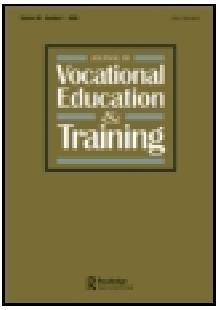

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Characteristics of hands-on simulations with added value for innovative secondary and higher vocational education

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

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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 competencies and professional identity. This paper 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 two fundamental characteristics of constructive vocational learning (i.e. authenticity and increasing students' ownership) propose ideas about how hands-on simulations can have added value to innovative curricula. This paper concludes with concrete strategies for designing and implementing hands-on simulations from the social constructive learning theory with the aim of stimulating not only technical and procedural skills, but also competencies and professional identity.

Keywords: competence; vocational education & training; curriculum innovation; vocational HE; learning theory

Introduction

Concerns about the limited applicability of educational learnt-outcomes to the workplace (Billett 2003; Griffiths and Guile 2003) have led to innovations in secondary and higher vocational education, such as the implementation of competence-based education (Biemans et al. 2004). 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 et al. 2007, 47). Innovative vocational curricula attempt to realise this integration of lifelong learning, such as the development of competencies and professional identity, by building on social constructivist learning principles (De Bruijn and Leeman 2011), including collaborative, active, authentic

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or real-life learning, and increasing students' ownership of learning (Loyens and 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 competencies and professional identity development (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 1).

Simulated learning environments are a 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 and Millis 2002). The simulations that are subject in this paper 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 paper 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.

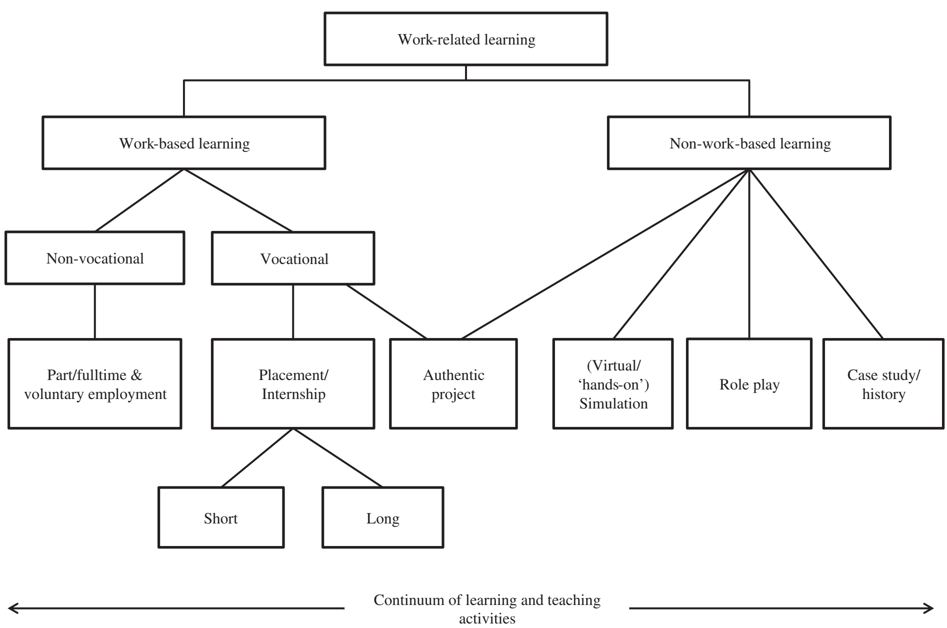

Figure 1. Diagram with activities on the continuum of work-related learning (based on Hills et al. 2003).

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 et al. (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 competency development and professional identity 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, 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 and 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. One might question whether the 'traditional' approach to hands-on simulations is appropriate for developing competencies and professional identity or whether more constructive, pedagogical-didactic approaches to teaching and student learning that align with innovative vocational education are desired. This paper will introduce a more explicit conceptual discussion regarding the opportunities for using hands-on simulations in innovative curricula that aim at developing competencies and professional identity.

This paper intends to discuss characteristics of hands-on simulations that have an 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 that was 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 social constructive learning. In secondary and higher vocational education, specifically two constructivist learning environment characteristics are argued to be important for integrating knowledge, skills, and attitudes (i.e. competencies) and developing professional identity; that is *authentic learning* and giving students *ownership of learning* (De Bruijn and Leeman 2011; Geurts and Meijers 2009; Gulikers et al. 2006; Kicken, Brand-Gruwel, and van Merriënboer 2008; Van Bommel, Kwakman, and Boshuizen 2012). Therefore, an additional *in-depth* analysis of specific literature about these two 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 social constructive learning theory with the aim of stimulating competencies and professional identity.

Hands-on simulations in secondary and higher vocational education

As Hertel and Millis (2002, 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 in 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 paper 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, competencies and professional identity. 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 (Helle et al. 2007; Boud and Costley 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 and 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 and Leeman (2011). Their model 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 et al. 1956), technical skills (Romiszowski 1999), attitudes (Martin and Reigeluth 1999), or competencies from the Dutch Qualification Framework (COLO 2006), transfer (Illeris 2009) and 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, and Adams 1997). During the discussion, the average 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 0.66 (70.2% agreement) and for the learning outcome categories 0.63 (70.6% agreement), which is good according to the criteria for kappa (Strijbos and 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 (see Appendices 1 and 2 for the full results).

Findings

Tables 1 and 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 1). The outcomes that were mentioned most (i.e. metacognitive knowledge and the competency Applying expertise) in hands-on simulations 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. More than half of the studies about hands-on simulations examined transfer of learning and the one study that reported on technical skills development was a study about hands-on simulations.

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 competency development 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,

Table 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
Programme characteristic			
Authenticity	Partial authenticity: not all types of hands-on simulations are perceived as realistic by students.	Variety of learning in class and in profession	Chance to act as a real professional, Adopting limited professional roles
	One or more professional roles assigned to students	One or more professional roles assigned to student	
Student learning			
Construction individual	Repeating tasks	Applying knowledge in practice	Integrating classroom and workplace activities
	Learning from observation and mistakes		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) focuses 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.

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. 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 and 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

Table 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		
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	• Applying expertise • Adhering to principles and values • Planning • Formulating and reporting • Cooperating • Learning • Following instructions and procedures • Showing care and understanding • Using materials • Analysing

(*Continued*)

Table 2. (*Continued*).

Learning outcomes	Hands-on simulation	Authentic project	Internship
		• Adapting and responding to change • Operating efficiently	
Transfer	• Transfer from simulation to workplace		
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

showed that the students had almost no ownership over their learning processes. This includes having opportunities to control their learning and having freedom to self-regulate the learning. Hands-on simulations were almost always teacher-driven, and teachers did not, at least not explicitly, stimulate the students' self-regulative learning (see also Table 2).

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, and were used for the development of knowledge, technical skills and transfer of learning. But based on these results, it is hard to indicate the added value of hands-on simulations in innovative curricula in which competencies 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), or for hands-on simulations (e.g. 'laboratory'), or authentic projects (e.g. 'live project'), or for 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. Third, 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 competencies and professional identity (De Bruijn and Leeman 2011; Geurts and Meijers 2009; Gulikers et al. 2006; Kicken, Brand-Gruwel, and van Merriënboer 2008; Van Bommel, Kwakman, and Boshuizen 2012). The review study identified that authenticity and increasing students' ownership over learning (including self-directed and self-regulated 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 (Zitter and Hoeve 2012; Cremers et al. 2013) 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. This has led to a total of 11 additional relevant studies: seven about authenticity and four about ownership in hands-on simulations. Based on these additional studies, we deduced strategies for fostering authenticity and ownership in hands-on simulations for the purpose of stimulating competence development or professional identity. This study 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, and Dueber 2000) and because students are not fully accountable for the outcomes of simulated learning (Cumming and 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, and 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 and Baker 2004; Maran and 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 e.g. 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 the primary training goal, which is *authentic learning*; involving students in a problem and engaging them in situational meaningful thinking and interaction (De Bock et al. 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 and colleagues (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 learning environments, considered to be authentic by the teacher, are automatically perceived as realistic by students. Authenticity involves subjectivity (Gulikers, Bastiaens, and Kirschner 2006). According to Barab and colleagues (2000, 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 and Sjöblom 2012). For example, 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 and 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, Bastiaens, and Kirschner 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 glass house with only peppers in the beginning of the trajectory and a full-scale glass house 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, then 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. And hands-on simulations can foster more authentic learning than 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, and 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, 18). A main design feature of SDL is that the learning environments offers students a certain amount of *freedom of choice* to pursue their learning goals (Loyens, Magda, and Rikers 2008) because giving students control over what they want to learn increases students' motivation to take part in learning activities (Corbalan, Kester, and Van Merriënboer 2006).

Brydges and colleagues (2009, 2010) were the first to examine the possibilities and effects of SDL in hands-on simulations. Brydges et al. (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 et al. (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 towards 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 towards, 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, and 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 et al. 2010). According to Zimmerman (2001), SRL occurs when students are meta-cognitively, motivationally and behaviourally active participants in their learning, and when they use self-reflection via monitoring and feedback to change their behaviour. There are several teaching approaches that are typical for hands-on simulations and at the same time stimulate SRL: in hands-on simulations, the teachers usually start the simulation by demonstrating or *modelling* desired behaviour. 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, for example, 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, and Swennen 2007). During the simulations, teachers walk around, provide instruction and help students when needed. Hands-on simulations are mostly conducted in small groups, which give teachers good opportunities to guide students in groups or individually. Activities that teachers can perform to guide 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, and 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, Brown, and Holum 1991). Guiding moments can also be used to stimulate 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 and 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 and 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 social 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 competencies and professional identity. Based on this analysis, a framework with concrete strategies for designing and implementing innovative hands-on simulations was generated (Table 3), showing possibilities for increasing authenticity and students' ownership. The assumption is that a hands-on simulation that is designed and implemented with the suggested strategies leads to more competency development and will contribute to gaining professional identity. 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

Table 3. Strategies for adding authentic learning, self-directed learning and self-regulated 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.

at technical and procedural knowledge and skills cannot have a place in 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, SDL and SRL 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 competency development?' and 'What is the right balance of authenticity, SDL, and SRL in hands-on simulations?'. When these questions are answered, we could possibly state with more conviction what exactly the position is of hands-on simulations in an innovative vocation-oriented curriculum in which competencies and professional identity are the main learning outcomes.

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Appendix 1. Overview of learning environment characteristics for hands-on simulations, authentic projects and internships traced in current empirical literature

Learning environment characteristics	Hands-on simulation	Authentic project	Internship
Program characteristics			
Authenticity	• Replicas of professional tasks and physical context (Alinier et al. 2006; McCaughey and Traynor 2010; Wenk et al. 2009) varying from low fidelity to high fidelity simulations (Alinier et al. 2006; Grady et al. 2008; Levett-Jones et al. 2011; Wenk et al. 2009) • Integration of real clients in simulated learning environment (Zeng and Johnson 2009) • One (Alinier et al. 2006) or more professional roles assigned to students (Zeng and Johnson 2009) • Not all practical simulations are being perceived as realistic by students (McCaughey and 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 (Curtis and Mahon 2010; Cooper, Bottomley, and Gordon 2004; Govekar and Rishi 2007; Lu and Lambright 2010; Montgomery 2004; Schäfer and Richards 2007; Tschopp 2004) • One (Schäfer and Richards 2007) or more professional roles (Lu and Lambright 2010) assigned to student • The authenticity of the physical context and the tasks stimulates student motivation (Cooper, Bottomley, and Gordon 2004; Goto and Bianco-Simeral 2009) and learning outcomes (Curtis and Mahon 2010; Lu and Lambright 2010) • Students benefit from variety of professional learning environments (Lu and Lambright 2010) but need clear role description (Schäfer and Richards 2007)	• Chance to act as a real professional (Freestone et al. 2007; Hoifodt, Olstad, and Sexton 2007) • Individual responsibilities and roles are negotiable (Grande et al. 2009) • Limited learning experience in some internships due to many assistant and administrative tasks (Hoifodt, Olstad, and Sexton 2007; Jackson and Jackson 2009; Pence and Macgillivray 2008; Yang 2011) • Rotation of roles stimulates student learning (Hoifodt, Olstad, and Sexton 2007)

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Learning environment characteristics	Hands-on simulation	Authentic project	Internship
Student learning			
Construction Individual	• Hands-on experience through practicing/repeating tasks (Alinier et al. 2006; Rush et al. 2010; Levett-Jones et al. 2011; Zeng and Johnson 2009) • Learning from mistakes without consequences (Rush et al. 2010) • Observing peers (Alinier et al. 2006; Rush et al. 2010)	• Apply knowledge in practical, hands-on situations (Cooper, Bottomley, and Gordon 2004; Schäfer and Richards 2007) • Less valuable for students who prefer traditional instructional methods (Curtis and Mahon 2010)	• Additional field assignments (Cannon 2008; Mariani and Klinkner 2009) • Observing mentor (Spooner et al. 2008) Videotaped sessions (Cannon 2008) • Discuss prepared dilemma's in-class (Cannon 2008; Mariani and Klinkner 2009) plans/concerns during the weekly seminars and through blackboard (Laframboise and Shea 2009; Mariani and Klinkner 2009) • Lack of opportunities to practice (Laframboise and Shea 2009)
Construction cooperative	• Working in groups of 2–6 students (Alinier et al. 2006; Levett-Jones et al. 2011; Rush et al. 2010; Zeng and Johnson 2009) • Discussing performance in groups (Zeng and Johnson 2009) • Giving peer feedback in debriefs (Alinier et al. 2006; Nestel and Kidd 2003; Rush et al. 2010)	• Working in groups of 2–5 students (Goto and Bianco-Simeral 2009; Govekar and Rishi 2007; Montgomery 2004) • Interdisciplinary groups (Cooper, Bottomley, and Gordon 2004; Schäfer and Richards 2007) • Tasks allocated according to each members strengths (Goto and Bianco-Simeral 2009) • Joint responsibility of project success (Tschopp 2004)	• Individual or in pairs (Sahin 2008) • Cooperation with colleagues/ workplace supervisor (Sahin 2008) • Assistance provided by friends from school (Laframboise and Shea 2009)

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Learning environment characteristics	Hands-on simulation	Authentic project	Internship
		• Meeting in own time (Cooper 2004; Goto and Bianco-Simeral 2009) • Students benefit from working in groups (Montgomery 2004) and some students do not (Goto and Bianco-Simeral 2009) but according to some students developing professional skills is inhibited compared to working individually (Lu and Lambright 2010)	
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 points of improvement in next session or episode (Alinier et al. 2006; Rush et al. 2010; Nestel and Kidd 2003; Zeng and Johnson 2009) • Reflection by looking back on videotaped session(Nestel and Kidd 2003) • Reflection by keeping reflective journals (Schlairet and Pollock 2010)	• Reflection by reflective journals (Cooper, Bottomley, and Gordon 2004; Govekar and Rishi 2007) and in-class discussion on performance (Lu and Lambright 2010; Montgomery 2004)	• Reflection by assignments (Laframboise and Shea 2009), reflective journals (Cannon 2008; Helfeldt et al. 2009; Pence and Macgillivray 2008; Yang 2011)and discussions on blackboard (Laframboise and Shea 2009) and in-class (Cannon 2008; Grande et al. 2009)

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Learning environment characteristics	Hands-on simulation	Authentic project	Internship
Ownership of learning process	• 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 and Mahon 2010; Goto and Bianco-Simeral 2009; Schäfer and Richards 2007) • High self-responsibility of students success in learning process expected (Lu and Lambright 2010; Schäfer and Richards 2007)	• Proactive attitude of the student is expected. Students must initiate (challenging) activities or ask for feedback themselves (Helfeldt et al. 2009; Sahin 2008; Jackson and Jackson 2009; Laframboise and Shea 2009; Mihail 2006)
Guidance			
Instruction and modelling	• Teacher instructs, gives cues and helps students during the simulation (Rush et al. 2010; Schlairet and Pollock 2010; Wenk et al. 2009)	• Teacher gives lectures (Montgomery 2004; Schäfer and Richards 2007) • Teacher gives examples of good practices (Curtis and Mahon 2010) • Skills are demonstrated by client (Cooper, Bottomley, and Gordon 2004)	• Workplace supervisors function as a model (e.g. teaching techniques) (Helfeldt et al. 2009; Laframboise and 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 and Kidd 2003; Rush et al. 2010; Wenk et al. 2009)	• Tutorial support is an integral element of the project (Cooper, Bottomley, and Gordon 2004; Curtis and Mahon 2010; Schäfer and Richards 2007) • Sometimes lack of support and time for guidance by teachers and clients (Goto and Bianco-Simeral 2009; Schäfer and Richards 2007)	• Support and mostly oral feedback provided by teachers and workplace supervisors during internship (Cannon 2008; Caprano, Caprano, and Helfeldt 2010; Freestone et al. 2007; Helfeldt et al. 2009; Mihail 2006; Pence and Macgillivray 2008; Sahin 2008; Spooner et al. 2008) and after internship (Laframboise and Shea 2009)

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Learning environment characteristics	Hands-on simulation	Authentic project	Internship
			• 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, Olstad, and Sexton 2007; Jackson and Jackson 2009; Yang 2011)
Stimulating self-regulated learning	xx	• Scaffolding by reducing guidance and dividing assignment in smaller proportions (Curtis and Mahon 2010; Schäfer and Richards 2007) • Reducing guidance can lead to difficulties (Schäfer and Richards 2007)	• Teachers help with formulating learning goals for self-directedness (Jackson and 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 and Jackson 2009) Not much autonomy given by workplace supervisors (Sahin 2008)

Appendix 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 and Traynor 2010; Nestel and Kidd 2003; Rush et al. 2010) • Conceptual knowledge (McCaughey and Traynor 2010; Zeng and Johnson 2009) • Factual knowledge (Zeng and Johnson 2009) • Procedural knowledge (Zeng and Johnson 2009)	• Procedural knowledge (Curtis and Mahon 2010; Govekar and Rishi 2007; Goto and Bianco-Simeral 2009; Montgomery 2004) • Conceptual knowledge (Montgomery 2004; Govekar and Rishi 2007) • Metacognitive knowledge (Curtis and Mahon 2010; Govekar and 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)		
Attitude	• Self-confidence to function in practice (McCaughey and Traynor 2010; Wenk et al. 2009)	• Self-confidence, inspiration, motivation (Schäfer and Richards 2007) • Interest in the core subject matter (Montgomery 2004) • Self-reliance (Curtis and Mahon 2010) • Diversity awareness (Govekar and Rishi 2007) • Professional demeanour (Tschopp 2004)	• Self-confidence (Freestone et al. 2007; Hoifodt, Olstad, and Sexton 2007; Laframboise and Shea 2009; Pence and Macgillivray 2008; Sahin 2008) • Sense of responsibility (Mariani and Klinkner 2009; Sahin 2008) • Efficacy (Mariani and Klinkner 2009; Helfeldt et al. 2009) • Appreciation for diversity (Pence and Macgillivray 2008) • Attitude towards psychiatry (Hoifodt, Olstad, and Sexton 2007)

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Learning outcomes	Hands-on simulation	Authentic project	Internship
			• Self-motivation (Sahin 2008) • Independency (Sahin 2008) • Trust (Mariani and Klinkner 2009)
Competencies	• Applying expertise (Alinier et al. 2006; McCaughey and Traynor 2010; Zeng and Johnson 2009) • Deciding and initiating action (McCaughey and Traynor 2010) • Showing care and understanding (Nestel and Kidd 2003) • Cooperating (McCaughey and Traynor 2010) • Planning (McCaughey and Traynor 2010)	• Planning (Cooper 2004; Govekar and Rishi 2007; Schäfer and Richards 2007; Tschopp 2004) • Cooperating (Cooper, Bottomley, and Gordon 2004; Govekar and Rishi 2007; Lu and Lambright 2010; Schäfer and Richards 2007) • Showing care and understanding (Cooper, Bottomley, and Gordon 2004; Govekar and Rishi 2007) • Leading (Govekar and Rishi 2007; Lu and Lambright 2010; Tschopp 2004) • Formulating and reporting (Tschopp 2004; Lu and Lambright 2010; Schäfer and Richards 2007) • Researching (Goto and Bianco-Simeral 2009; Schäfer and Richards 2007; Tschopp 2004) • Analysing (Govekar and Rishi 2007; Lu and Lambright 2010; Schäfer and Richards 2007; Tschopp 2004) • Presenting (Govekar and Rishi 2007; Tschopp 2004)	• Applying expertise (Caprano, Caprano, and Helfeldt 2010; Helfeldt et al. 2009; Hoifodt, Olstad, and Sexton 2007; Laframboise and Shea 2009; Mihail 2006; Spooner et al. 2008) • Adhering to principles and values (Cannon 2008; Grande et al. 2009; Pence and Macgillivray 2008; Sahin 2008; Yang 2011) • Planning (Caprano, Caprano, and Helfeldt 2010; Laframboise and Shea 2009; Mihail 2006) • Formulating and reporting (Freestone et al. 2007; Laframboise and Shea 2009) • Cooperating (Freestone et al. 2007; Mihail 2006) • Learning (Caprano, Caprano, and Helfeldt 2010; Pence and Macgillivray 2008) • Following instructions and procedures (Jackson and Jackson 2009; Spooner et al. 2008) • Showing care and understanding (Sahin 2008)

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Learning outcomes	Hands-on simulation	Authentic project	Internship
		• Relating and networking (Govekar and Rishi 2007) • Persuading and influencing (Govekar and Rishi 2007) • Creating and innovating (Govekar and Rishi 2007) • Decision and initiating action (Tschopp 2004) • Learning (Govekar and Rishi 2007) • Meeting customer expectations (Tschopp 2004) • Adapting and responding to change (Govekar and Rishi 2007) • Operating efficiently (Tschopp 2004)	• Using materials (Sahin 2008) • Analysing (Freestone et al. 2007)
Transfer	• Transfer to clinical practice according to students (McCaughey and Traynor 2010; Rush et al. 2010; Wenk et al. 2009)		
Professional identity	• Professional development (Rush et al. 2010) • Insight in developing professional role (McCaughey and Traynor 2010)	Insight into requirements of future profession (Cooper 2004; Curtis and Mahon 2010) Insights into career choices (Cooper 2004)	• Insight into requirements of future profession (Jackson and Jackson 2009; Laframboise and Shea 2009) • Insight into career choices and prospects (Mihail 2006; Jackson and Jackson 2009)

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Appendix 2. (*Continued*).

Learning outcomes	Hands-on simulation	Authentic project	Internship
			• Insight into problems in professional field (Jackson and Jackson 2009) • Insight into personal work habits (Jackson and Jackson 2009) • Willingness to teach (Grande et al. 2009)