effective strategy for self-guiding their learning, especially for students in the early and intermediate phase of skills acquisition (Hattie, 2009). Likewise, teachers who verbalise their thinking, for example choices that they make during problem-solving, foster SRL (Collins, Brown, & Holum, 1991; Lunenberg, Korthagen, & Swennen, 2007). During task performance, teachers should *coach* individuals or groups while performing a task by giving hints and cues and support them with help or additional materials or resources (*scaffolding*) (Collins, Brown, & Hollum, 1991). Another important stimulator of SRL is *attributional feedback*. Teachers who link prior achievements to the students' effort ('You're good at this, you have been working hard.') increase students' self-efficacy, motivation and achievement during task performance (Schunk, 2001), which in turn can stimulate competency development (Baeten, Kyndt, Struyven, & Dochy, 2010).

Self-reflection

In the self-reflection phase students stop, look back on their actions and performance and assess whether they met their intended learning goals. For this, students need to be able to accurately estimate their competence. S*elf-monitoring* (keeping track of the learning process) and *self-evaluation* (judging one's performance) are essential strategies in this phase. Teachers can help students to gain insight into their abilities and help them with their self-judgement by providing *feedback on their progress* ('You are doing well because you applied the steps in order') (Schunk, 2001). With feedback on behaviour and progress, students can adapt strategies for better performance in the subsequent session or in another work-based learning context. High quality feedback has repeatedly shown to be an effective stimulant for SRL (e.g. Hattie & Timperley, 2007). Feedback on performance improves students' judgement about their performance, and the judgements that students make can influence their direct performance and their SRL process (Stone, 2000). Moreover, making students aware of the gap between current and desired performance helps them to increase motivation and self-esteem, which in turn improves self-regulation (Nicol & MacFarlane-Dick, 2006).

In sum, because competence-based education is implemented in the Netherlands and increasing attention is paid to its principles, one might assume that also teachers in hands-on simulations might have picked up these principles and introduced them, to at least some extent, in hands-on simulations. However, empirical evidence is lacking regarding ownership of learning in hands-on simulations. To examine this we used the theoretical framework of SRL including subs-processes of SRL in three phases (Zimmermann, 2001; Schunk, 2001). Most of the existing research defines self-regulating learning as an aptitude or personal characteristic (i.e. ability to be self-regulative) and mostly rely on survey methods to investigate SRL rather than investigating what students and teachers *actually do* to stimulate SRL in a specific educational context (Patrick & Middleton, 2002; Perry, 2002). This chapter aims to gain insight into the occurrences and quality of SR, and precisely what this looks like hands-on simulations.

Insights into the occurrence and quality of SRL strategies in hands-on simulations will provide implications for teachers on how to better facilitate SRL during the three phases. Also, this study will set the stage for further research on the effect that SRL hands-on simulations have on learning outcomes, such as professional competence. The research questions guiding this chapter are:

1) To what extent do teachers show the various types of behaviour for promoting self-regulated learning in hands-on simulations?
2) To what extent do students show the various types of self-regulated learning behaviour in hands-on simulations?
3) What is the quality of the teachers' strategies that promote self-regulated learning and the students' self-regulated learning strategies in the three phases, and how do teachers' and students' self-regulated learning behaviours look in the three phases with lower, medium and higher quality?
4) What types of behaviour do teachers and students show in hands-on simulations with lower, medium and higher *overall* self-regulated learning quality?

Method

From 2010 to 2012, eight hands-on simulations—as part of vocational education curricula in the life-sciences—were observed as they are, in their *naturalistic setting*, without interference or interventions from researchers. To obtain a variation of hands-on simulations, a set of eight simulations was selected representing different vocational educational levels and domains in the life-sciences. A precondition for selection was that a simulation had to last at least two full days because SRL activities are more likely to occur in longer-lasting simulations.

Participants

Data was collected from secondary vocational education students, higher vocational education students and their expert teachers. With the implementation of competence-based education in the Netherlands, it could be expected that the participants were exposed to SRL in some form throughout the curriculum. However, this was not identified, nor controlled for, beforehand. Each simulation was instructed and guided by a main expert teacher and was usually supported by other teachers who were experts in the field of the specific subject-matter. The teachers followed courses for coaching and guiding students, but were not specifically educated in stimulating SRL. Table 6.1 gives an overview of the domains, main tasks, duration, educational levels and distribution of students across the eight hands-on simulations.

Table 6.1 Overview of the Hands-on Simulations Included in this Study

Domain	**Main tasks**	**Duration (Half days)**	**Level**	**Year**	***n***	**Gender (% Male)**	**Mean age (*SD*)**
Engineering Technology	Analysing malfunctions in the transmission system of a tractor, adjusting the transmissions system of a tractor, repairing transmission systems of a tractor	10	MBO 3	1	8	100%	20.71 (1.70)
Engineering Technology	Maintenance of hydraulic systems and troubleshooting of hydraulic systems in tractors	6	MBO 3	Mixed	7	100%	22.86 (6.72)
Engineering Technology	Diagnosing electronic systems in tractors, diagnosing and adjusting motor systems	8	MBO 2	2	4	100%	18.50 (1.29)
Animal Husbandry	Organising a concourse hip pique, managing a horse stable	38	HBO	1	18	0%	18.79 (1.44)
Pigs, Poultry & Animal husbandry	Identifying, analysing and guiding breeding processes of various animals (pigs, rodents, reptiles)	8	MBO 3	1	18	22.2%	17.16 (0.69)
Retail	Applying various skills of a florist, such as decorating a shop window, wrapping gifts and sales techniques	14	MBO 4	1	8	0%	19.29 (8.30)
Retail	Developing a corporate identity, decorating a shop window and furnishing a retail space for a florist	8	HBO	2	13	7.7%	24.16 (9.60)
Rural Environmental Development	Conducting applied research on various flora and fauna in nature reserves	9	HBO	1	51	51%	19.80 (2.42)

Note. See Chapter 1 page 12. for an illustration of the Dutch educational system.

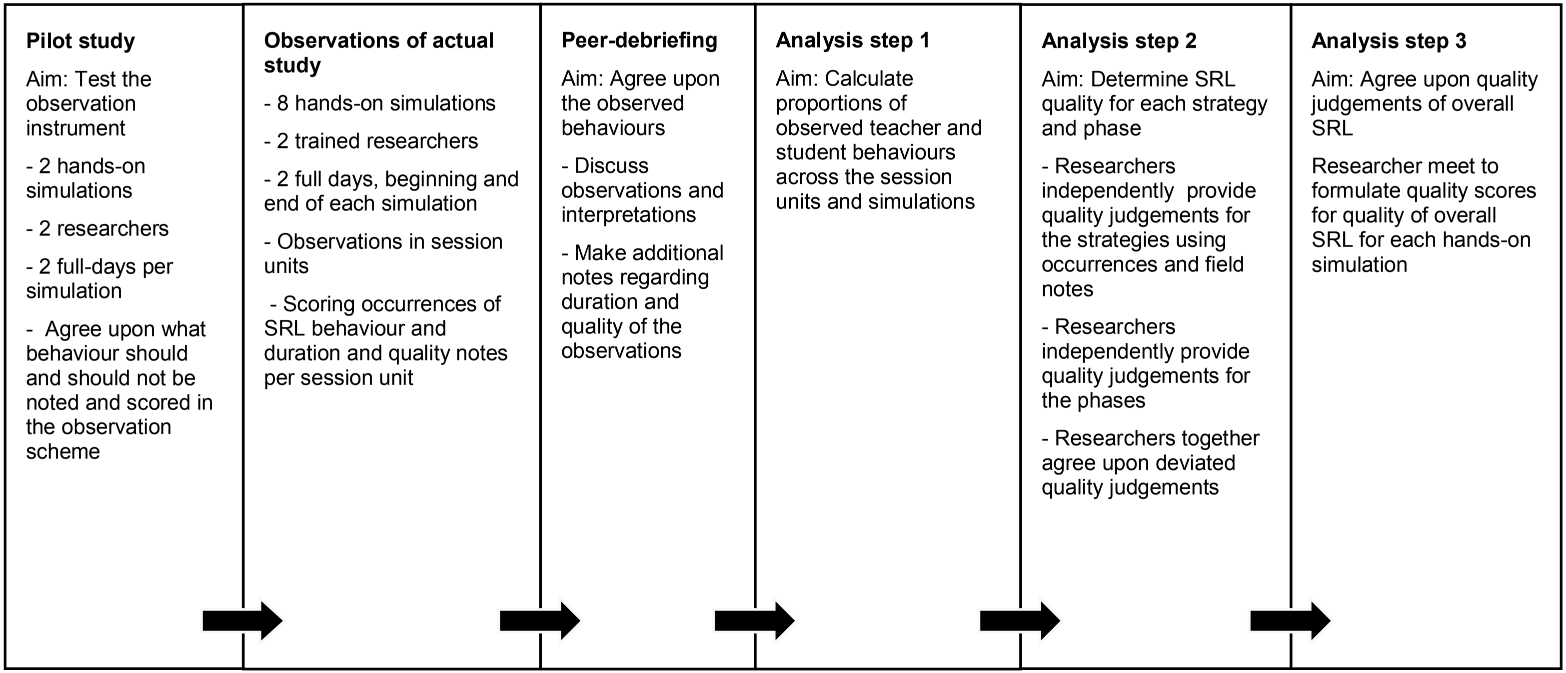

Figure 6.1 Research process.

Data collection

Figure 6.1 summarises the research process. Two researchers performed non-participant observations for two full days per hands-on simulation. The teachers as well as the students did not receive any instruction about SRL and were not informed about the aim of the observations; they were told that the researchers observed the learning situation as it occurred in practice. The observations were conducted using the validated observation schemes for *Powerful Vocational Learning Environments* (De Bruijn & Leeman, 2011; De Bruijn et al., 2005). The observation schemes consisted of detailed, visible student and teacher activities and behaviour. The student and teacher observation schemes included: 1) powerful SRL strategies; 2) descriptions of concrete behaviour per strategy; 3) room for noting how many times the behaviour occurred and 4) room for noting down examples of observed behaviour (see Appendix 6.1).

The observations were conducted on the first and the last day of each simulation to ensure that the three phases of self-regulation were covered in the observations. SRL was observed as an event (Winne & Perry, 2000), meaning that a certain student SRL behaviour and SRL promoting teacher behaviour was ticked off in the observation scheme when it occurred. Also, notes regarding the duration of the behaviours and many examples of behaviours were written down. Observations were conducted in session units; when the students transferred to another task, a new observation unit started. Thus, for each simulation, multiple session units were observed during two full days.

During the sessions, one researcher focussed her observations on the main teacher; this was a different teacher for each simulation. The other researcher followed a specific group of 3-4 students on whom (s)he focussed the observations during all sessions. At the end of each day, the researchers had a peer-debriefing approximately one hour to discuss all observed teacher and student behaviours extensively. During these debriefing moments, the researchers made additional notes regarding duration and quality of observed behaviours across all session units to increase thickness of the data and decrease subjectivity of the observations. Lastly, the data for each hands-on simulation were placed in an Excel sheet, ordered per SRL strategy and session units (see Appendix 6.1 for an example).

Analysis

Analysis of the data was performed in three steps (Figure 6.1). The first focused on how much behaviour the teachers and students showed related to the various SRL strategies. Presence or absence of the behaviours was counted across the session units per simulation. Based on these occurrence ratings, proportions of observed teacher behaviour and student behaviour were calculated (% occurrence of the behaviours across session units of each simulation and mean % of occurrences across the eight simulations), and placed in an overview.

Next, the quality of SRL for each *phase* and the *overall* simulation was analysed. First, a quality score of SRL *per phase* was attributed. To set a baseline, all strategies for each simulation were given a quality score based on the proportions of observed behaviour per strategy (0-25%= - , 25-50% = +/- , 50-75%= +, 75- 100%= ++; see Table 6.2). To achieve a quality judgement for the phases, two researchers first independently reviewed teachers' SRL promoting strategies and student SRL strategies, using qualitative field notes and peer-debriefing notes. Then, the researchers independently gave a quality score to the SRL phases. These quality judgements (- low, +/- medium, + high or ++ very high) were based on observation and debriefing notes about whether the observed behaviour was related to the theoretical framework in combination with observation and debriefing notes about the duration of a specific behaviour:

1) When the SRL behaviour occurred only very briefly (e.g. evaluation after simulation lasted five minutes) and the behaviour was not good according to the theory (e.g. the teacher only asks the students whether they have learnt something without further interaction with them), a lower quality judgement was given. When the SRL behaviour lasted longer and was of good quality (e.g. evaluations lasted a whole hour and teachers gave each student progress feedback), a higher quality score was given.
2) When SRL behaviour was short but was of very good quality (e.g. requesting the teachers' help in finding a fault in the motor), high scores were given for help-seeking. When the SRL behaviour lasted longer but was of poor quality (e.g. constantly asking the teacher where to find the hammer), lower quality judgement were given for help-seeking.

After that, the two researchers met for a face-to-face meeting in which they agreed upon deviated quality judgements regarding the phases. Lastly, the two researchers interpreted the quality of SRL in the phases and the simulations as a whole. Simulations that scored low, medium and high for *overall SRL* were identified in dialogue and described in concrete student and teacher behaviour by the first author using field and peer-debriefing notes.

Reliability and validity

This section describes how the reliability and validity of the data collection and analysis in this study were assured following Poortman and Schildkamp (2012).

Reliability was firstly assured by using instruments and a data collection method is consistent with the theoretical framework of SRL and the research questions. Secondly, a systematic approach to data collection was used. All 16 observations were conducted according to the same protocol: 1) all simulations were observed at the beginning and at the end; 2) standardised observation schemes were used in the eight simulations and 3) at the end of each observation day, observation data were discussed in peer-debriefings to minimise subjective interpretations of the observations. Thirdly, the researchers avoided influencing the behaviour of the observed students by placing themselves in the corner of the room or by standing at a distance from the students. Also, students were informed that the observations could not influence their grading. Lastly, agreement about the quality judgements at the level of the phases was established during face-to-face discussions. Also, the inter-rater agreement (Kappa) of the quality scores regarding the SRL phases was calculated and was .80, which is substantial (Maclean, Wilson, & Gessler, 2009).

Construct validity was enhanced by observation training for the researchers and by collecting thick information. The researchers were trained in using the observation schemes in a pilot with two hands-on simulations for four full days. During this pilot, the researchers constantly discussed what behaviour should and should not be noted in the scheme. Also, observing for two full days in order to gather more varied information and to collect data that are rich enough to draw conclusions upon enhanced construct validity. Lastly, the two researchers noted as many example behaviours in each observation as possible to supply a chain of evidence.

Peer-debriefing between the two researchers during data collection and data analysis contributed to the internal validity. To eliminate alternative causal interpretations, the two researchers discussed (for approximately one hour) what their observations were and the interpretations they gave to the observations during the debriefings at the end of each observation day. Internal validity was also enhanced by the use of uniform Excel sheets in which the thick descriptions of all eight simulations were summarised for each simulation separately (see Appendix 6.1), and after that combined in one overview Excel sheet. These sheets were used as additional material for the individual quality rating and during the face-to-face discussion between the researchers about the quality judgements.

External validity was enhanced by: 1) observing the hands-on simulations that are part of regular educational practice; 2) including simulations across domains in the life-sciences; 3) including students from various vocational educational levels and pathways; 4) directly connecting the observations to the SRL theory and 5) providing concrete descriptions and examples of teacher and student behaviours.

Results

RQ1: To what extent do teachers show the various types of behaviour for promoting self-regulated learning in hands-on simulations?

Table 6.2 displays what behaviour the teachers showed for promoting SRL within the session units of a simulation and across the session units of the eight simulations. The results show that the extent to which teachers promote SRL varied considerably across the simulations. But overall, the teachers used SRL promoting strategies in the forethought, performance control and in the self-reflection phases. On average, in almost half of the simulation sessions teachers gave the students moments to choose (44%) and the teachers modelled in more than half (57.1

%) of the sessions. During the sessions in the performance phase, the teachers verbalised (51%), coached (38.8%) and scaffolded (55.6%), while offering very little attributional feedback (5.2%). In approximately one third of the sessions, teachers promoted self-reflection via progress feedback (33.8%) and evaluation (34.4%).

RQ2: To what extent do students show the various types of self-regulated learning behaviour in hands-on simulations?

The extent to which students show the various types of self-regulated learning behaviour varied across the eight simulations (Table 6.2). Nonetheless, the mean occurrences across the simulations show that there was SRL behaviour in all three phases. In the forethought phase, students proposed a method for task performance (58.3%), while less goal setting was observed (17.1%). Regarding performance control, the students showed help-seeking behaviours in more than two thirds (68.1%) of the simulation sessions, but self-verbalised their learning and asked the teacher for feedback in only 12.5 % of the sessions. To conclude, self-reflection behaviour was also observed. In more than one third of the sessions (37.5%), self-evaluation took place, while in 16.1% of the sessions, self-monitoring was observed.

RQ 3: What is the quality of the teachers' strategies that promote self-regulated learning and the students' self-regulated learning strategies in the three phases, and how do teachers' and students' self-regulated learning behaviours look in the three phases with lower, medium and higher quality?

Table 6.2 shows the quality judgements for the phases and Table 6.3 illustrates exemplary behaviour instances of teacher SRL promoting strategies and student SRL strategies in the three phases with lower, medium and higher quality.

Quality of forethought

Five simulations (1, 2, 3, 4 and 8) had a medium score on forethought. In these simulations, there were some moments of choice for students, but the teacher predefined most sessions and students did not set goals intentionally. In the three simulations (5, 6 and 7) with high forethought, the SRL promoting strategies that the teachers used were more on the level of the individual student (e.g. helping individual students choose challenging themes) and students were more able to plan some sessions according to their personal goals. No simulations scored low, because the students or the teacher showed forethought behaviour in all simulations and the baseline for three out of the four forethought behaviours already exceeded the low rating (proportions were > 25 %). No simulation scored very high because offering choices and goal-setting was not optimal looking at the theoretical framework in any session of the simulations.

Table 6.2 Occurrence and Quality of the Teachers' SRL Promoting Behaviours and Students' SRL Behaviour for the Various Session Units in Each Phase and the Overall Hands-on Simulation

Phase	Strategy	Hands-on simulation								Mean % (range)
		1	2	3	4	5	6	7	8	
Forethought	Teacher									
	Offering choices	60% (3/5)	25% (1/4)	16.7 % (1/6)	50% (1/2)	33.3% (1/3)	75% (3/4)	66.7% (2/3)	25% (1/4)	44% (33.3-75%)
	Modelling	20% (1/5)	100% (4/4)	16.7% (1/6)	100% (2/2)	33.3% (1/3)	50% (2/4)	66.7% (2/3)	75% (3/4)	57.1% (16.7-100%)
	Student									
	Goal setting	20% (1/5)	0% (0/4)	0% (0/6)	50% (1/2)	66.7% (2/3)	0% (0/4)	0% (0/3)	0% (0/4)	17.1% (0-66.7%)
	Proposing approach for task performance	100% (5/5)	25% (1/4)	66.7% (4/6)	100% (2/2)	33.3% (1/3)	75% (3/4)	66.7% (2/3)	0% (0/4)	58.3% (0-100%)
	Quality	+/-	+/-	+/-	+/-	+	+	+	+/-	
Performance control	Teacher									
	Attributional feedback	0% (0/5)	0% (0/4)	16.7% (1/6)	0% (0/2)	0% (0/3)	0% (0/4)	0% (0/3)	25% (1/4)	5.2% (0-25%)
	Verbalisation	0% (0/5)	50% (2/4)	50% (3/6)	50% (1/2)	33.3% (1/3)	75% (3/4)	100% (3/3)	50% (2/4)	51% (0-100%)
	Coaching	40% (2/5)	50% (2/4)	33.3% (2/6)	100% (1/2)	0% (0/3)	25% (1/4)	33.3% (1/3)	25% (1/4)	38.8% (0-100%)
	Scaffolding	20% (1/5)	50% (2/4)	66.7% (4/6)	100% (2/2)	66.7% (2/3)	25% (1/4)	66.7% (2/3)	50% (2/4)	55.6% (20-100%)
	Student									
	Asking for feedback	0% (0/5)	0% (0/4)	0% (0/6)	50% (1/2)	0% (0/3)	50% (2/4)	0% (0/3)	0% (0/4)	12.5% (0-50%)
	Self-verbalisation	0% (0/5)	0% (0/4)	50% (3/6)	0% (0/2)	0% (0/3)	50% (2/4)	0% (0/3)	0% (0/4)	12.5% (0-50%)
	Help seeking	20% (1/5)	25% (1/4)	66.7% (4/6)	100% (2/2)	66.7% (2/3)	100% (4/4)	66.7% (2/3)	100% (4/4)	68.1% (20-100%)
	Quality	-	-	+/-	+/-	-	+/-	+/-	+/-	

Phase	Strategy	Hands-on simulation								Mean % (range)
		1	2	3	4	5	6	7	8	
Self-reflection	Teacher									
	Progress feedback	20% (1/5)	25% (1/4)	0% (0/6)	50% (1/2)	100% (3/3)	50% (2/4)	0% (0/3)	25% (1/4)	33.8% (0-50%)
	Evaluation	0% (0/5)	0% (0/4)	16.7% (1/6)	50% (1/2)	100% (3/3)	50% (2/4)	33.3% (1/3)	25% (1/4)	34.4% (0-100%)
	Student									
	Self-monitoring	20% (1/5)	0% (0/4)	16.7% (1/6)	0% (0/2)	66.7% (2/3)	25% (1/4)	0% (0/3)	0% (0/4)	16.1% (0-66.7%)
	Self-evaluation	0% (0/5)	25% (1/4)	33.3% (2/6)	50% (1/2)	66.7% (2/3)	75% (3/4)	0% (0/3)	50% (2/4)	37.5% (0-75%)
	Quality	-	-	-	+/-	+	+	-	-	
Overall SRL		-	-	+/-	+/-	+/-	+	+/-	+/-	

Note. Proportion of SRL behaviour (%) was calculated using the occurrences of the observed behaviour across the session units for each simulation (between brackets). Quality of the SRL strategies was rated – (low), +/- (medium), + (high), or ++ (very high) for each phase and the overall simulation.

Quality of performance control

The performance control was rated low for three out of eight simulations (1, 2 and 5), because neither teachers nor students used many SRL strategies during task performance and when they did show SRL behaviours, this was mainly occasional, unintentional and did not fit the theoretical framework. The quality of the performance control was medium for five simulations (3, 4, 6, 7 and 8). In these, the teacher coached and scaffolded the students more during task performance and the activities were more in line with the theoretical framework. In one simulation with medium quality, the teacher did not show many SRL stimulating strategies, while the students showed considerably more SRL strategies during task performance that fit the theoretical framework than in low scoring simulations. High or very high performance control was not observed mostly because the SRL behaviours, for the teacher and for the students, seemed incidental instead of intentional and did not relate to the exemplary behaviours of the theoretical framework.

Quality of self-reflection

The quality of self-reflection varied considerably between the eight simulations. In the five simulations with low quality (1, 2, 3, 7 and 8), there were almost no self-reflection strategies from the theoretical framework observed; sometimes the teacher asked in a plenary session what the students had learnt from the simulations. In the simulation with medium quality (4), there were student SRL strategies in the form of evaluation, but they were highly directed by the teacher. The two simulations with high quality ratings (5 and 6) were characterised by teachers' strategies for promoting SRL in combination with students' SRL reflection strategies that appropriately reflect the exemplary behaviours of the theoretical framework. Since the reflective strategies often took place at the end, rather than during the simulation sessions, no simulation scored very high for self-reflection.

RQ 4: What types of behaviour do teachers and students show in hands-on simulations with lower, medium and higher overall self-regulated learning quality?

Combining the quality of the phases of each simulation led to an overall quality of SRL. The overall quality was low for two simulations, medium for five simulations and high for one simulation. Table 6.4 illustrates examples of strategies that students and teachers used in a simulation with lower, medium and higher *overall* SRL quality.

The overall quality of SRL was low in simulations 1 and 2. Both simulations started with a lot of modelling and instruction, and there was limited goal setting and options to choose, only on the level of self-composing groups.

Table 6.3 Examples of Teachers' SRL Promoting Strategies and Students' SRL Strategies in the Three Phases with Lower, Medium and Higher Quality

		Forethought	Performance control	Self-reflection
Lower quality of SRL	Teacher	*Not observed*	- Walks around and watches students working and incidentally coaches or scaffolds students - Gives help on demand	- Asks in a plenary closing conversation with the students, whether they want to reflect on their cooperation progress - Closes the simulation sessions without evaluation or reflection
	Students	*Not observed*	- Asks for help on call, but questions are of a practical nature (e.g. 'Where can I find the hammer?')	- Proceed to another session without reflection
Medium quality of SRL	Teacher	- Predefines the content of all the simulation sessions - Gets students to fill in some simulation time on their own	- More prominent place of scaffolding behaviour - Provides students with visual representations of the problem on a worksheet or with a picture - Provides students with extra information for solving the problem via the internet - Verbalises problem-solving strategies in interaction with student	- Gives the students a mark for their performance - Elaborates in an individual conversation his/her motivation for grading - Gives progress feedback to individual students (e.g. 'I will not give you a high mark because I had to spoon-feed you throughout the process')

		Forethought	Performance control	Self-reflection
Medium quality of SRL	Students	- Choose their own working groups with respect to size and composition - Allocate tasks based on interests and personal qualities - Do not intentionally set goals for their learning - Continue working on the task without making a plan	- Articulate processes (e.g. 'My challenge was to…And I did ……') - Question their problem-solving strategies regularly (e.g. 'I can drape this (..curtain…) towards the back of the window, but then it is not that innovative anymore..') - Ask the teacher for feedback on performance (e.g. 'What do you think of the product I made?' or 'Could you give me a hint so I can improve the product?')	- Reflect on learning process in an individual closing conversation with the teacher - Explain to the teacher why they thought they deserved a certain mark
Higher quality of SRL	Teacher	- Gives considerable freedom to choose what tasks to perform in the sessions - Discusses individual learning goals of students and how they think they are going to achieve these goals during the simulation - Models how to perform technical tasks before the students start to work on their own	*Not observed*	- Gives students progress feedback on their learning process (e.g. 'Very good that you were able to adjust the task during the simulation', 'You did not adhere to the requirements of the task') - Evaluates by giving each student a mark, with comments, for their performance as well as for their learning progress
	Students	- Choose the theme of the task according to interests, for example from a folder with all possible options/tasks - Choose how to complete the tasks	*Not observed*	- Articulate their learning progress between the sessions - Give peer feedback for improvement in the form of tips and tricks

Table 6.4 Examples of Hands-on Simulations with Higher, Medium and Lower Overall SRL Quality Judgements

		Forethought	Performance control	Self-reflection
Less quality of overall SRL	Simulation 2 First day	- A lot of modelling and instruction by the teacher - The only choice that students have is composing their group	- Students practise skills individually with help of practical assignments from a folder - The teacher helps both individuals and groups of students	- Student do not show self-monitoring activities and barely show self-reflection behaviour - The teacher asks once if the students have learnt something during a plural conversation. One student answers that question.
	Last day	- A lot of modelling and instruction by the teacher - Only one student proposes his own approach for fulfilling the task	- Students practise skills individually with help of practical assignments from a folder - The teacher helps both individuals and groups of students	- Student do not show self-monitoring activities and no self-reflection behaviour - The teacher does not stimulate students to self-reflect
Medium quality of overall SRL	Simulation 4 First day	- The teacher instructs and models task performance - Students watch and listen to the instruction	- Students perform the practical assignments - Teacher supports students who need help	- There is no reflection phase because the students will continue their work the next day
	Last day	- Teacher asks students what tasks they need to accomplish to fulfil the simulation task - Teacher gives students the option to choose what tasks from the folder they want to complete - One student makes a working schedule for the simulation	- Teacher stands next to the students to support them and they finalise the task together - Teacher gives students tips - Students work independently on the assignments	- The teacher scores the students' performance and motivates the score - Students explain to the teacher why he deserves a certain score

		Forethought	Performance control	Self-reflection
Higher quality of overall SRL	Simulation 6 First day	- Students choose the theme of their assignment and choose how they want to perform the assignment - Teacher models and instructs regarding several skills and techniques	- Students perform the practical assignments individually - Teacher support students when they ask for help - The teacher thinks along with students who find the assignment challenging and discusses alternatives for the problem with the students - The teacher verbalises how to approach problems	- Teacher stimulates students to self-monitor their learning process during task performance
	Last day	- Students choose how to perform the task - Student propose own approaches for fulfilling the task - Teacher models one technique	- Students perform the practical assignments in groups - Teacher support students when they ask for help - The teacher thinks along with students who find the assignment challenging and discusses alternatives for the problem with the students - Students verbalise their problem solving strategies in interaction with the teacher	- The teacher gives each student feedback on their learning process during the whole simulation course - The teacher scores the students' performance and motivates the score - During the debriefing, the teacher asks students questions to stimulate self-reflection - During the debriefing, students reflect on their own learning process and final product and give each other feedback

During the performance phase, students were 'just' working on the task instead of self-controlling their learning processes; also the teachers were not an active stimulator for SRL during performance. In these simulations, self-reflection barely took place.

Simulations 3, 4, 5, 7 and 8 scored medium for overall SRL. The quality of the SRL phases varied considerably across the simulations, which makes it a challenge to typify them. Some simulations, such as simulation 5 and 7, started rather strongly with offering choices and students proposing methods but continued weakly with low performance control (simulation 5) or low self-reflection (simulation 7). Other simulations started by offering some choices and without goal setting (simulation 3 and 8) or with some goal setting (simulation 4). They continued with some teacher strategies, such as coaching and scaffolding, and lacked student strategies, such as asking for feedback (simulations 3,4 and 8). Simulations with medium overall quality ended with very minimal self-reflection strategies by the teacher as well as by the students (simulations 3 and 8) or some teacher strategies to stimulate self-regulation and student self-evaluation (simulation 4).

Only simulation 6 scored high on overall SRL. The description in Table 6.4 shows that in this simulation there was a balance between teacher control and student control; the teacher modelled, directed the students' learning, supported them when needed and the students had opportunities to choose the theme of the simulation and how they wanted to perform their task. The students more actively engaged in learning and self-evaluation and actively used SRL strategies, such as asking for feedback and self-verbalisation. The SRL strategy goal setting was not observed in this simulation. Also, the main teacher strategies that were not optimally present in this simulation were providing attributional feedback and coaching students, which explain why simulation 6 was not rated with very high quality for overall SRL.

Conclusion and discussion

This study identified students' ownership of learning in hands-on simulations by examining occurrences and quality of teachers' strategies for promoting SRL and students' SRL strategies in the forethought, performance control and self-reflection phases (Zimmerman, 2001; Schunk, 2001). The analysis of observation data from eight hands-on simulations revealed that there was considerable variation in the occurrence as well as quality of the teachers' and the students' SRL strategies.

In all eight simulations, however, some forethought, performance control and self-reflection strategies occurred. This suggests that today's hands-on simulations are not totally controlled by the teachers but that they, to some extent, stimulate SRL and that students use strategies to regulate their learning in hands-on simulations. However, the picture of SRL in the observed hands-on simulations is by no means perfect. The results clearly show that there is considerable room for improvement with respect to occurrence and quality of teacher SRL promoting strategies and students' use of SRL strategies across the hands-on simulations. Three explanations for these findings are discussed.

First, it was striking that there was very little proper self-reflection observed across the simulations while a recent literature review showed that stimulating self-reflection is precisely one of the strong learning environment characteristics of hands-on simulations (Chapter 2).

Hands-on simulations offer ample opportunities for reflection-in-action by pausing simulations to reflect, as well as for reflection-on-action by reflecting on, for example, videotaped behaviours. In our study, teachers did not adopt these reflection stimulating activities and students, perhaps in response to that, did not employ reflection behaviour. Occasionally, the teachers reflected with the students at the end of the simulation. However, self-monitoring was rarely observed, although it is an essential aspect of self-reflection (Winne & Hadwin, 1998). Self-monitoring provides awareness of one's performance, which can be used for further steps towards learning goals (Zimmerman, 2001). Simulations lasting longer than one session or that students have to participate in multiple times during their educational pathway (which is often the case in life-science education), provide many opportunities for self-monitoring. Teachers can, for instance, structurally use the time between simulation sessions to guide students with monitoring their competence and help them determine what they need in subsequent sessions to fulfil their learning needs.

Another problem was goal-setting in the forethought phase. Teachers generally gave students possibilities to choose, and students felt free to propose methods for their task performance. For students to make proper use of this freedom and goal-setting, they need to adopt task orientation behaviour. Students' task orientation, including orientation on learning needs and goals, is an important step in the process of SRL; students who score high on task orientation tend to use more self-regulatory learning strategies (Suárez Riveiro, Cabanach, & Arias, 2001). Similar to Jossberger (2011), we observed that this step was skipped; it was common for students to immediately start working on their task, without making an elaborate plan with goals and timing. This might be explained by the fact that students in our study were in their first or second year of vocational education. Novice vocational students are used to teacher-provided structure of learning and are not naturally capable of using SRL strategies, with the consequence that they are not capable of selecting the right tasks on their own (Kicken, Brand-Gruwel, van Merriënboer, & Slot, 2009). SRL skills, such as goal setting and planning, are developed gradually scaffolded by teachers (Taks, 2003). This gradual development is complicated by the fact that hands-on simulations are often treated as an isolated learning activity instead of an integrative part of the vocational curriculum (Chapter 2). The hand-on simulations in this study are even outsourced to a professional external training centre. To gradually help developing goal-setting skills, intertwining learning in school and learning in hands-on simulations is required. Hands-on simulations should offer opportunities to work on goals or personal gaps identified in school and vice versa. For example, teachers can introduce self-assessment via e-learning tools prior to the simulation. Because students' self-assessment is most accurate when they are presented with standards (Andrade & Du, 2007; Kicken et al., 2009; Stefani, 1994), simulation teachers can provide students with video-recorded examples of good performance tasks (including process steps) via the e-learning tool that students can use to self-assess and set goals before going into the actual hand-on simulation.

A third explanation for the findings can be that SRL is often not the primary focus of many teachers in vocational education. This includes teachers in schools that claim to have innovative curricula that aim at increasing students' self-regulatory behaviour (Sturing, Biemans, Mulder, & De Bruijn, 2011). In a previous study, vocational teachers were asked to rank the importance of ten principles for competence-based education in which stimulating self-regulation had an important place (Sturing et al., 2011). The results showed that self-regulated learning was ranked only in seventh place. Since teachers are proven activators of effective SRL (Hattie, 2009), it is no surprise that SRL is still underexposed and underdeveloped in vocational students and in specific learning environments in vocational education, like hands-on simulations. Thereby, the life-science teachers (mostly men) in our study have a passion for their domain but tend to have less affection for educational innovations. Problems with confidence and commitment to SRL often have to do with the teachers misconception that SRL equals minimal guidance (Van Hout-Wolters, Simons, & Volet, 2000). Therefore, there is much to gain by increasing teachers' awareness of the importance of SRL for the development of professional competence, also in hands-on simulations.

In addition, there was no systematic relationship found between SRL and other factors that explain the results. It was difficult to pinpoint other factors that possibly influenced self-regulated learning. For example, we could not confirm the assumption that the use of self-regulated strategies is related to cognitive abilities and information processing capabilities (e.g. Winne, 2001). Because there were no structural differences in results between the simulations at the secondary and higher vocational education level. Also, there were no structural differences between the simulations in which the majority of the students were female compared to the simulations in which the majority was male. Thus, gender-bound differences in SRL, such as the preference for female students to use self-regulatory learning strategies compared to boys (e.g. Matthews, Ponitz, & Morrison, 2009; Zimmerman & Martinez-Pons, 1990), also did not hold for our study.

Limitations

In this study, two researchers observed students and teachers during their participation in a hands-on simulation. The advantage of this method, compared to asking teachers and students in retrospect, is that this exposed what teachers and students actually did to regulate learning instead of assuming that what they say they did actually happened. This method also has some limitations: for example, SRL is a process that is not completely observable (Perry et al., 2002). Outsiders, such as researchers, cannot see what teachers and students think. Therefore, we might have missed strategies related to SRL that were not verbalised or expressed in observable behaviour. Second, although we observed each simulation for two full days at the beginning and the end, we were not involved as observers in the simulation sessions in-between these days. It is possible that SRL strategies, other than those reported in this study, were used in the simulations when the observers were absent. Third, this study was conducted in hands-on simulations in domains within the life-sciences at a simulation training centre outside the school setting; further research on SRL strategies in other educational domains might lead to different outcomes, as the structure of hands-on simulations might slightly differ between domains, and simulations in training centres might have different structures than simulations inside vocational school settings.

In sum, even though our hands-on simulations were all part of an innovative vocational curriculum that aimed at implementing competence-based education in which stimulating SRL is seen as an important process towards competence development, stimulating SRL did not reach as far as hands-on simulations. Specifically, the goal-setting and self-monitoring of the students, and teachers' belief in SRL and the ways in which they more explicitly create opportunities for adopting SRL behaviour (see also Jossberger, 2011) need improvement. Nevertheless, the findings of our research open doors to self-regulated learning in simulations. We found that hands-on simulations were not totally controlled by the teachers and that students had possibilities to self-regulate their learning. Future research should first focus on improving SRL in hands-on simulations if (and only if) fostering learning outcomes such as competencies is the goal of the hands-on simulations. After that, educationalists can examine how hands-on simulations with low, medium and high SRL affect the intended learning outcomes in vocational education and precisely how the various SRL strategies contribute to these outcomes through hands-on simulations.

Appendix 6.1 Examples of Students and Teacher Observations Based on De Bruijn et al. (2005; 2011).

		First day				Last day			
		Session unit 1		Session unit 2		Session unit 1		Session unit 2	
Strategy	Concrete behaviour	Occurrence	Examples	Occurrence	Examples	Occurrence	Examples	Occurrence	Examples
Teacher									
Offering choices	a. The teacher lets the students decide on how they are going to complete the task	1	The teacher lets the students choose how they want to present their results (for example via PowerPoint, via a collage or with photo's)	1	The teacher lets the students choose the theme of the mood board.			2	The teacher tells the students that they may choose how to design the store
	b. The teacher lets the students decide on what tasks they are going to choose	1	The teacher tells the students they can choose what they want to do during the coming sessions (e.g. work on the corporate design of the shop, work on the internet site of the shop)						

Chapter 7

Conclusions and general discussion

This final chapter combines the findings of the systematic literature review and the empirical studies. Furthermore, the main question '*What is the added value of hands-on simulations in an innovative vocational curriculum?*' and questions that emerged from this dissertation are discussed from a theoretical perspective ('*To what extent should we 'innovative' hands-on simulations for competence development?*') and a practical perspective ('*What further steps do we need to take to integrate hands-on simulations in an innovative vocational curriculum*?'), including suggestions for future research and practical guidelines for educationalist and teachers who work with hands-on simulations.

Introduction

A lot of value is attached to work-related learning contexts attempting to connect school learning to workplace learning (Mulder, 2012). Students are enthusiastic about these learning environments; they experience them as 'fun' and 'exciting' (Jossberger, 2011). During our studies examining hands-on simulations, students regularly told us: 'I have learnt more in one day of simulated training than in a whole school year!' A long history of research shows that hands-on simulations are not only enjoyable learning environments but also suitable for learning technical and procedural knowledge and skills (see Chapter 2). The problem is, however, that policy makers experience difficulty defining hands-on simulations and teachers have difficulty integrating hands-on simulations into an innovative vocational curriculum in which the main outcomes, are new ones, such as professional competence (Mulder, 2014). This stems mainly from the fact that hands-on simulations are not well conceptualised from the constructivist learning theory perspective that underlies innovative vocational curricula. This chapter presents an integrated discussion about the question guiding this dissertation *'What is the added value of hands-on simulations in an innovative vocational curriculum?'* The discussion will be done through a theoretical and a practical perspective incorporating directions for future research as well as practical guidelines for implementing hands-on simulations in an innovative curriculum. Before we introduce this discussion, this chapter first provides the main findings of this PhD research and discusses its limitations.

Main findings

To answer the main question we conducted a systematic literature review, a survey study, an experimental study and an observation study, and we validated a competency self-report instrument. This section outlines the major findings by summarising all five individual studies.

Firstly, a systematic literature review was conducted to position hands-on simulations in relation to two other work-related learning environments (i.e. authentic projects and internships) based on their learning environment characteristics and their learning outcomes (Chapter 2). The results of the literature review showed that, compared to other work-related learning contexts, hands-on simulations are powerful because they provide opportunities for learning from feedback, intensive coaching, learning by doing, learning from observing others and learning by reflection-in-action. However, evidence of the development of competencies and the presence of the three learning environment characteristics regarded as important for developing competence: authenticity and ownership of learning (self-directed learning (SDL) and self-regulated learning (SRL)) were structurally lacking in the included studies. An additional literature search showed, nevertheless, that hands-on simulations do have potential to be 'innovative' in the sense that they can stimulate authentic learning, SDL and SRL for competence development.

In the empirical chapters an in-depth examination was made of authenticity and ownership of learning in hands-on simulations. We questioned whether authenticity and ownership of learning indeed foster the development of competencies in hands-on simulations. The empirical studies showed that this is not directly the case. The results of the survey study with 516 students in 23 simulations (Chapter 3) showed that authentic design of hands-on simulations, as perceived by the teachers, negatively predicted the development of *operational* competencies—'applying expertise', 'using materials and products', 'following instructions and procedures' and *conceptual* competencies—'planning and organising, 'deciding and initiating' and 'analysing'. The extent to which the hands-on simulation was self-directed did not directly affect competency development, but *through* the perceptions of the students regarding the learning environment; this means that self-directed learning activities affect students' perceptions regarding the learning environment in a positive manner, leading in turn to competency development.

In the experimental study (Chapter 5) our objective was to examine the effect of authenticity and ownership of learning on competency development in more detail (not only clusters of operational and conceptual competencies as in Chapter 3). To assess these competencies, we chose to use a competency self-report instrument. Because such an instrument did not exist for competencies from the Dutch competence-based qualification framework, we developed and validated a self-report questionnaire (Chapter 4). The results of this study revealed that a competency instrument with multiple indicators per competency showed face validity, construct validity and robustness, meaning that the self-report instrument can be used for measuring competency development across different levels of vocational and higher education. This is, however, only the case for competencies that align with the aim of the course that the teacher intends to evaluate and for competencies that are concrete and easy to relate to specific situations, such as 'applying expertise' and 'planning'. Caution is advised when using abstract competencies, such as 'deciding and initiating', in competency self-reports.

The experimental study (Chapter 5), which compared a traditional and an innovative hands-on simulation with first-year Applied Biology students attending five days of sessions simulating aspects of their future profession, showed that the students developed four out of five intended competencies in the hands-on simulation. Unexpectedly, adding authenticity and ownership of learning to the hands-on simulation (i.e. the innovative simulation) did not increase competency development as well as near transfer of professional competence. The 'innovative' hands-on simulation (n = 58) was even perceived as less authentic than the traditional simulation (n = 65) and resulted in less far transfer of professional competence.

Both the experimental study (Chapter 5) and the observational study of teachers and students in eight hands-on simulations (Chapter 6) zoomed in on the frequency and quality of SDL and SRL in hands-on simulations. Where the experimental study suggest that actually implementing innovative strategies is challenging, the observation study shows that there is indeed a lot to gain with respect to teachers promoting strategies for giving students ownership of learning and students using strategies for gaining ownership of learning in hands-on simulations. Both chapters illustrate that students have some ownership over their learning in hands-on simulations. But the observations (in which ownership of learning was operationalised as self-regulated learning (SRL)), also showed that hands-on simulations vary a lot in terms of the frequency and quality of SRL and that there were few, if any, significant teacher strategies for promoting SRL, such as giving attributional feedback and evaluation. Moreover, students were using few, if any, strategies for SRL, such as goal setting and self-monitoring.

Because of the mixed findings, one might question whether hands-on simulations add value in an innovative vocational curriculum? We will discuss this issue and work towards suggestions for practice and future research, but before this several methodological limitations of the studies included in this dissertation have to be pointed out.

Limitations

First of all, the *context* of the included studies was limited to *Dutch secondary and higher vocational education*. The European Qualification Framework level of the participating students ranged from 2-4 and 6 (see Figure 1.1, p. 12). It is, however, a challenge to generalise vocational education contexts across Europe and beyond. For example, while *higher vocational education* constitutes a distinctive educational pathway in the Netherlands, in many other counties the more profession-oriented pathways in higher education are included in university education. We were aware that hands-on simulations are being used across all possible educational levels and in further and continuing education, but to ensure alignment between our samples and the literature we chose to limit our literature search and references to the context of vocational and higher education. This might have resulted in an exclusion of other, relevant, references about hands-on simulations and their learning characteristics and learning effects (Chapter 2). Thereby, the context of the hands-on simulations in this dissertation was *life-science education* across the width, including domains of animal husbandry and dairy farming, rural environmental development, engineering technology and retail floristry. As hands-on simulations are used across all possible educational levels, they are also used across many disciplines. In all those disciplines simulations have different kinds of features. For example, nursing students often work with a critical incident protocol on a mannequin and husbandry students often work with live animals. Those features might have different effects on students' perceptions of the learning environment and, therefore, their learning outcomes. Another issue with hands-on simulations is that they vary a lot in *duration*. In our studies we chose a lower limit of two full simulation days and no upper limit, because it is not plausible to expect competency development in a simulation training that last only a few hours. It is possible, or even likely, that our findings regarding competency development are not applicable to simulations with a shorter duration, or that more learning gain is experienced in longer simulations that last for weeks. Though we have examined several types of hands-on simulations in this dissertation, the question remains whether the findings and following discussion can be generalised to other types of simulations, in other domains with shorter or longer duration, therefore one should be careful and critical when interpreting our results in other contexts.

Second, all simulations were examined in their *naturalistic setting*, in their full complexity. This made it possible to collect rich data and to formulate implications directly helpful for practice. This 'research in the wild' enhances the ecological validity of the dissertation but made it impossible to indicate the isolated effects of authenticity, ownership of learning and student perceptions. Other factors that are hard to grasp and examine could have influenced the results, such as group dynamics, students' interest in the simulation theme and even varying weather conditions. How researchers can overcome these problems in future research will be elaborated on pages 135-137 in the discussion section of this chapter.

Third, the *teachers* in the present work had specific characteristics that could have influenced the design process of the experimental study and the findings of the studies. The teachers were experts, often with many years of professional experience, in a specific life-science domain. Generally, the teachers in this simulation training centre had a lot of knowledge about their field, were strongly developed in technical and procedural skills and were passionate about their professional field. The teachers' didactic skill and teacher guidance strategies that are important for competence-based education, such as coaching, were covered through courses that were not part of this study. But before the start of the experimental (innovative) hands-on simulation, the expert teachers were never officially educated in implementing authentic learning and fostering strategies for self-directed and self-regulated learning. It is plausible that the expert teachers' primary focus on the more technical aspect of learning in the simulations and their lack of experience with education in constructivist learning (see Chapter 6) were reflected in the findings in this dissertation.

Fourth, the data were collected mainly from novice and intermediate students (first and second year) in *secondary and higher vocational education*, while hands-on simulations are used as training tools across all levels of vocational education, higher education and continuing education. Studies about the effect of authenticity and SDL and SRL in hands-on simulations might turn out differently with students or employees that possess more expertise. For example, experts are known as efficient performers because their information and knowledge is better organised than novices (Ericsson & Charness, 1994). Therefore, new, complex and authentic tasks are more likely to be recognised as authentic by an expert than by a novice student (Van Merriënboer & Sweller, 2010) and experts have more capacity to use SDL and SRL learning strategies than novices (Candy & Brookfield, 1991).

Fifth, not all strategies presented in the overview of characteristics of innovative hands-on simulation (Chapter 2) were specifically examined in our studies. Most of our decision to exclude the characteristics *co-creation*, formulating *progress* goals and *fading* of teacher guidance were taken for pragmatic reasons. For example, implementing an innovative hands-on simulation with expert teachers who were inexperienced in constructivist learning concepts was challenging, and involving students in co-creating an authentic task would make the design and implementation process too complex. Therefore, the implementation of the innovative hands-on simulation (Chapter 5) and the results presented above should not be seen as a result of the full model that describes the strategies for innovative hands-on simulations (Chapter 2), but as a first step in investigating how innovative hands-on simulations affect student learning. Future research can focus more on the effects of the aforementioned characteristics.

Sixth, the outcome measurement of learning in this dissertation was a set of distinctive competencies (Chapters 3, 4 and 5) and transfer of professional competence (Chapter 5). However, only the competencies that were relevant for the hands-on simulations at study were examined with a validated self-report instrument (Chapters 4 and 5). Thus, not all 25 competencies from the Dutch Qualification Framework were covered by this dissertation. Consequently, the findings are drawn from a limited set of competencies and there is still a knowledge gap about the effectiveness of hands-on simulations for other potentially relevant competencies. Furthermore, the competencies and their qualification criteria from the Dutch qualification framework are different from other Qualification Frameworks, which is important to bear in mind when interpreting the findings of our studies.

Lastly, innovative vocational curricula do not aim only at fostering competencies and professional competence, but also at other outcomes, such as professional identity (De Bruijn & Leeman, 2011). The discussion of this dissertation restricts itself to the specific aim of vocational education: competence development through hands-on simulations.

Discussion

The question that emerged from our findings *'Do hands-on simulations add value in an innovative vocational curriculum?'* is discussed first from a theoretical perspective (*'To what extent should we 'innovate' hands-on simulations for competence development?'*) and second from a practical perspective (*'What further steps do we need to take to integrate hands-on simulations into an innovative vocational curriculum?'*), including suggestions for future research and guidelines for practice. Figure 7.1 illustrates the outline of the discussion.

1. Are hands-on simulations suited for competence development or should we not use them for this type of outcome and continue using them to develop technical/procedural knowledge and skills?

The concept of competence has wider implications than just performing workplace tasks. 'A professional is competent when he/she acts responsibly and effectively according to given standards of performance.' (Mulder, 2014, p. 3). To be competent a person needs competencies. Competencies are part of professional competence; they are a coherent cluster of knowledge, skills and attitudes which one uses during job performance (Mulder, 2014). Given this, competence development needs a learning environment that integrates knowledge, skills and attitudes. Chapter 2 indicated the potential of hands-on simulations for competence development when adding authenticity and ownership of learning to the hands-on simulations. We already stated that there is a sound base of evidence that hands-on simulations are well suited for the development of technical and procedural knowledge and skills across several domains, such as medical and nursing education (Kneebone, 2005; Salas & Burke, 2002; Wenk et al., 2009) and supply chain management (Zeng & Johnson, 2009). We took the first step in examining competence development in hands-on simulations.

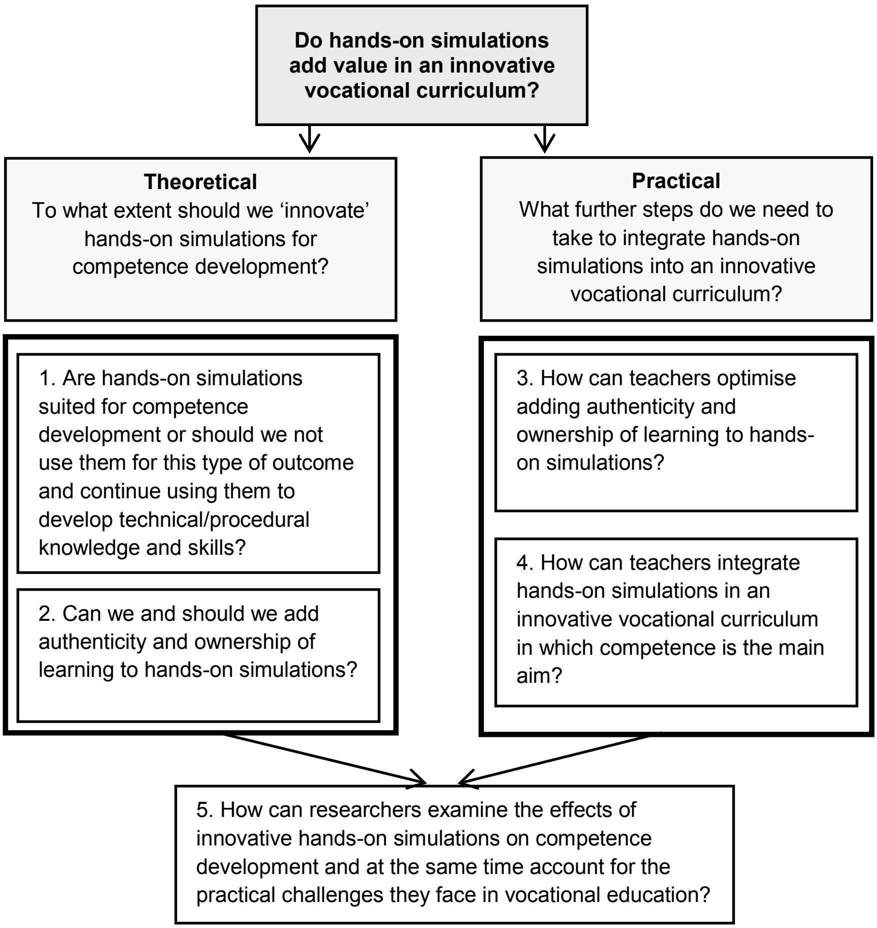

Figure 7.1. Discussion outline.

The results of our studies show that hands-on simulations foster the development of distinctive competencies and the transfer of professional competence. We have shown that students evaluated their competency gain positively in a wide range of hands-on simulations and pre- and post-tests showed that competencies were developed through the hands-on simulations (Chapters 3 and 5). Also, most students were capable of completing a case-based task (near transfer) and an authentic project (far transfer) that required transfer of professional competence directly related to the hands-on simulation, assuming that the hands-on simulations contributed to this transfer result (Chapter 5).

Although we have provided evidence that competencies can be developed in hands-on simulations, the competencies that were developed were mostly concrete and directly related to task performance, such as 'applying expertise' and 'using materials and equipment', and competencies that address cognitive processes, such as 'planning' (Chapter 5). We were not able to confirm that the competency 'cooperating' could be developed through hands-on simulations, which is surprising because students work in groups and giving each other feedback are powerful characteristics of hands-on simulations (Chapter 2). Our literature review showed that there was very little evidence of attitude development in hands-on simulations in vocational education (Chapter 2). Similarly, our experience was that teachers barely addressed *attitude-related aspects of competence* in hands-on simulations (Chapter 6), which is recognisable for functional training contexts that focus on the first type of competencies (Mulder, 2014). Most of the teachers' feedback focused on the accuracy of the students' skills performance consistent with the 'traditional' simulations. Reflection or feedback on essential attitude-related aspects of competence, such as coping with setbacks, tolerating others and self-confidence, were hardly observed. The fact that hands-on simulations are not utilised for attitudes is alarming and does not contribute to the possibility of developing other kinds of competencies in hands-on simulations. Just as knowledge, skills and attitudes towards others, oneself, the professional field and the client/patient/customer, are essential for competence development. Literature in initial and continuing medical education recently discovered the potential of hands-on simulations for team competencies (Beaubien & Baker, 2004; Miller, Riley, Davis, & Hansen, 2008), suggesting that hands-on simulations can foster competencies like 'cooperating' or other less concrete, performance-related competencies. These medical simulated learning environments reflected the professional practice including the social dynamics of the team. Performing the simulation task as a 'team' and reflection moments that specifically addressed communication patterns, situation monitoring, dividing roles and responsibilities and addressing what team members feel or value enhanced attitude towards the professional practice as well as team competencies (Salas, DiazGranados, Weaver, & King, 2008; Sigalet, Donnon, & Grant, 2012). Vocational education and other disciplines can take this as an example, and also take the social dynamics of professional practice into account when designing a hands-on simulation since this is becoming increasingly important in today's professions. The main message is that hands-on simulations can be and should be used for competency development in vocational education; however, more attention needs to be paid to the students' attitude development in hands-on simulations. Only then can a larger set of competencies from a qualification framework be developed through hands-on simulations.

2. Can we and should we add authenticity and ownership of learning to hands-on simulations?

It was hypothesised that hands-on simulations foster constructivist learning (the basis of innovative vocational education), but that specific strategies for authenticity and ownership of learning (i.e. SDL and SRL) should be added to the 'traditional' constitution of hands-on simulations (Chapter 2). The empirical studies (Chapters 3, 5 and 6) further investigated constructivist learning in hands-on simulations and found mixed results regarding the implementation of authenticity ownership of learning and its effect on student learning. These outcomes raise the question whether educationalists should or try to 'innovate' by increasing authenticity and ownership of learning in hands-on simulations. The answer basically depends on the context and the aim for which hands-on simulations are used. Alignment between the teaching method/learning environment and the learning outcome is essential (Biggs, 1996). Therefore, we should approach this question from the perspective of the intended outcomes formulated at the level of the curriculum; in this dissertation innovative vocational education, or competence-based vocational education. The aim of these curricula is to develop the ability to function as a professional in various professional tasks and situations, and to develop specific competencies that are necessary for functioning in the job and in society, such as problem solving, analysing, and being innovative, creative and inquisitive (see Qualification Frameworks, Chapter 4). When hands-on simulations are utilised in the context of innovative vocational education there are two possible answers to the question:

A. To not add authenticity and ownership of learning to hands-on simulations

When teachers and educationalists decide that students need to learn specific professional procedural and technical knowledge and skills, the more 'traditional' approach to hands-on simulations can be adopted. The approach behind this leads back to late behaviourist and early cognitivist learning theory and can result in two types of learning: *low-road* and *high-road integration* of knowledge and skills (Baartman & De Bruijn, 2011). Baartman and De Bruijn drew an analogy with transfer to conceptualise the integration process of knowledge and skills necessary for functioning as a professional. The idea behind this is that for transfer to occur, students must first build relationships between pieces of knowledge and skills, which Baartman and De Bruijn call low-road and high-road integration. We think that 'traditional' hands-on simulations are suitable for the integration of professional knowledge and skills because they stimulate low-road and high-road integration of knowledge and skills.

Low-road integration means the process of integrating knowledge and skills by practising towards automatic performance. Adopting a skill or change in behaviour is considered to be a result of rehearsing and reinforcement, i.e. positive feedback on desired behaviour (Anderson, Magill, & Sekiya, 2001). This type of learning is easy to foster in hands-on simulations. Hands-on simulations provide instruction moments in which students can practise a specific skill to perfection because tasks can easily be repeated in a single simulation session.

High-road integration means the process integrating of knowledge and skills in which the student is conscious of what he/she is doing. Organising information and students' prior knowledge and expectations play an important role in learning (Gredler, 1997). Individual learning occurs when new experiences are recognised and fit a student's existing cognitive structure or schemata. Experiences that students encounter for the first time and do not fit their cognitive schemata challenge existing structures to be changed (Piaget, 1964; Piaget & Cook, 1952). An essential aspect in these learning processes is that the individuals are aware when experiences do or do not fit their predictions and prior experiences. This so-called meaningful learning can be established perfectly in hands-on simulations by pausing the realistic simulated event, reflecting on what happened (reflection-in-action), reviewing what was learned from the experience and adapting behaviour in another subsequent simulation session (Rutherford-Hemming, 2012). In these learning environments, the teacher structures the learning activities based on the desired learning outcomes and the students' prior knowledge. A common strategy is the progressive approach: starting with a simulation that matches the students' prior knowledge and skills and increases the complexity of the learning (Case, 1975).

Thus, when the low-road and high-road integration processes are accomplished in traditional simulations, specific professional knowledge and skills can be developed in these 'traditional' hands-on simulations. Some educationalists state, however, that more traditional instructional methods do not fit within an innovative vocational curriculum (Wesselink, 2010). We suggest that traditional vocational learning environments, such as hands-on simulations, *can* have a place in an innovative curriculum. *But for this to be true*, the performance criteria and learning outcomes (from the Qualification Framework) for which the hands-on simulations are utilised must be made transparent. When teachers do decide to use the 'traditional' form of hands-on simulations in an innovative vocational simulations it is suggested not to promote them as learning environments for competence development. At all times, teachers have to communicate that the 'traditional' simulations are used for *acquisition of specific knowledge and skill* and explain how they contribute to these outcomes. Furthermore, they have to be transparent about *how the simulations relate to the bigger picture*, i.e. their competency qualification framework and students' future profession.

B. To further optimise the process of adding authenticity and ownership of learning to hands-on simulations

The essential aim of vocational education is developing professional competence. To develop competence, learning processes that go together with low-road and high-road integration of knowledge and skills are not enough; *transformative integration* of knowledge, skills *and attitudes* is required (Baartman & De Bruijn, 2011). Transformative integration goes further than low-road and high-road integration, it encompasses the critical reflection on oneself and one's actions, reassessing one's perspectives and transforming them if necessary. Moreover, it involves social and emotional learning processes. Transformative integration of knowledge, skills and attitudes involves willingness to change practices and not just to add skills. In a 'traditional' learning environment, the learner can easily be shaped by his/her environment through practise and reinforcement (low-road and high-road integration). Though students are confronted with new situations and stimulated to reflect on their learning to change their behaviour, the teachers feed them with information that they think is relevant for the students. Thus, in more 'traditional' simulations, the student is less of an independent thinker and learner. The foundation of innovative curricula, however, is to prepare students for the world with independence and self-regulation−attributes that are necessary for becoming a competent professional. In an 'innovative' learning environment, the student is central to learning and learning is always an active process (Baeten, Kyndt, Struyven, & Dochy, 2010). This requires not only the arrangement of authentic learning, i.e. learning that resembles the students' reality of work (Duffy et al., 1993), but also opportunities for students to influence their behaviour, to choose what they want to learn and to control their motivation and opportunities for achieving goals (Boekaerts, 1999; Loyens & Gijbels, 2008). Since students in a hands-on simulation often encounter workplace contexts for the first time, hands-on simulations that are implemented according to constructivist learning theory are the perfect place to experiment with the difficulties they may face in a context that reflects the complexity of their profession and requires self-directedness and self-regulation. This way, a first step in transformative integration of knowledge, skills and attitudes can be taken in hands-on simulations with purposefully added authenticity and characteristics of self-directedness and self-regulation.

Our interpretation is that the students in our studies underwent the more traditional form of hands-on simulations and were exposed to low-road and high-road integration of knowledge and skills instead of transformative integration of knowledge, skills and attitudes. For example, it was shown in Chapter 5 that traditional approaches to instruction and learning, i.e. instruction and rehearsing, still took a prominent place in the simulations. To improve constructivist learning in hands-on simulations and foster transformative integration of knowledge, skills and attitudes for competence development, the process of adding authenticity and ownership of learning can be further optimised (see next section for practical implications). But for innovative hands-on simulations to actually add value to a vocational curriculum, one step forward in implementing constructivist principles in the whole curriculum has to be made. Teachers as well as students have to be familiar with and trained in guiding and learning in constructivist contexts. Our observation was that secondary and higher vocational students barely had the skills for self-directing and self-regulating their learning in more complex authentic settings. If their educational trajectory does not prepare students for these kinds of situations, it is no surprise that it is such a challenging task to accomplish in hands-on simulations. Therefore, students can benefit from *innovative* hands-on simulations only when the *whole curriculum* actively stimulates constructivist learning, right from the beginning. Teachers and school leaders are advised to determine to what extent their curriculum is innovative, for example by using the Matrix of competence-based education (Sturing, Biemans, Mulder, & De Bruijn, 2011; Wesselink, 2010), and after that to decide whether they are ready to expose their students to authentic and self-directed work-related learning environments.

3. How can teachers optimise adding authenticity and ownership of learning to hands-on simulations?

The first empirical chapter resulted in a framework with strategies for adding authenticity and ownership to hands-on simulations (Chapter 2, p. 35). Based on the studies in this dissertation, this framework can be complemented (see Table 7.1).

Stimulate authentic learning

The original framework described five strategies for adding authenticity to hands-on simulations. The perceptions of the student were already included in these strategies. However, the student perceptions regarding the learning environment had much more influence than expected (Chapter 3). Therefore, we advise co-creating authentic tasks with the students when designing a hands-on simulation. The teacher can explicitly discuss with students what an authentic professional situation looks like and, together with the students, translate this into an authentic simulation. On the other hand, a simulation can also be used more explicitly to help create or challenge students' images of professional practice. During the simulation, students should form realistic images of their future profession. We advise regularly checking the students' perceptions regarding the authenticity of the task and context, and when students do not feel the task or the learning environment is realistic, explicitly explaining what makes the task or learning environment valuable for the profession. In other words, help students to accept and understand the 'as-if' factor of the simulation (Dieckmann, Gaba, & Rall, 2007).

Give students more ownership of their learning, stimulate self-directed and self-regulated learning

Though the implementation and execution of SDL and SRL was not optimal in the hands-on simulation in our study, we are confident that students can have some ownership of their learning in hands-on simulations. But to accomplish this, teachers (i.e. school teachers and simulation teachers) should intertwine school learning and learning in the hands-on simulations. A prerequisite is that simulation teachers examine the extent to which their students have SDL and SRL skills. Based on this, teachers can estimate the amount of freedom they can give the students. In the case of hands-on simulations this can be done by including a preparation phase in which the teacher introduces self-assessment via e-learning tools. For example, teachers can provide students with video recorded examples of well-performed tasks that students can use to self-assess, after which the teacher contacts students to formulate goals and plan their learning path. Teachers can guide students in this phase by not only giving them options to choose from, but also explaining what the options are and how students can benefit from them (Loyens, Magda, & Rikers, 2008). Teachers can go a step further too: by giving students school assignments for preparation before entering the simulation. Currently, at least in our studies, learning in school and learning in the simulations were two almost completely separate tracks.

In our studies, we saw that there were challenges regarding students' ownership of learning during the hands-on simulations. For example, in Chapter 3 we saw that teacher guidance activities that should have stimulated SDL did not predict competency development and in Chapter 5 and 6 we observed that important SDL and SRL strategies from both teachers and students were lacking in most simulations. Teachers can contribute to SDL and SRL by taking the role of an activator more than that of a facilitator (Hattie, 2009). This can be done by planning coaching and scaffolding moments during the simulation. Also, feedback is an important activator while in our studies; quality feedback was probably the least observed teacher strategy. Teachers can stimulate SRL by giving students attributional feedback (e.g. 'You are good at this, you have been working hard.') and progress feedback (e.g. 'You are doing well because you applied the steps in order.') (Schunk, 2001) and explicitly evaluate the quality of their learning progress and product at the end of the simulation session. Furthermore, students can also more actively engage in simulated learning. Strategies, such as asking for feedback and self-reflection, were hardly observed. It is, however, a common problem for vocational students that they rarely initiate SDL and SRL strategies on their own (Kicken, Brand-Gruwel, Van Merriënboer, & Slot, 2009). Therefore, the teacher can help students to structure their learning by explaining self-regulation strategies beforehand, modelling these strategies and, when the simulation lasts long enough, they can fade external support and increase students ownership of learning.

Another worrying observation was that the teacher as well as the students considered the completion of the simulation as the end of the learning process, which is a common problem in formal training (Grossman & Salas, 2011). What happens in the months after training is crucial for maintaining a skill or for the probability of transferring what was learnt to another work-related learning environment (Grossman & Salas, 2011).

Table 7.1 Improved Overview of Strategies for Adding Authenticity and Ownership of Learning to Create Innovative Hands-on Simulations for Competence Development

Stimulate authentic learning

Preparation

- *Co-create authentic tasks and a realistic physical context that integrate knowledge, skills and attitudes with students*
    - Include ill-defined problems in the tasks that require authentic cognitive processes
    - Adapt authenticity to the level of the student

During simulation

- *Co-create a realistic image of the professional task and context*
    - *Regularly check whether authenticity fits students perception*
    - *Help students to accept and understand the 'as-if' factor. Explain why the simulation does not always fit their idea of authenticity and by articulating what exactly makes the simulation valuable for the profession.*

Give students more ownership of their learning, stimulate self-directed and self-regulated learning

Preparation (optionally via e-learning tools)

- *Critically examine whether the students have the skills to self-direct and self-regulate their learning*
- *Provide self-assessment*
- Formulate progress goals (working towards accurate execution of the task) or let students formulate progress goals
- Create moments of choice with students
    - Let students choose what tasks to perform. Let students choose how to perform the tasks
    - *Explicitly discuss choice options with students and how students can benefit from them*
- *Give students assignments to prepare the simulation in school*

During simulation session

Teacher strategies

- *Take the role of an activator instead of a facilitator*
- Model and verbalise: model desired behaviour and verbalise process steps, problem-solving strategies and self-regulatory strategies
- *Feedback: provide attributional feedback (link prior achievements to students' effort) and progress feedback*
- Plan coaching (give students hints and cues) and scaffolding (support students with help or additional materials or resources) moments for each group and for each individual
- Fade: decrease guidance and increase students' responsibility over time
- *Evaluate learning*

Student strategies

- Analyse observations and mistakes
- *Ask for feedback*
- Self-verbalise actions and regulatory strategies
- Self-monitor performance and progress goals
- *Self-evaluate learning*

After simulation session (optionally via e-learning tools)

- *Follow-up*

Note: the strategies in italics were added to the overview as a result of this PhD research.

In simulations teachers can increase the probability of transfer teachers by stimulating students to reflect on their learning during *follow-up* learning activities. They give students the opportunity to ask for feedback, give students feedback and discuss practical problems (Baldwin, Ford, & Blume, 2009; Grossman & Salas, 2011). Similarly to the preparation phase, e-learning tools can be used when such a follow-up is difficult to organise. This way, hands-on simulations can become learning environments that are more integrated with the school learning processes.

4. How should teachers integrate hands-on simulations in an innovative vocational curriculum in which competence development is the main aim?

Earlier we stated that hands-on simulations can have a place in innovative vocational curricula, such as competence-based education, but in *what position* depends on the intended learning outcomes. We suggest two options: 1) use more traditional hands-on simulations only for procedural and technical knowledge and skills or 2) use more innovative hands-on simulations for a full range of competencies from a Qualification Framework, including the more attitude-related competencies. What teachers should take into account is that both options are best accompanied by different approaches to learning (Table 7.2).

Table 7.2 Two Modalities and their Components of Hands-on Simulation in an Innovative Vocational Education Curriculum

Learning intentions	Learning process	Learning context	Approaches to teacher guidance	Approaches to student learning
Procedural and technical knowledge and skills (as specific parts of professional competence)	Low-road and high-road integration of knowledge and skills	Standardised well-defined tasks and ill-defined tasks Realistic physical context	Expert teacher is a facilitator of - Instruction/ modelling - Feedback - Coaching and scaffolding of learning	Learning by doing thorough and diverse practise Reflection-in-action
Professional competence/ Competencies (based on a Qualification Framework)	Transformative integration of knowledge, skills and attitudes	Complex ill-defined tasks Authentic context	Teacher is an activator of authentic, self-directed and self-regulated learning (see Table 7.1).	Student-centred learning and continuity of learning in across learning sites (see Table 7.1) Social aspects of learning (e.g. team learning)

The first, more 'traditional' modality of hands-on simulation, focusses mainly on technical/ procedural knowledge and skills and fosters low-road and high-road integration of knowledge and skills. The teacher is a facilitator of learning. He/she is an expert who provides students with relevant information when needed, for example through instruction and displaying correct performance of the skills and desired behaviour (modelling). The expert teacher is present for giving students tips and tricks on how to improve their skills and students learn by performing and repeating the same or comparable tasks. To stimulate transfer, students rehearse the skill within various learning situations since transfer is to be expected not only when students learn how to apply their knowledge, but also when they can practice their performance multiple times in diverse settings (Baldwin & Ford, 1988; Perkins & Salomon, 1992). The teachers must communicate to students how the knowledge and skills relate to their professional work. The teacher can for example ask 'How prominent is the place of these knowledge and skills in your future profession?' or 'To what competencies do these knowledge and skills relate and what do you need to learn to further develop these competencies?'

The second, more 'innovative' modality of hands-on simulation fosters transformative integration of knowledge, skills *and* attitudes as combined in competencies. It includes the approaches to teacher guidance and student learning as presented in Table 7.1. The teacher is more an activator of learning and in this modality the student has a role in the design and the learning processes. This approach to student learning can be seen as *student-centred* (Baeten et al., 2010) and requires *continuity of learning* across different sites (Akkerman & Bakker, 2011) through preparation assignment in school and follow-up assignments. Additionally, in an innovative hands-on simulation more explicit attention for attitudes is desired. According to Vygotsky (1978), learning is a social activity that is manifested in meaningful contexts, for example by communicating about ideas and thoughts to peers of that specific social setting. Hands-on simulations are typically learning environments in which students work together (Chapter 2). But when students are in hands-on simulations more explicitly exposed to *social aspects of learning* with explicit attention to attitudes, for example by team learning or working with real clients or patients, we expect that also the more attitudes-based competencies can be developed in hands-on simulations, such as showing empathy and working in teams. This can be done by, for example, explicitly giving students team member roles, making students aware of these roles and critically reflecting on their competencies during reflection moments. Take the florist, for example. The teacher can give one student the role of manger, two students the role of florist and one student the role of shop assistant. The teacher introduces an ill-defined task/problem; a big order of bouquets for the funeral of the mayor. Now, the teacher has plenty opportunities to reflect on accurate performance of the task (e.g. 'What did you think of the quality of the bouquets?'), and to critically reflect with students on critical moments of the simulation and address attitude related competencies (e.g. 'What happened at the moment you got in an argument'?, 'Why did this happen?', 'How did you feel?', 'What did you learn about yourself (as a manager, florist, or assistant) and tolerating others in such situations?', 'How will you use the competency tolerating others in future problems?').

5. How can researchers examine the effects of innovative hands-on simulations on competence development and at the same time account for the practical challenges they face in vocational education?

We have suggested to continue adding authenticity and ownership of learning to hands-on simulation when they are intended to foster competence development, instead of only technical or procedural skills, and we have provided practical implications to further optimise hands-on simulations. Because many questions remained as a result of this dissertation, future research about the effects of constructivist learning and competence development in hands-on simulations is required. The main questions to examine further are: 'Can hands-on simulations with constructivist elements (Table 7.1) foster the development of other more attitude-related competencies?', 'How do the proposed teacher guidance approaches and student learning approaches account for competence development?', 'Which of the characteristics for innovative hands-on simulations contribute the most to competence development?', 'And do innovative hands-on simulations foster transfer of professional competence?' To do so, this section proposes two possible ways of examining hands-on simulations: to examine hands-on simulations in a laboratory setting and to examine them in their naturalistic setting, through applied research. Earlier we formulated seven limitations that we encountered during our research: 1) limited context of the studies; 2) simulations were examined in their full complexity; 3 & 4) specific characteristics of the expert teachers and the students; 5) not integrating student perceptions in the experimental study and 6 & 7) measuring only a limited set of competencies from the qualification framework with a self-report instrument. Both proposed research methods have their advantages and challenges regarding these limitations.

A. Examine hands-on simulations in laboratory settings

The advantage of examining hands-on simulations within a laboratory setting is that researchers can control and manipulate the learning context. Take the example of veterinary assistant students who have to learn how to handle an intake of a sick dog. Students can be randomly allocated to four conditions that differ in SDL and authenticity. For example, condition one is completely teacher-directed without SDL and students are not involved in creating a role-play script; in condition two the students' learning goals are leading for the simulation but students are not involved in creating the authentic role-play script; in condition three the simulation is teacher-directed but the students are involved in creating the role-play script and in condition four the students' learning goals are leading for the simulation and students co-created the authentic role-play script with the teachers.

Several limitations that we encountered in this dissertation can be tackled with this study design. First of all, the isolated effects of the learning context and learning approaches can be measured. Also, specific teacher characteristics or behaviours are less of an influence in the process. Teachers as well as students work with scripts to guide them through the simulations. This way, correct implementation of the intervention is assured. Laboratory simulation settings can be designed for many kinds of professional tasks, for students from various educational levels, making it easier to generalise the findings. It is even possible to overcome the limitation we had with basing our findings mostly on self-reports. Authentic assessment forms can be used that require students to perform a task at the end of the simulation (Gulikers, Bastiaens, & Kirschner, 2004), which makes it possible to actually measure and compare professional competence across the simulations.

There are, however, limitations. Hands-on simulations are very expensive to develop and to maintain, which is why educators increasingly turn to virtual simulations and design simulations of short duration, making the development of competencies a challenge. Also, the social dynamics that go together with a work environment—an important aspect for constructivist learning—are very hard to replicate in a simulated learning environment that is controlled and scripted. Moreover, controlled and scripted learning without social dynamics of the workplace can also inhibit (perceived) authenticity. Furthermore, in laboratory settings it is not possible to increase authenticity by expanding the learning contexts to other contexts outside the simulation centre. The power of our study was that students simulate working on professional tasks in various authentic contexts, for example in a stable with real cows especially designed for training, and in real local farms where specific materials for the task were at hand.

B. Examine hands-on simulations through applied research

The studies in our research were all 'in the wild', meaning that we as researchers did not have much control over the implementation of the learning intervention and other factors that could have influenced the learning. Though we have experienced the complexity of examining hands-on simulations this way, we think that most can be gained by paying attention to specific teacher training since implementation of innovative learning environments depends heavily on teachers' skills and beliefs about the concepts of the intended innovation (Guskey, 1994). We believe that the expert teachers were not familiar enough with the innovations the researchers intended to establish in Chapter 5 and that were examined in Chapter 3 and 6. Teacher training programmes can be effective for this purpose; however, for its effectiveness it is important that teacher training is directly related to the teachers' teaching practise and subject matter (Van Veen, Zwart, Meirink, & Verloop, 2010). This can be done through a *double layered* training method. To increase teachers' skills in guiding complex work-related learning we suggest that teachers themselves go through the phases of an authentic work-related task by working on an authentic (subject-related) assignment in groups including a preparation and follow-up phase, and that they reflect (through active teaching methods) on their experiences with various guidance approaches and how they use them in daily practice while working on self-formulated learning goals. Such a training was developed as a result of the researchers' experiences with and findings of this dissertation (Khaled & Luchtman, 2013) and was pilot tested with teachers from a simulation centre and from a higher vocational education institute. Experiences from this pilot were positive and a training self-evaluation even showed that: 1) teacher roles became more stronger connected to the phases of an authentic task; 2) teachers were more conscious of group dynamics; 3) teachers focussed more on how to guide students and 4) they felt more confident in approaching students. A prerequisite for the success of this training is that the teachers are familiar with designing an authentic, self-directed and self-regulated learning environment. When this is still a struggle for teachers, training should first focus on how to design such learning environment. As such the double layered training should increase the probability that teachers implement the intervention as intended.

Thus, researchers can eliminate many practical issues by examining hands-on simulations in laboratory settings. However, it will be a challenge to establish laboratory settings that last long enough for competence development. Moreover, laboratory settings affect social dynamics of work-related contexts that are important for competence development. Therefore, we think that researching in the wild offers more potential for examining competency development. Although examining hands-on simulations in their naturalistic settings was a challenge, we think that research in the wild combined with teacher training and better integrating constructivist learning in the whole curriculum puts researchers one step closer to examining what actually matters for competence development in hands-on simulations.

To sum up, the answer to the first central question '*To what extent should we 'innovate' hands-on simulations for competence development?*' depends on the specific learning outcomes of the vocational curriculum for which the simulations are used. When educationalist strive to utilise hands-on simulations for a wide range of competencies, innovations in the form of adding authenticity and ownership of learning are encouraged. A very important condition is, however, that the whole curriculum strives for constructivist learning and that students are familiar with and practised to some extent in taking ownership of learning in authentic learning tasks. When teachers and educationalists do not strive for competency development in hands-on simulations, innovations in hands-on simulations is not a first priority. However, meaningful learning, such as pausing simulations, reflection-in-action and consequently adapting behaviour remains essential. Research showed that meaningful learning frequently lacks in hands-on simulations, but when teachers have more attention for this we think also traditional simulations can have a place in an innovative curriculum.

The answer to the second central question '*What further steps do we need to take to integrate hands-on simulation in an innovative vocational curriculum?*' is that there are steps to take for teachers of both the traditional and the innovative hands-on simulations. Teachers in the traditional simulations should explicitly formulate that the simulation is used only for specific procedural and technical knowledge and skills that are part of the professional competence, and we suggest that teachers should communicate to students how the knowledge and skills relate to their professional work. We suggest that teachers and educationalist who want to innovate their simulations should use the strategies for adding authenticity and ownership of learning in hands-on simulations (Table 7.1) to integrate social aspects of learning with explicit attention to attitudes, to communicate better with school teachers to promote continuity of learning between learning contexts and to include preparation and follow-up in hands-on simulations.

To conclude, our answer to the main question *'Do hands-on simulations add value to an innovative vocational curriculum?'* is yes, provided that 1) traditional hands-on simulations are used only for specific technical and procedural knowledge and skills as part of professional competence and that meaningful learning is assured, that 2) students are learned to use SRL and SDL skills throughout the vocational curriculum and that 3) innovative, constructivist, hands-on simulations integrate social aspects of learning and students' development of competence including their attitudes.

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Summary

Hands-on simulations in vocational education

An essential aim of vocational education is to develop profession-specific knowledge and skills as well as new outcomes required by the workplace, such as dealing with a wide range of ill-structured problems and being creative, innovative and inquisitive—referred to in combination as professional competence. To accomplish this, innovations in vocational education emerge with a strong emphasis on outcomes formulated in collaboration with the labour market. Active learning in work-related learning environments should strengthen the connections between school learning and workplace learning. This situative perspective on learning originates from the idea that preparing students for their future requires confronting them with real-world problems and contexts, including the social dynamics related to that practice. Although educationalists and teachers increasingly put effort into designing new meaningful work-related learning contexts, such as hybrid learning environments and regional learning, hands-on simulations have been used in secondary and higher vocational education for decades. In hands-on simulations, professional contexts and tasks are replicated in a live environment at school or at a training centre with tangible materials and equipment. Novice or intermediate students, who are inexperienced in their professional field, will learn in a safe and controlled environment to perform professional tasks, from simple to complex. Benefits of simulation-based learning include standardization and repetition of tasks, 'training' many students in a short time, learning in real-life contexts without consequences, pausing the session whenever felt necessary and the ability to create a goal-oriented learning environment.

Problem statement

The problem with hands-on simulations in vocational education is, however, that educationalists and teachers increasingly use hands-on simulations in vocational curricula but struggle with integrating them in the *innovative* curriculum. The first reason is that pedagogical-didactic approaches in hands-on simulations are not well conceptualised from the constructivist learning theory perspective underlying innovative vocational education for competence development. Specifically two aspects of constructivist learning claim to foster competence development, namely 1) *authenticity* – realistic learning contexts and tasks and 2) *taking ownership of learning* (i.e. *self-directed learning* – students steer their learning by choosing learning content, and *self-regulated learning* – students control their learning during task performance). However, research on the effects of authentic design of hands-on simulations for competence development is ambiguous and research on taking ownership of learning in hands-on simulations is scarce. The second reason is that there are no straightforward guidelines for teachers about how to implement and use hands-on simulations in an innovative curriculum. Therefore, the objective of this dissertation was to examine the added value of hands-on simulations in vocational curricula that aim at new outcomes, such as professional competence. This dissertation investigated how the specific constructivist learning environment characteristics, authenticity and ownership of learning, *are* and *can* be integrated in hands-on simulations and how they affect student learning.

Context of this dissertation

The context of this dissertation was secondary and higher vocational life-science education in the Netherlands. Every year, vocational life-science students participate in a hands-on simulation in training centres outside school, which is where we collected our data. Since 2010, the educational innovation *competence-based education* has been implemented in Dutch vocational education aiming at professional competence development. The standard of performances for professional competence are formulated in National Qualification Frameworks with *competencies* as *parts of professional competence*; a cluster of knowledge, skills and attitudes that one uses during job performances. For example, a florist needs to have: 1) broad knowledge about all the flowers he/she sells and about all innovations in the field and about how to do the bookkeeping; 2) he/she needs to have the skills to assemble flower bouquets and to dress the shop window and 3) he/she needs to be able to communicate in a friendly manner with (complaining) customers and in a professional manner with suppliers. This requires competencies, such as problem solving, planning, innovating, coping with stress, communicating, showing empathy and craftsmanship. The competencies formulated in the Dutch qualification framework were the main outcomes measured as a result of learning in hands-on simulations.

Content of this dissertation and main findings

To answer the question *'What is the added value of hands-on simulations in an innovative vocational curriculum?'* we conducted a systematic literature review, a survey study, an experimental study and an observation study and we validated a competency self-report instrument.

Firstly, a systematic literature review was conducted to position hands-on simulations in relation to two other work-related learning environments (i.e. authentic projects and internships) based on their learning environment characteristics and their learning outcomes (Chapter 2). The results of the literature review showed that, compared to other work-related learning contexts, hands-on simulations are powerful because they provide opportunities for learning from feedback, intensive coaching, learning by doing, learning from observing others and learning by reflection-in-action. However, evidence of the development of competencies and the presence of the learning environment characteristics regarded as important for developing competence: authenticity and ownership of learning (i.e. self-directed learning and self-regulated learning), were structurally lacking in the included studies. An additional literature search showed that hands-on simulations do have potential to be 'innovative' and resulted in a framework with strategies for stimulating authentic learning and ownership of learning for competence development in hands-on simulations.

The empirical chapters made an in-depth study of the authenticity and ownership of learning in hands-on simulations. We examined whether authenticity and ownership of learning indeed foster the development of competencies in hands-on simulations. The empirical studies showed that this is not directly the case.

Chapter 3 describes a survey study with 516 students in 23 hands-on simulations aiming at answering the following questions:

1) To what extent do authenticity and self-directedness foster the development of conceptual and operational competencies for secondary and higher vocational education students in hands-on simulations?
2) Do students' perceived value, authenticity and choice explain additional variance in the relationship between authentic and self-directed design of the hands-on simulation and conceptual and operational competency development?

The results showed, unexpectedly, that authentic design of hands-on simulations, as perceived by the teachers, negatively predicted the development of *operational* competencies – 'applying expertise', 'using materials and products', 'following instructions and procedures', and *conceptual* competencies – 'planning and organising, 'deciding and initiating' and 'analysing'. The extent to which the hands-on simulation was self-directed did not directly affect competency development, but *through* the perceptions of the students regarding the learning environment; this means that self-directed learning activities affect students' perceptions regarding the learning environment in a positive manner, leading in turn to competency development.

In the experimental study (Chapter 5) our objective was to examine the effect of authenticity and ownership of learning on competency development in more detail (not only clusters of operational and conceptual competencies as in Chapter 3). To assess a wider range of competencies, we chose to use a competency self-report instrument. Because such an instrument did not exist for competencies from the Dutch competence-based Qualification Framework, we developed and validated a self-report questionnaire. Chapter 4 addressed following questions:

1) What is the construct validity of a competency self-report instrument with distinguishing competencies and indicators?
2) Is a competency measurement with such a self-report instrument robust across educational levels?

The results revealed that a competency instrument with multiple indicators per competency showed face validity, construct validity and robustness, meaning that the self-report instrument can be used for measuring competency development across different levels of vocational and higher education. This is, however, only the case for competencies that align with the aim of the course that the teacher intends to evaluate and for competencies that are concrete and easy to relate to specific situations, such as 'applying expertise' and 'planning'. Caution is advised when using abstract competencies, such as 'deciding and initiating', in competency self-reports.

The experimental study (Chapter 5) compared a traditional and an innovative hands-on simulation with first-year Applied Biology students attending sessions simulating aspects of their future profession for five days. Concrete strategies for adding authentic learning and ownership of learning to create innovative hands-on simulations (see Chapter 2) were added to a hands-on simulation. This 'innovative' simulation was compared to a 'traditional' hands-on simulation. Aiming at answering following research questions:

1) What is the influence of an authentic, self-directed and self-regulated hands-on simulation on higher vocational students' competency development?
2) What is the influence of an authentic, self-directed and self-regulated hands-on simulation on higher vocational students' near and far transfer of learning?
3) Is the effect of an authentic, self-directed and self-regulated hands-on simulation on student learning mediated by the students' perceptions regarding the learning environment?

The findings showed that the students developed four out of five intended competencies in the hands-on simulation. Unexpectedly, adding authenticity, self-directed learning and self-regulated learning to the hands-on simulation (i.e. the innovative simulation) did not increase development of competencies as well as near transfer of professional competence. The 'innovative' hands-on simulation was even perceived as less authentic than the traditional simulation and resulted in less far transfer of professional competence.

As the experimental study (Chapter 5) included observations of students' ownership of learning to assure the implementation of the innovation, Chapter 6 examines ownership of learning in more detail using the three phases of self-regulated learning from Zimmerman (2001) and Schunk (2001) as the theoretical framework. Eight hands-on simulations were observed for two days. The research questions were:

1) To what extent do teachers show the various types of behaviour for promoting self-regulated learning in hands-on simulations?
2) To what extent do students show the various types of self-regulated learning behaviour in hands-on simulations?
3) What is the quality of the teachers' strategies that promote self-regulated learning and the students' self-regulated learning strategies in the three phases, and how do teachers' and students' self-regulated learning behaviours look in the three phases with lower, medium and higher quality?
4) What types of behaviour do teachers and students show in hands-on simulations with lower, medium and higher *overall* self-regulated learning quality?

Where the experimental study suggests that actually implementing innovative strategies is challenging, the observation study shows that there is indeed a lot to gain with respect to students using self-regulated learning strategies and teachers promoting self-regulated learning strategies in hands-on simulations. The studies illustrate that students have some ownership over their learning in hands-on simulations. But the observations also showed that hands-on simulations vary a lot in terms of the frequency and quality of self-regulated learning and that there were few, if any, significant teacher strategies for stimulating self-regulated learning, such as giving attributional feedback and evaluation. Moreover, students were using few, if any, self-regulated learning strategies, such as goal setting and self-monitoring.

Conclusion and discussion

Because of the mixed findings, Chapter 7 presents an integrative discussion regarding the question '*Do hands-on simulations add value in an innovative vocational curriculum*?'

From a theoretical perspective we questioned: '*To what extent should we 'innovate' hands-on simulations for competence development?'* The answer depends on the specific learning intentions, and thus the involved learning processes, of the vocational curriculum for which the hands-on simulations are used. When educationalists strive to utilise hands-on simulations for a wide range of competencies, innovations in the form of adding authenticity and ownership of learning are encouraged. A very important condition is, however, that the whole curriculum strives for constructivist learning and that students are familiar with and practised to some extent in taking ownership of learning in authentic learning tasks. When teachers and educationalists do not strive for competence development in hands-on simulations and want to focus on learning processes for knowledge and skills development, innovations in hands-on simulations is not a first priority. However, meaningful learning, such as pausing simulations, reflection-in-action and consequently adapting behaviour remains essential. Research showed that meaningful learning frequently lacks in hands-on simulations, but when teachers have more attention for this we think also traditional simulations can have a place in an innovative curriculum.

From a practical perspective we questioned: '*What further steps do we need to take to integrate hands-on simulation in an innovative vocational curriculum?'* We argue that there are steps that can be taken by teachers of both the traditional and the innovative hands-on simulations. Teachers in the traditional simulations should explicitly formulate that the simulation is only used for specific procedural and technical knowledge and skills that are part of the professional competence and we suggest that teachers should communicate to students how the knowledge and skills relate to their professional work. We suggest that teachers and educationalist who want to innovate their simulations should use the revised framework with strategies for adding authenticity and ownership of learning in hands-on simulations (presented in Chapter 7), to integrate social aspects of learning with explicit attention to attitudes, to communicate better with school teachers to promote continuity of learning between learning contexts, and to include preparation and follow-up in hands-on simulations.

To conclude, our answer to the main question *'Do hands-on simulations add value to an innovative vocational curriculum?'* is 'yes', provided that 1) traditional hands-on simulations are used only for specific technical and procedural knowledge and skills as part of professional competence and assure meaningful learning, that 2) students are learned to use self-regulated and self-directed learning skills throughout the vocational curriculum and that 3) innovative, constructivist, hands-on simulations integrate social aspects of learning and students' development of competence including their attitudes.

Samenvatting (Dutch Summary)

Achtergrond

Het beroepsonderwijs wordt telkens meer ingericht om zogenaamde competente professionals op te leiden. De ontwikkeling van vakgerichte kennis en vaardigheden alsmede de meer 'nieuwe' uitkomsten zijn daarbij belangrijke doelen van het huidige beroepsonderwijs. Die nieuwe uitkomsten omvatten de vraag vanuit het beroepenveld om studenten beter voor te bereiden op een beroep waarin ze niet alleen de fijne kneepjes van het vak onder de knie hebben, maar ook kunnen omgaan met een grote variëteit aan complexe problemen én meer creatief, innovatief en onderzoekend gedrag vertonen. Om dit te bereiken zijn grote onderwijsinnovaties in het beroepsonderwijs ingevoerd, gebaseerd op het situatieve perspectief van leren. De basis van dit situatieve perspectief is dat studenten regelmatig confronteert moeten worden met realistische beroepsproblemen en -contexten, inclusief de sociale dynamiek die samengaat met het beroep, om ze goed te kunnen voorbereiden op hun toekomst als professional. Concreet gezien heeft dit in het beroepsonderwijs geleid tot onder andere de ontwikkeling en uitvoering van werk gerelateerde leeromgevingen, waarin actief en betekenisvol leren wordt gestimuleerd, zoals hybride leeromgevingen en regionaal leren.

Hands-on simulaties

Praktijksimulaties (in dit proefschrift gerefereerd als 'hands-on simulaties') zijn ook werk gerelateerde leeromgevingen. Zij niet nieuw; al tientallen jaren worden hands-on simulaties in het beroepsonderwijs gebruikt om werksituaties zo nauwkeurig mogelijk na te bootsen voor het aanleren van vooral technische en procedurele kennis en vaardigheden. Hands-on simulaties zijn praktijkgericht, wat betekent dat studenten in een gecontroleerde en veilige leeromgeving werken aan een echte beroepstaak, van simpel tot complex, met tastbaar materiaal. Voorbeelden zijn verpleegkundestudenten die in een compleet uitgeruste ziekenhuiskamer op een patiëntsimulator oefenen hoe te handelen bij een beroerte, of monteur studenten die op een echte tractor hydrauliekstoringen oplossen. Voordelen van hands-on simulaties zijn dat het doelgerichte leeromgevingen zijn, ze makkelijk te standaardiseren zijn en de mogelijkheid hebben tot het 'trainen' van studenten in een zo kort mogelijk tijdsbestek. Ook bieden ze kansen voor het oefenen in een realistische beroepsomgeving zonder consequenties, kunnen leersituaties worden herhaald en kan een docent een sessie op elk moment pauzeren voor feedback en reflectie.

Probleemstelling

Onderwijskundigen en docenten hebben door innovaties in het beroepsonderwijs steeds meer de behoefte om hands-on simulaties in hun onderwijspraktijk te integreren, het probleem is echter dat ze daar veel moeite bij ervaren. De eerste reden hiervoor is dat pedagogisch-didactische aanpakken niet goed zijn geconceptualiseerd vanuit de constructivistische leertheorie die ten grondslag ligt aan de onderwijsinnovaties gericht op de ontwikkeling van een competente professional of beroepsbeoefenaar. Er zijn twee aspecten van constructivistisch leren waarvan geclaimd wordt dat ze competentieontwikkeling stimuleren: 1) *authenticiteit:* realistische leercontexten en leertaken en 2) *eigenaarschap* (i.e. *zelfsturend leren*: studenten geven richting aan het leren door zelf de inhoud te kiezen en *zelfregulerend leren*: studenten hebben controle over hun leren tijdens het uitvoeren van de taak). We weten nog te weinig over het effect van deze twee aspecten op competentieontwikkeling in hands-on simulaties. De resultaten van eerder onderzoek naar de effecten van authenticiteit op competentieontwikkeling zijn ambigu en onderzoek naar de effecten van eigenaarschap in hands-on simulaties is schaars. Een tweede reden waardoor het moeilijk is om hands-on simulaties te integreren in het innovatieve beroepsonderwijs is dat er geen eenduidige richtlijnen zijn voor het implementeren en begeleiden van hands-on simulaties in een huidig beroepsgericht curriculum. Daarom heeft dit proefschrift het doel te onderzoeken wat de toegevoegde waarde van hands-on simulaties is in een huidig, innovatief, beroepsgerichte curriculum wat doelt op nieuwe leeruitkomsten zoals competentie ontwikkeling. Wij hebben onderzocht hoe de twee specifieke constructivistische leeromgevingskenmerken, authenticiteit en eigenaarschap, *zijn* en hoe deze *kunnen worden* geïntegreerd in hands-on simulaties en wat het effect daarvan is op het leren van studenten.

Context van dit proefschrift

De context van dit proefschrift is het groene middelbaar beroepsonderwijs (mbo) en groene hoger beroepsonderwijs (hbo) in Nederland. Het merendeel van de studenten in het groene onderwijs gaan gedurende hun onderwijstraject naar een trainingscentrum waar ze deelnemen aan hands-on simulaties. Hier hebben wij onze data voor dit proefschrift verzameld. De onderwijsinnovatie die sinds 2010 is ingevoerd in het Nederlandse beroepsonderwijs is *het competentiegericht onderwijs*. Het doel van het competentiegerichte onderwijs is het ontwikkelen van competente beroepsbeoefenaren. Op landelijk niveau zijn kwalificatiecriteria benoemd in de vorm van *competenties*. Deze landelijk geformuleerde competenties vormen in dit proefschrift de uitkomstmaat voor het leren in hands-on simulaties. Die competenties zijn onderdeel van het handelen van een *competente* beroepsbeoefenaar. Competenties vormen een cluster van kennis, vaardigheden en attituden die een persoon gebruikt voor het uitoefenen van zijn/haar beroep. Een bloemist moet bijvoorbeeld bezitten over: 1) brede kennis over alle bloemen die hij/zij verkoopt, over de innovaties die gaande zijn in het vakgebied en over het uitvoeren van de boekhouding; 2) de juiste vaardigheden om boeketten samen te stellen en het decoreren van de winkeletalage en 3) hij/zij moet in staat zijn om op een vriendelijke manier met (klagende) klanten te communiceren en om op een professionele manier met leveranciers te communiceren. Dit vereist competenties, zoals problemen oplossen, plannen, innoveren, omgaan met stress, communiceren, tonen van empathie en natuurlijk vakmanschap.

Inhoud van het proefschrift en de belangrijkste resultaten

Om antwoord te geven op de centrale *vraag 'Wat is de toegevoegde waarde van hands-on simulaties in een innovatief beroepsgericht curriculum?'* hebben we vijf studies uitgevoerd. Hoofdstuk 2 bevat een systematische literatuurreview, hoofdstuk 3 een vragenlijststudie, hoofdstuk 4 een validatie van een zelfrapportage instrument voor competentieontwikkeling, hoofdstuk 5 een experimentele studie en hoofdstuk 6 een observatiestudie.

De literatuurreview (hoofdstuk 2) vormt het theoretisch kader van dit proefschrift. Het doel van deze review is om hands-on simulaties beter te conceptualiseren in relatie tot de constructivistische leertheorie. Daarvoor hebben we hands-on simulaties gepositioneerd ten opzichte van twee andere werkplek gerelateerde leeromgevingen (i.e. authentieke projecten en stages). De positionering is gebaseerd op de leeromgevingskenmerken en de leeruitkomsten. De resultaten van de systematische literatuurstudie laten zien dat, in vergelijking met andere werk gerelateerde leeromgevingen, hands-on simulaties krachtige leeromgevingen zijn op het gebied van het leren van feedback, intensieve coaching, leren door te doen, leren door observatie van anderen en leren door te reflecteren gedurende de taak. De resultaten lieten ook zien dat er structureel bewijs miste over competentieontwikkeling in hands-on simulaties en over de aanwezigheid van de leeromgevingskenmerken die belangrijk zijn voor competentieontwikkeling (i.e. authenticiteit en eigenaarschap van het leren) in hands-on simulaties. Daarom werd er een aanvullende literatuurstudie uitgevoerd die liet zien dat hands-on simulaties de potentie hebben om 'innovatief' te zijn en een bijdrage kunnen leveren aan het huidige beroepsonderwijs. Dit resulteerde in een raamwerk met strategieën voor het stimuleren van authentiek leren en eigenaarschap van het leren in hands-on simulaties die het doel hebben om competentieontwikkeling te stimuleren.

De empirische hoofdstukken van dit proefschrift vormen een 'in-depth' onderzoek naar authenticiteit en eigenaarschap van het leren in hands-on simulaties. We hebben onderzocht of authenticiteit en eigenaarschap daadwerkelijk competentieontwikkeling tot gevolg hebben in hands-on simulaties. De empirische studies laten zien dat dit niet direct het geval is.

Hoofdstuk 3 beschrijft de vragenlijststudie, uitgevoerd bij 516 studenten uit 23 simulaties. De onderzoeksvragen van deze studie waren:

1) In welke mate zorgen authenticiteit en zelfsturing in hands-on simulaties voor het ontwikkelen van conceptuele en operationele competenties bij mbo en hbo studenten?
2) Verklaren de percepties van studenten over de authenticiteit, keuzevrijheid en waarde die ze hechten aan de leeromgeving, extra variantie in de relatie tussen een authentiek en zelfgestuurd design van hand-on simulaties en de ontwikkeling van conceptuele en operationele competenties?

De resultaten van de vragenlijststudie laten zien dat een authentiek design van hands-on simulaties de ontwikkeling van *conceptuele* competenties ('plannen en organiseren', 'beslissen en initiëren', 'analyseren') én *operationele* competenties ('vakvaardigheden toepassen', 'materialen en middelen inzetten', 'instructies en procedures opvolgen') *negatief* voorspellen. De mate waarin studenten zelfsturing hadden, voorspelde niet direct de conceptuele en operationele competentieontwikkeling van studenten, maar had effect *via* de percepties die studenten hadden van de leeromgeving. Dit betekent dat zelfsturende activiteiten die docenten in hands-on simulaties inzetten weldegelijk een positief invloed hebben op de percepties die studenten van de leeromgeving hebben, wat weer een positieve invloed heeft op hun competentieontwikkeling.

De experimentele studie (hoofdstuk 5) heeft het doel om het effect van authenticiteit en eigenaarschap van het leren in meer detail te onderzoeken. We wilden niet alleen clusters van operationele en conceptuele competenties onderzoeken, zoals in hoofdstuk 3. Om het mogelijk te maken een bredere selectie van competenties gelijk aan de landelijk vastgestelde competenties te toetsen hebben we een zelfrapportage instrument ontwikkeld. Een dergelijk instrument bestond nog niet voor de nationaal geformuleerde competenties van het Nederlandse beroepsonderwijs. Hoofdstuk 4 rapporteert over de ontwikkeling en validatie van dit instrument. De volgende onderzoeksvragen staan hierbij centraal:

1) Wat is de validiteit van een zelfrapportage instrument met onderscheidende competenties en indicatoren?
2) Is een competentiemeting met een dergelijk zelfrapportage instrument robuust voor verschillende onderwijsniveaus?

De resultaten lieten zien dat een zelfrapportage met meerdere indicatoren per competentie valide (indruksvaliditeit en begripsvaliditeit) en robuust is. Dit betekent dat een zelfrapportage instrument gebruikt kan worden voor het meten van competentieontwikkeling voor verschillende onderwijsniveaus in het beroepsonderwijs en het hoger onderwijs. Dit is echter alleen het geval voor competenties die in lijn zijn met het doel van de cursus die de docent wil evalueren én voor competenties die concreet zijn geformuleerd en makkelijk te koppelen zijn aan specifieke (werk)situaties, zoals 'vakdeskundigheid toepassen' en 'plannen'. Wij adviseren om in zelfrapportage instrumenten kritisch om te gaan met abstracte competenties, zoals 'beslissen en initiëren'.

De experimentele studie (hoofdstuk 5) maakt een vergelijking van een 'traditionele' en 'innovatieve' hands-on simulatie. Eerstejaars studenten participeerden gedurende 5 dagen in een simulatie die sterk gericht was op hun toekomstige beroep als toegepaste bioloog. Concrete strategieën voor authentiek leren en eigenaarschap van het leren (innovatieve simulaties, zie hoofdstuk 2) werden aan een hands-on simulatie toegevoegd. De studenten moesten bijvoorbeeld werken aan een overkoepelende authentieke opdracht en er waren meer keuzemomenten. Hoofdstuk 5 vergelijkt de leeruitkomsten (competenties en transfer:

toepassen van de competenties in een andere situatie) en de studentpercepties van de 'innovatieve' simulatie met die van de 'traditionele' simulatie. De onderzoeksvragen waren:

1) Wat is de invloed van een authentieke, zelfgestuurde en zelfregulerende hands-on simulatie op de competentieontwikkeling van hbo-studenten?
2) Wat is de invloed van een authentieke, zelfgestuurde en zelfregulerende hands-on simulatie op de nabije en verre transfer van het leren van hbo-studenten?
3) Wordt het effect van een authentieke, zelfgestuurde en zelfregulerende hands-on simulatie op competentieontwikkeling gemedieerd door de percepties die hbo-studenten hebben van de leeromgeving?

De resultaten lieten zien dat studenten in beide simulaties vier van de vijf competenties ontwikkelden. Tegen verwachting in was dit gelijk voor beide simulaties. Ook had het toevoegen van authenticiteit en eigenaarschap (zelfsturing en zelfregulatie) geen effect op de nabije transfer van het leren. De 'innovatieve' hands-on simulatie werd zelfs gezien als minder authentiek dan de 'traditionele' hands-on simulatie en resulteerde in mindere mate tot verre transfer.

Om de implementatie van de strategieën – afgeleid uit de literatuurreview - voor een innovatieve hands-on simulatie te waarborgen, hebben we in de experimentele studie (hoofdstuk 5) ook gebruik gemaakt van observaties van eigenaarschap. In hoofdstuk 6 gaan we dieper in op eigenaarschap van het leren door middel van een analyse van observaties van acht simulaties. Het theoretisch raamwerk voor deze studie bevat de drie fasen voor zelfregulerend leren van Zimmermann (2001) en Schunk (2001). De onderzoeksvragen waren:

1) In welke mate laten docenten de verschillende gedragingen voor het stimuleren van zelfregulerend leren zien in hands-on simulaties?
2) In welke mate laten studenten de verschillende gedragingen van zelfregulerend leren zien in hands-on simulaties?
3) Wat is de kwaliteit van de strategieën die docenten laten zien voor het stimuleren van zelfregulerend leren en van de zelfregulerende strategieën die de studenten gebruiken, en hoe zien deze gedragingen eruit in de drie fases met een lagere, gemiddelde en hogere score voor kwaliteit?
4) Wat voor typen gedrag laten docenten en studenten zien in hands-on simulaties met een lagere, gemiddelde en hogere totale score voor kwaliteit?

De experimentele studie liet al zien dat het daadwerkelijk implementeren van innovatieve strategieën in hands-on simulaties een grote uitdaging is. De observaties laten zien dat er inderdaad nog veel te verbeteren valt als het gaat om het gebruik van zelfregulerende strategieën in hands-on simulaties. Zowel voor het stimuleren van zelfregulatie door docenten als het gebruik van zelfregulerende strategieën door studenten. De experimentele en de observatiestudie lieten zien dat studenten in enige mate eigenaar zijn van hun leren. Maar de observaties lieten ook zien dat de frequentie en de kwaliteit van de zelfregulerende strategieën erg veel varieerde tussen de acht simulaties. Ook observeerden we erg weinig van de belangrijke strategieën voor het stimuleren van zelfregulatie, zoals het geven van attributionele feedback en evalueren. Bovendien, gebruikten studenten bepaalde belangrijke strategieën maar heel weinig, zoals het stellen van doelen en zelfmonitoren.

Conclusie en discussie

Omdat dit proefschrift gemixte resultaten opleverde, bevat hoofdstuk 7 een aantal ideeën voor toekomstig experimenteel en praktijkonderzoek naar innovaties in hands-on simulaties. Daarnaast bevat hoofdstuk 7 een geïntegreerde discussie over de vraag *'Hebben hands-on simulaties wel een toegevoegde waarde in een innovatief beroepsgericht curriculum?'*

Vanuit een theoretisch perspectief vroegen we ons af: *'In welke mate moeten we voor competentieontwikkeling hands-on simulaties nu 'innoveren'?'* Het antwoord hangt af van de specifieke leerintenties, en dus de specifieke leerprocessen, van het betreffende curriculum waarvoor de simulaties gebruikt worden. Wanneer onderwijskundigen of docenten ernaar streven om de hands-on simulatie in te zetten voor het ontwikkelen van een brede variatie aan competenties moedigen wij ze aan om door te gaan met het innoveren van de simulaties. Daarbij is het belangrijk dat het *gehele* curriculum streeft naar constructivistisch leren en dat studenten bekend zijn met of geoefend hebben in het nemen van eigenaarschap en authentiek leren. Wanneer docenten en docenten niet streven naar competentieontwikkeling en meer leerprocessen willen stimuleren die passen bij beroepsgerichte kennis en vaardighedenontwikkeling, dan heeft het innoveren van hands-on simulaties geen prioriteit. Betekenisvol leren, zoals het pauzeren van sessies, reflecteren op wat er gebeurde (reflectie-in-actie) en het gedrag daarop aanpassen in de volgende sessie zijn in een traditionele simulatie dan wel essentieel. Het onderzoek liet zien dat dit nog regelmatig miste in simulaties, maar als hier meer aandacht voor is dan verwachten wij dat ook traditionele simulaties een plek kunnen hebben in een innovatief curriculum.

Vanuit een praktisch perspectief vroegen we ons af: *'Welke vervolgstappen moeten we nemen voor het integreren van een hands-on simulatie in een innovatief beroepsgericht curriculum?'* De conclusie is dat stappen te nemen zijn voor zowel docenten ven een innovatieve simulatie als van een traditionele simulatie. Voor docenten van traditionele simulaties is het belangrijk dat de doelen van de simulaties zich ook echt beperken tot alleen technische en procedurele kennis en vaardigheden. Daarbij is het belangrijk dat docenten in de laatste situatie expliciet maken hoe de vaardigheden en kennis in verhouding staat tot wat er van de studenten wordt verwacht (de kwalificatiecriteria en -competenties).We adviseren docenten die wel willen innoveren gebruik te maken van het bijgestelde raamwerk met strategieën voor het toevoegen van authenticiteit en eigenaarschap (zie hoofdstuk 7) in hands-on simulaties, de sociale aspecten van het leren te integreren en daarvoor extra aandacht te hebben voor attitudes, beter te communiceren met de andere schooldocenten die betrokken zijn bij het curriculum om zo de continuïteit tussen onderwijs en beroep te versterken en om voorbereidingsactiviteiten en follow-up activiteiten aan de hands-on simulaties toe te voegen.

Samengevat is het antwoord op de vraag *'Hebben hands-on simulaties wel een toegevoegde waarde in een innovatief curriculum?'* 'ja' wanneer 1) traditionele hands-on simulaties alleen gebruikt worden voor technische en procedurele kennis en vaardigheden en betekenisvol leren garanderen, 2) studenten gedurende het gehele curriculum geleerd wordt om zelfsturende en zelfregulerende strategieën in te zetten en 3) innovatieve, constructivistische, hands-on simulaties sociale aspecten van leren aanstippen en de ontwikkeling van attitudes bevordert.

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Anne

About the author

Anne Khaled was born on October 12, 1983, in Nijmegen. After secondary school she studied Teacher-training College (B) at the HAN University of Applied Sciences and Orthopedagogics & Educational Sciences (BSc) and Educational Sciences (MSc) at the Radboud University Nijmegen. After graduation in 2008, she worked as a HRD consultant in Utrecht. In 2009, she started her PhD-project on the topic of hands-on simulations in vocational education at the Wageningen University. Anne currently works at the research group (lectoraat) Vocational Education at the University of Applied Sciences Utrecht and teaches on the topic of Learning in Organisations at the department of Education at Utrecht University.

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Completed Training and Supervision Plan
Anne Elisabeth Khaled
Wageningen School of Social Sciences (WASS)

in the context of the research school

Interuniversity Center for Educational Research

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Writing my proposal	WASS	2009	6
Competence theory and research	WASS/ICO	2012	4
Learning in and for vocations and professions	ICO	2012	3
B) General research related competences			
Introductory course	ICO	2010	7
Quantitative Data Analysis: Multivariate Techniques (YRM-60306)	WUR	2010	4
Qualitative research	ICO	2011	4
Qualitative research with Atlas.ti: a hands-on practical	WASS	2013	1
Academic writing	WUR Language Services	2010	1
Scientific writing	WUR Language Services	2011	1.5
Toogdagen/National fall school	ICO	2011	1
International fall school Girona	ICO	2012	1
"Het ontwikkelen van competenties in de beroepscontext: positioneren van praktijksimulaties"	National conference Onderwijs Research Dagen (ORD), Maastricht University	2011	1
"Learning for New Outcomes in Professional Contexts: Positioning Practical Simulations"	International Conference The European Conference on Educational Research (ECER), Freie Universität Berlin	2011	1
"The Effects of Authenticity and Self-regulation: Comparing the Power of Innovative and Traditional Practical Simulations"	Annual meeting of the American Educational Research Association, Vancouver, CA	2012	1
"De effecten van krachtige leeromgevingen: een vergelijking van innovatieve en traditionele praktijksimulaties"	National conference Onderwijs Research Dagen (ORD), WUR ECS/Stoas	2012	1
"Competentie en competentiegroei volgens zelfbeoordelingen afgezet tegen andere beoordelingsmethoden"	National conference Onderwijs Research Dagen (ORD), Vrije Universiteit Brussel	2013	1
Total			38.5

*One credit according to ECTS is on average equivalent to 28 hours of study load