BERJ | British Educational Research Journal
BERA

British Educational Research Journal
Vol. 41, No. 2, April 2015, pp. 265–286
DOI: 10.1002/berj.3138

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

Anne Khaled*, Judith Gulikers, Harm Biemans and Martin Mulder
Wageningen University, The Netherlands

Hands-on simulations are increasingly used in vocational oriented curricula to create meaningful, occupation-related learning experiences. However, more insight is required about precisely what characteristics in hands-on simulations enhance outcomes that students need for their future occupation, such as competencies. This study aims to examine how constructivist pedagogical–didactic design principles affect competence development of senior vocational education and professionally oriented bachelor's degree students in a wide range of hands-on simulations. 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 (operationalized as choice), as well as their competence 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 competence development; and (2) student perceptions of perceived value, authenticity and choice of *how* to perform tasks were the main predictors of competence 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 competence 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 competence development, are suggested.

Vocational educational institutes increasingly use hands-on simulations to create meaningful learning experiences that are closely related to the students' future occupation (Rush *et al.*, 2010). The main intention is to strengthen the links between school and workplace learning in order to develop expertise and more general competencies, which is a constant struggle for vocational education (Akkerman & Bakker, 2011). Hands-on simulation involves active learning with guidance from an expert teacher through tasks and contexts that are designed to reflect real occupational practice, including real materials and equipment (Bradley, 2006; Boersma *et al.*, 2009).

*Corresponding author. Education and Competence Studies, Social Sciences Group, Wageningen University and Research Center, PO Box 8130, 6700 EW Wageningen, The Netherlands. Email: anne.khaled@wur.nl

At the demand of the student or the teacher, simulated events can be paused, followed by reflection-on-action (Maran & Glavin, 2003). Vital in hands-on simulation is experiencing the difference between the ideal behaviour that is learnt in the theoretical part of education, and the true behaviour of the actual workplace (Elbadawi *et al.*, 2010). Despite the fact that hands-on simulations are more frequently used in vocational and professional-oriented curricula, there is very little insight into how their learning environment characteristics actually relate to contemporary learning outcomes, such as competencies (Rush *et al.*, 2010). The main reasons for this lack of insight are: (1) the little governmental supervision of hands-on simulation since it is often not recognized as an official form of workplace learning, e.g., in the Netherlands hands-on simulation is a 'special form of professional training' (Inspectie van het Onderwijs, 2012); (2) 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; and 3) hands-on simulations are often associated with the words 'fun' and 'exciting', but empirical research on learning in hands-on simulation is scarce (Jossberger *et al.*, 2010). The aim of this study is to examine how constructivist pedagogical-didactic design principles affect competence development of students in senior vocational education and professionally-orientated bachelor's degree in a wide range of hands-on simulations. We also examine how student perceptions of these learning environment characteristics contribute to their competence 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 occupation-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 occupation-related contexts (Mulder, in press). Thus, we view competencies as integrative constructs that gain meaning in a certain occupational context. Delamare-Le Deist and Winterton (2005) unify dominant approaches of the concept of competence across countries in a model (Figure 1); they distinguish competencies to function in the occupation and as a person. Competencies one needs in one's occupation 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 occupational dimension. Hands-on simulations aim at both conceptual and operational competencies.

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

Figure 1. Typology of competence by Delamare-Le Deist & Winterton (2005)

Therefore, this study 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, in press). 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 *et al.*, 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). In the past decades, various situated learning environments have been created to prepare students for their future occupation, e.g., problem-based learning (Dochy *et al.*, 2005) and virtual simulations (Kester *et al.*, 2007). Those situated learning environments are not always based on the same set of design principles. However, two key 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 *et al.*, 2005; Ning & Downing, 2012), we will also elaborate on how student perceptions of these principles influence their learning.

Authenticity and self-directedness 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 *et al.*, 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 *et al.*, 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 occupational practice (Dieckmann *et al.*, 2007; Jossberger *et al.*, 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 *et al.,* 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* competence development. However, Herrington and Herrington (2006) and Gulikers *et al.* (2004) argue that, next to a physical context that resembles the future occupation, 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* competence 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 (Beaten *et al.*, 2010). Though self-directed learning environments are typically student-oriented, teacher guidance is still important and more effective for novice and intermediate students (Kirschner *et al.*, 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 *et al.,* 2004). Since self-directed learning heavily relies on *conceptual* competencies, such as metacognitive awareness, involving goal setting, making a plan to achieve these goals and decision-making (Loyens *et al.*, 2008), teacher-centred learning environments are less likely to stimulate the development of these cognitive and metacognitive (i.e.

conceptual) competencies (Boeckaerts, 1999). This could explain why empirical research studying conceptual competence development in self-directed hands-on simulations is lacking. With respect to *operational* competencies, Brydges *et al.* (2010) recently examined 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* competence 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

According to Pridham and colleagues (2012), students learn through the interplay of mind, body, feelings and environment in work-based 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-oriented 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 *et al.*, 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 occupational 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 *et al.*, 2006)? According to Barab and colleagues (2000), the degree to which the students feel the learning environment, developed by teachers, resembles occupational 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 *et al.*, 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, such as problem-solving. Rystedt and Sjöblom (2012) state that it is a prerequisite for students to understand *what the simulation is a simulation of*. Boersma and colleagues (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 occupational 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 both operational and conceptual competence development.

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 and colleagues (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* competence 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 suggest that perceiving freedom of choice stimulates students' *conceptual* competence 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 cognitive complex situations inhibited students from challenging themselves and caused them to choose simple tasks to compensate for their feeling of incompetence, but 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 competence development. The research questions are:

1. To what extent do authenticity and self-directedness foster the development of conceptual and operational competencies for senior vocational and professionally-oriented bachelor's degree 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?

We hypothesise that: (1) authenticity and self-directedness in hands-on simulations stimulate more competence 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 competence 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 occupation-related learning environments in senior vocational and professional bachelor's degree education. Moreover, the findings result in practical guidelines on how hands-on simulations could best be designed and used for competence 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 vocation-oriented curriculum.

Method

Hands-on simulations

Data collection took place in hands-on simulations that were off school campus and functioned as the practical part of a particular semester or trajectory in the formal curriculum. The hands-on simulations in our study are characterised as follows: (1) the learning settings were *simulations* of workplace contexts and occupational tasks; (2) the simulations were *practical* and hands-on (working on tasks in a real life setting with real material and real equipment); (3) with the aim to *train* students for vocational-specific skills as well as for more generic competencies guided by expert teachers from a training centre outside school. A total of 23 hands-on simulations were evaluated in the domains of animal husbandry and 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). 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

In the Netherlands there are two vocational pathways that students can follow after secondary education: senior vocational education or a professionally-oriented bachelor's degree (Van der Sanden *et al.*, 2012). In the context of the European Qualification Framework, the Dutch senior vocational education pathway is practically oriented and equals EQF 1–4; the professional bachelor is more theoretically challenging and equals EQF 6. Both pathways prepare students for a specific occupation by integrating theory and practice in the curriculum. Both pathways include various work-based learning settings, such as internships, authentic projects and hands-on simulations, for developing vocational expertise and more general competencies. 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 senior vocational education levels 2, 3 and 4, frequently combined in mixed groups (mean age = 18.5, SD = 1.8). In the final analysis, senior vocational education students were combined because educational level was no significant predictor of the dependent variables (Table 2). 33.7% of the students were at the professionally-oriented bachelor 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 competence 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) operationalized authenticity by 'Authentic subject matter' and 'Authentic structure and scope', whereas 'SD learning activities' and 'SD guidance' represented self-directedness (see Table 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 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 1. Learning environment characteristics used in present research (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 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 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 occupation' 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 *et al.*, 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 occupational 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 $\alpha = .76$.

Perceived choice. Because self-directed learning in hands-on simulation was mainly operationalized 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*).

Operational and conceptual competence development. The students' competence development was assessed using two scales derived from The Competence Development Meter (COM) (Khaled *et al.*, in press). 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 competence 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 Appendix A). Two separate scales were constructed based on the theoretical division of Delamare-Le Deist and Winterton (2005). The operational competence scale consisted of the items referring to the competencies 'applying expertise', 'using materials and products', 'following instructions and procedures' and 'cooperating' (Cronbach's α= .80). The conceptual competency scale consisted of the items referring to the competencies 'planning and organising', 'deciding and initiating activities' and 'analysing' (Cronbach's α = .79).

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 (Lizzio & Wilson, 2004; Gulikers *et al.*, 2006). In step 2, the authenticity and self-directedness were included as predictors of operational and conceptual competence 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 0.02, medium at 0.15 or large at 0.35 (Cohen, 1988).

Results

Means, standard deviations and correlations of all variables are illustrated in Table 2. The correlations between the student background, authenticity and self-directedness, student perceptions and competence 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

Table 2. Means, standard deviations, and zero-order correlations between the variables included in the study (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***	—
Mean	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 competence development; CONCOM = conceptual competence 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]senior vocational education = 1; professionally-oriented bachelors' degree = 2, *$p < .05$; **$p < .01$; ***$p < .001$ (two tailed).

negatively with operational and conceptual competence development. As expected, all four student perception variables had significant positive correlations with the competence development variables. To answer the research questions, however, hierarchical regression analyses were needed.

Hierarchical regression analyses

Operational competence development. Table 3 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 competence development (β = - .12) and positive significant relationships between three out of four student perception variables, and operational competence development, i.e., perceived value (β=.28), perceived authenticity (β = .19) and perceived

Table 3. Hierarchical regression analysis of LE characteristics and student perceptions as predictors of operational competence development controlled for student background variables (N = 516)

	Operational competence development								
	Step 1			Step 2			Step 3		
Predictors	B	SE B	β	B	SE B	β	B	SE B	β
Control variables									
Gender	–0.15	0.13	–0.06	–0.13	0.13	–0.05	0.02	0.12	0.01
Age	0.02	0.04	0.02	0.00	0.04	0.00	–0.01	0.03	–0.01
Level	–0.27	0.08	–0.19**	–0.21	0.09	–0.14*	–0.13	0.08	–0.09
Year	–0.01	0.11	–0.01	–0.12	0.12	–0.06	–0.03	0.11	–0.02
LE characteristics									
Authentic subject matter				–0.08	0.09	–0.04	–0.08	0.08	–0.04
Authentic structure & scope				–0.23	0.08	–0.15**	–0.19	0.07	–0.12*
SD learning activities				0.18	0.07	–.13*	–0.01	0.07	–0.01
SD guidance				–0.06	0.10	–0.04	0.01	0.08	0.01
Student perceptions									
Perceived value							0.33	0.06	0.28***
Perceived authenticity							0.42	0.11	0.19***
Perceived choice, what							0.05	0.04	0.07
Perceived choice, how							0.13	0.04	0.15**
R^2			0.03			0.05			0.30
Adjusted R^2			0.02			0.04			0.28
ΔR^2						0.02*			0.25***
f^2						0.02			0.36

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

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 = 0.02). However, when adding the student perception variables to the equation, the predicted variability increased from .04 to .28 (ΔR^2 = .25, p < .001). The effect size of student perceptions was large (f^2 = 0.36). Also, 'SD learning activities', which showed a significant positive relationship in model 2, became an insignificant predictor.

Conceptual competence development. Table 4 shows that, under control of students' background variables, 'Authentic subject matter' (β = - .12) and 'Authentic structure and scope' (β=–.15) predicted conceptual competence negatively. In line with the findings on operational competence development, three out of four student perception variables significantly predicted conceptual competence development, i.e.,

Table 4. Hierarchical regression analysis with LE characteristics and student perceptions as predictors of conceptual competence development controlled for student background variables (N = 516)

	Conceptual competence development								
	Step 1			Step 2			Step 3		
Predictors	B	SE B	β	B	SE B	β	B	SE B	β
Control variables									
Gender	–0.29	0.15	–0.09	–0.26	0.15	–0.08	–0.08	0.14	–0.03
Age	0.04	0.04	0.04	0.00	0.04	0.00	–0.01	0.04	–0.01
Level	–0.34	0.10	–0.20***	–0.23	0.11	–0.13*	–0.14	0.10	–0.08
Year	0.15	0.13	0.06	–0.00	0.14	–0.00	0.07	0.13	0.03
LE characteristics									
Authentic subject matter				–0.28	0.11	–0.12**	–0.28	0.01	–0.12**
Authentic structure & scope				–0.31	0.10	–0.18**	–0.26	0.09	–0.15**
SD learning activities				0.28	0.09	0.17**	0.08	0.08	0.10
SD guidance				–0.07	0.11	–0.03	–0.01	0.10	–0.00
Student perceptions									
Perceived value							0.28	0.08	0.20***
Perceived authenticity							0.49	0.13	0.19***
Perceived choice, what							0.08	0.04	0.09
Perceived choice, how							0.15	0.05	0.15**
R^2			0.05			0.09			0.29
Adjusted R^2			0.05			0.08			0.27
ΔR^2						0.04***			0.20***
f^2						0.04			0.28

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

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 = 0.04) 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 competence development, 'SD learning activities' became an insignificant predictor for conceptual competence 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 which we chose to unravel. The significant positive relationship between the 'SD learning activities' and operational and conceptual competence 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 *et al.* (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 pairwise 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 *et al.*, 2007). The size of an indirect effect is either small at 0.01, medium at 0.09, or large at 0.25 (Kenney, 2012). First, we conducted a bootstrap analysis with operational competence development as the dependent variable, the 'SD learning activities' as the independent variable, and students' perceived value, authenticity, choice of *what* and *how* as mediator variables. The same procedure was followed for the dependent variable conceptual competence development.

The bootstrap results indicated that all proposed mediators were statistically significant mediators in the relationship between 'SD learning activities' and both operational and conceptual competence development since no confidence intervals contained zero (see Table 5). Moreover, the direct effect became insignificant for the relationship between 'SD learning activities' and operational competence

Table 5. 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 competence 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 competence 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.

development (–0.082, $p = .15$), as well as for the relationship between 'SD learning activities' and conceptual competence development (–0.009, $p = .91$), meaning that student perceptions completely mediated the relationship between 'SD learning activities' and competence development. The total indirect effect of student perceptions was moderate for the relationship between 'SD learning activities' and operational competence development (0.169, 95% BCa CI between 0.092 and 0.250) and conceptual competence 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 competence development. To be more concrete, simulations that facilitate self-directed learning activities have a positive effect on operational and conceptual competence 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 study 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 senior vocational education and professional bachelor's degree 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 competence 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 competence 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 competence 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 occupational practice explain the unexpected finding regarding authenticity: teacher-rated authenticity was a small but significant *negative* predictor of competence development, while students' perceived authenticity was a significant *positive* predictor of competence 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 study. 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 *et al.*, 2008). The findings also suggest that teacher authenticity is somewhat more negatively related to conceptual competence development than to operational competence development (see Table 3 and 4). 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 example, 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 competence 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' competence 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 competence 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 competence development through the perceptions of the student (see Table 2), 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 (Schunk, 2001; Hattie, 2009).

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, competence 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 *et al.*, 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 and self-directedness, and student perceptions. This means that there were other factors involved in competence development in simulations which we did not measure. Although we investigated *perceived choice* and *perceived value for the future occupation* 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 competence development.

References

Akkerman, S.F. & Bakker, A. (2011) Boundary crossing and boundary objects, *Review of Educational Research*, 81(2), 132–169.

Baeten, M., Kyndt, E., Struyven, K. & Dochy, F. (2010) Using student-centred learning environments to stimulate deep approaches to learning: Factors encouraging or discouraging their effectiveness, *Educational Research Review*, 5(3), 243–260.

Barab, S., Squire, K. & Dueber, W. (2000) A co-evolutionary model for supporting the emergence of authenticity, *Educational Technology Research and Development*, 48(2), 37–62.

Beaubien, J. & Baker, D. (2004) The use of simulation for training teamwork skills in health care: how low can you go?, *Quality and Safety in Health Care*, 13(supplement 1), i51–i56.

Biemans, H., Wesselink, R., Gulikers, J., Schaafsma, S., Verstegen, J. & Mulder, M. (2009) Towards competence-based VET: Dealing with the pitfalls, *Journal of Vocational Education and Training*, 61(3), 267–286.

Billett, S. (2012) Authenticity in learning activities and settings, in: N.M. Seel (Ed.) *Encyclopedia of the sciences of learning* (Dordrecht, Springer), 388–391.

Bradley, P. (2006) The history of simulation in medical education and possible future directions, *Medical Education*, 40(3), 254–262.

Braun, E., Woodley, A., Richardson, J. T. E. & Leidner, B. (2012) Self-rated competences questionnaires from a design perspective, *Educational Research Review*, 7(1), 1–18.

Brydges, R., Carnahan, H., Rose, D. & Dubrowski, A. (2010) Comparing self-guided learning and educator-guided learning formats for simulation-based clinical training, *Journal of Advanced Nursing*, 66(8), 1832–1844.

Brookfield, S. (2009) Self-directed learning, in: R. Maclean M. Wilson (Eds) *International handbook of education for the changing world of work* (Netherlands, Springer), 2615–2627.

Brown, J. S., Collins, A. & Duguid, P. (1989) Situated cognition and the culture of learning, *Educational Researcher*, 18(1), 32–42.

Boekaerts, M. (1999) Self-regulated learning: Where we are today, *International Journal of Educational Research*, 31(6), 445–457.

Boersma, A., ten Dam, G., Volman, M. & Wardekker, W. (2009) 'This baby… it isn't alive.' Towards a community of learners for vocational orientation, *British Educational Research Journal*, 36(1), 3–25.

Boud, D. & Falchikov, N. (1989) Quantitative studies of student self-assessment in higher education: A critical analysis of findings, *Higher Education*, 18(5), 529–549.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences* (Hillsdale, NJ, Lawrence Erlbaum Associates).

Cumming, J.J. & Maxwell, G.S. (1999) Contextualising authentic assessment, *Assessment in education: Principles, Policy & Practice*, 6(2), 177–194.

De Bruijn, E. & Leeman, Y. (2011) Authentic and self-directed learning in vocational education: Challenges to vocational educators, *Teaching and Teacher Education*, 27(4), 694–702.

De Corte, E. (2003) Transfer as the productive use of acquired knowledge, skills and motivations, *Current Directions in Psychological Science*, 12(4), 142–146.

Delamare-Le Deist, F.D. & Winterton, J. (2005) What is competence?, *Human Resource Development International*, 8(1), 27–46.

Dieckmann, P., Gaba, D. & Rall, M. (2007) Deepening the theoretical foundations of patient simulation as social practice, *Simulation in Healthcare*, 2(3), 183–193.

Dochy, F., Segers, M., Bossche, P. & Struyven, K. (2005) Students' perceptions of a problem-based learning environment, *Learning Environments Research*, 8(1), 41–66.

Doyle, W. (1977) Paradigms for research on teacher effectiveness, in: L. S. Schulman (Ed.) *Review of research in education* (vol. 5) (Itasca, IL, F. E. Peacock), 163–198.

Elbadawi, I., McWilliams, D.L. & Tetteh, E.G. (2010) Enhancing lean manufacturing learning experience through hands-on simulation, *Simulation & Gaming*, 41(4), 537–552.

Gulikers, J., Bastiaens, T. & Kirschner, P. (2004) A five-dimensional framework for authentic assessment, *Educational Technology Research and Development*, 52(3), 67–86.

Gulikers, J., Bastiaens, T.J., Kirschner, P.A. & Kester, L. (2006) Relations between student perceptions of assessment authenticity, study approaches and learning outcome, *Studies in Educational Evaluation*, 32(4), 381–400.

Gulikers, J.T., Bastiaens, T.J., Kirschner, P.A. & Kester, L. (2008) Authenticity is in the eye of the beholder: student and teacher perceptions of assessment authenticity, *Journal of Vocational Education and Training*, 60(4), 401–412.

Hattie, J. (2009) *Visible learning* (London, Routledge).

Herrington, T. & Herrington, J. (2006) *Authentic learning environments in higher education* (Hershey, PA, Idea Group).

Inspectie van het Onderwijs (2012) *Onderzoek onderwijstijd BVE 2012 [Research education time in workplace learning 2012]*. Available online at: http://www.onderwijsinspectie.nl/actueel/publicaties/onderzoek-onderwijstijd-bve-2012.html (accessed 9 April 2013).

Jeffries, P.R. (2005) A frame work for designing, implementing and evaluating simulations used as teaching strategies in nursing, *Nursing Education Perspectives*, 26(2), 96–103.

Jossberger, H., Brand-Gruwel, S., Boshuizen, H. & Van de Wiel, M. (2010) The challenge of self-directed and self-regulated learning in vocational education: A theoretical analysis and synthesis of requirements, *Journal of Vocational Education & Training*, 62(4), 415–440.

Katz, I. & Assor, A. (2007) When choice motivates and when it does not, *Educational Psychology Review*, 19(4), 429–442.

Kenney, D. (2012) Mediation. Available online at: http://davidakenny.net/cm/mediate.htm (accessed 29 April 2013).

Kester, L., Kirschner, P. & Corbalan, G. (2007) Designing support to facilitate learning in powerful electronic learning environments, *Computers in Human Behavior*, 23(3), 1047–1054.

Khaled, A., Gulikers, J., Tobi, H., Biemans, H., Oonk, C. & Mulder, M. (in press) Exploring the validity and robustness of a competency self-report instrument for vocational and higher competence-based education, *Journal of Psychoeducational Assessment*.

Kirschner, P., Sweller, J. & Clark, R. (2006) Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching, *Educational Psychologist*, 41(2), 75–86.

Könings, K.D., Brand-Gruwel, S. & Merriënboer, J.J. (2005) Towards more powerful learning environments through combining the perspectives of designers, teachers and students, *British Journal of Educational Psychology*, 75(4), 645–660.

Lizzio, A. & Wilson, K. (2004) First-year students' perceptions of capability, *Studies in Higher Education*, 29(1), 109–128.

Loyens, S.M., Magda, J. & Rikers, R.M. (2008) Self-directed learning in problem-based learning and its relationships with self-regulated learning, *Educational Psychology Review*, 20(4), 411–427.

MacKinnon, D.P., Fairchild, A.J. & Fritz, M.S. (2007) Mediation analysis, *Annual Review of Psychology*, 58, 593–614.

Maran, N.J. & Glavin, R.J. (2003) Low- to high-fidelity simulation—a continuum of medical education?, *Medical Education*, 1(37), 22–28.

Maxwell, N.L., Mergendoller, J.R. & Bellisimo, Y. (2004) Developing a problem-based learning simulation: An economics unit on trade, *Simulation & Gaming*, 35(4), 488–498.

Mulder, M. (in press) Conceptions of professional competence, in: S. Billet, C. Harteis, H. Gruber (Eds) *International handbook on research into professional and practice-based learning* (Dordrecht, Springer), 1–22.

Nestel, D., Groom, J., Eikeland-Husebø, S. & O'Donnell, J. M. (2011) Simulation for learning and teaching procedural skills: The state of the science, *Simulation in Healthcare*, 6(7), S10–S13.

Ning, H.K. & Downing, K. (2012) Influence of student learning experience on academic performance: The mediator and moderator effects of self-regulation and motivation. *British Educational Research Journal*, 38(2), 219–237.

Patrick, J. (1992) *Training. Research and practice* (London, Academic Press Limited).

Preacher, K.J. & Hayes, A.F. (2004) SPSS and SAS procedures for estimating indirect effects in simple mediation models, *Behavior Research Methods, Instruments, & Computers*, 36(4), 717–731.

Preacher, K.J., Rucker, D.D. & Hayes, A.F. (2007) Addressing moderated mediation hypotheses: Theory, methods and prescriptions, *Multivariate Behavioral Research*, 42(1), 185–227.

Pridham, B., O'Mallon, S. & Prain, V. (2012) Insights into vocational learning from an applied learning perspective, *Vocations and Learning*, 5(2), 77–97.

Rudolph, J. W., Robert S. & Daniel B. R. (2007) "Which reality matters? Questions on the path to high engagement in healthcare simulation." *Simulation in Healthcare*, 2(3), 161–163.

Rush, S., Acton, L., Tolley, K., Marks-Maran, D. & Burke, L. (2010) Using simulation in a vocational programme: does the method support the theory? *Journal of Vocational Education & Training*, 62(4), 467–479.

Ryan, R.M. & Deci, E.L. (2000) Intrinsic and extrinsic motivations: Classic definitions and new directions, *Contemporary Educational Psychology*, 25(1), 54–67.

Rystedt, H. & Sjöblom, B. (2012) Realism, authenticity and learning in healthcare simulations: Rules of relevance and irrelevance as interactive achievements, *Instructional Science*, 40(5), 785–798.

Schunk, D. H. (2001) Social cognitive theory and self-regulated learning, in: B. Zimmerman & D. Schunk (Eds) *Self-regulated learning and academic achievement: theoretical perspectives* (Mahwah, NJ, Lawrence Erlbaum Associates, Inc.), 125–151.

Tabachnick, B. G. & Fidell, L. S. (2007) *Using multivariate statistics* (5th ed.) (New York, Allyn and Bacon).

Van der Sanden, K., Smit, W. & Dashorst, M. (2012) The referencing document of The Dutch National Qualification Framework to the European Qualification Framework. Utrecht: NCP-

NLQF; CEDEFOP Refernet (2010) *Netherlands. VET in Europe—country report 2010* (Thessaloniki, CEDEFOP).

Van Merriënboer, J. (1997) *Training complex cognitive skills: A four-component instructional design model for technical training* (Englewood Cliffs, NJ, Educational Technology Publications).

Van Merriënboer, J. & Sweller, J. (2010) Cognitive load theory in health professional education: Design principles and strategies, *Medical Education*, 44(1), 85–93.

Wigfield, A., Eccles, J. S., Schiefele, U., Roeser, R. W. & Davis-Kean, P. (2006) Development of achievement motivation, in: W. Damon & N. Eisenberg (Eds) *Handbook of Child Psychology* (vol. 3) (New York, Wiley), 933–1002.

Appendix A: 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