Learning manual and procedural clinical skills through simulation in health care education

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I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.

R. Kipling, 1902
From the tale of “The Elephant’s Child”
in “Just So Stories”
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ABSTRACT

The general aim of this thesis was to contribute to a deeper understanding of students’ perceptions of learning in simulation skills training in relation to the educational design of the skills training. Two studies were conducted to investigate learning features, what clinical skills nursing students learn through simulation, and how.

Undergraduate nursing students were chosen in both studies. Study I was conducted in semester three, and study II in semester six, the last semester. Twenty-two students in study I practised intravenous catheterisation in pairs in the regular curriculum with an additional option of using two CathSim® simulators. In study II, ten students practised urethral catheterisation in pairs, using the UrecathVision™ simulator. This session was offered outside the curriculum, one pair at a time.

In study I, three questionnaires were answered - before the skills training, after the skills training and the third after the skills examination but before the students’ clinical practice. The questions were both closed and open and the answers were analysed with quantitative and qualitative methods. The results showed that the simulator was valuable as a complement to arm models. Some disadvantages were expressed by the students, namely that there was no arm model to hold and into which to insert the needle and that they missed a holistic perspective. The most prominent learning features were motivation, variation, realism, meaningfulness, and feedback. Other important features mentioned were a safe environment, repeated practice, active and independent learning, interactive multimedia and a simulation device that was easy to use.

In study II the students were video-recorded during the skills training. Afterwards, besides open questions, the video was used for individual interviews as stimulated recall. The interview data were analysed with qualitative content analysis. Three themes were identified: what the students learn, how the students learn, and how the simulator can contribute to the
students’ learning. When learning clinical skills through simulation, motivation, meaningfulness and confidence were expressed as important factors to take into account from a student perspective. The students learned manual and procedural skills and also professional behaviour by preparing, watching, practising and reflecting.

From an educational perspective, variation, realism, feedback and reflection were seen as valuable features to be aware of in organising curricula with simulators. Providing a safe environment, giving repeated practice, ensuring active and independent learning, using interactive multimedia, and providing a simulation tool that is easy to use were factors to take into account. The simulator contributed by providing opportunities to prepare for skills training, to see the anatomy, to feel resistance to catheter insertion, and to become aware of performance ability.

Learning features, revealed from the students’ thoughts and experiences in these studies, are probably general to some extent but may be used to understand and design clinical skills training in all health care educations. In transferring these results it is important to take the actual educational context into account.
LIST OF PAPERS


DEFINITIONS

Virtual reality, VR  A world created by computers to mimic reality.

Haptic  A technology that provides the ability to feel and touch the objects created by a computer.

High fidelity simulator  Simulators which present a realistic depiction of the human body in look, feel, and response to the provided care.

Low fidelity simulator  Static simulators without motion. They demonstrate few features with realism.

Implicit or tacit learning  The acquisition of knowledge independently of conscious attempts to learn and in the absence of explicit knowledge about what was learnt.

Peer  A peer is defined as ‘an equal in civil standing or rank or equal in any respect’.

Tacit knowledge  Knowledge (factual or procedural) that is learnt and/or applied almost unconsciously.

Skill  A skill can be defined as proficiency or dexterity that is acquired or developed through training or experience. Other definitions are that skill is an art or technique, requiring use of the hands or body or as a developed talent or ability.

Simulation  Consensual pretence and illusion in support of training and or assessment, typically through using some device, person, or environment. It should be more accurately termed ‘dissimulation’ as the intent is not to truly deceive.
Simulator: A machine that tries to emulate a real environment as credible as possible.

Device: A tool.

Hybrid simulation: Seamless linking of simulators with simulated patients.
INTRODUCTION

Over the last twenty years, simulation for skills training in health care education has been evolving at an accelerating rate (Khan et al., 2011). This has allowed the introduction of new methods of skills training besides the traditional ways. Simulating real situations has been likened to airline pilot education simulations, in which professionals and students are trained and test their skills. With virtual reality simulators, the students can make mistakes without harming anyone (Flanagan et al., 2004; Walsh, 2005; Baxter et al., 2009), and the training enables learning to take place in a safe, non-threatening environment (Cioffi et al., 2005; Jeffries, 2005; Hogg et al., 2006).

Clinical skills training is a basic and comprehensive part of health care education. Besides teaching these skills in clinical placements, educational programs organise modules for skills training. The students practise on each other, on body part models, on cadavers and on anaesthetised patients. However, both nationally and internationally, the students’ hands-on experience of clinical practice has been diminishing due to reasons of patient safety and ethics (Rystedt and Lindström, 2001; Gordon et al., 2001; Ziv et al., 2003). Obtaining clinical placements in undergraduate health care education is a challenge which has increased internationally (Schoening et al., 2006; Reilly and Spratt, 2007; Schiavenato, 2009).

To meet these challenges, interest in alternative possibilities has emerged. With increased use of computers in health care, and by learning from airline pilot education, simulation was considered a possible tool to develop even in health care education. To start with, the research focus was on technical development and how the simulators could be validated as learning tools. Several studies in health care have been conducted to evaluate simulators in relation to learning effects. From the focus on technical development, the learning perspective in skills training simulation is now receiving more attention (Bradley, 2006). Tun and Kneebone (2011) are certain that simulation is here to stay and that its role will increase. They believe that simulation
Introduction

offers particular benefits for mastering procedural skills where motor skills are crucial.

Training with a simulator has been shown to enhance factors that facilitate cognitive and motor learning, such as repeated testing, feedback and self-controlled practice (Wulf et al., 2010). Issenberg et al. (2005, 2008) and McGaghie et al. (2010) have discussed similar features to the above as well as best practices of simulation that educators should know and use. To obtain a deeper understanding of the learning processes, research from fields such as motor learning, neuroscience, and psychology is considered particularly valuable (Tun and Kneebone, 2011). From a review by Issenberg et al. (2005) it is known that simulation training can be an effective way of learning procedural skills, and Hatala (2011) states that the question now has changed from ‘Is simulation effective?’ to ‘How is simulation effective?’

This thesis focuses on undergraduate students’ perceptions, thoughts and experiences in their process of learning clinical skills through simulation.
The theoretical framework will address the concept of knowledge, different kinds of learning theories, and how simulators can contribute to students’ learning. The purpose is to promote a deeper understanding of what is already known in the field of learning manual and procedural clinical skills through simulation. The theories have different ontological perspectives, and conscious cognitive aspects have been chosen to provide a theoretical understanding.

A skill can be seen as the ability to do something. It is synonymous with competence (Attewell, 1990; Johnson, 2004). Aristotle, a pupil of Plato, linked the concept of knowledge to different kinds of activities. He believed that knowledge, or episteme, was connected to investigation and reflection, and he widened the concept of knowledge by adding two forms of practical knowledge, techne and phronesis. Episteme was the concept of scientific-theoretical knowledge, techne was practical-productive knowledge, and phronesis was practical wisdom. Phronesis is knowledge connected to ethics and actions in working life. Throughout history, these concepts have been and are still used to describe knowledge. Techne and phronesis are intertwined. A person who knows what is meaningful in a situation and is able to act from that possesses practical wisdom. The person has the ability to act appropriately in the right place at the right moment (Gustavsson, 2002).

Knowledge can also be described as facts, understanding, proficiency and familiarity, often associated with sensory experiences (Gustavsson, 2002; Pilhammar, 2011). Factual knowledge is theoretical, and built on evidence-based knowledge. Knowledge based on understanding has a qualitative dimension in perceiving the underlying meaning. Proficiency or skills knowledge is a form of non-verbal performance knowledge about what to do and how to do it. Skills knowledge includes both motor and intellectual skills, for example problem-solving. Familiarity or tacit knowledge is mainly experience-based knowledge obtained from the senses. A combination of different forms of knowledge can be expressed as building the mind and the
body together and that knowledge is not just placed in a separate mind, but in the whole body (Gustavsson, 2007).

In the view of skills competence as knowledge, the learning process can be compared with competence development. In psychology, four stages of competence, or the ‘conscious competence’ learning model, relate to the psychological states involved in the process of progressing from incompetence to competence in a skill (Figure 1). This suggests that learners are initially unaware of how little they know, or unconscious of their incompetence. As they recognise their incompetence, they consciously acquire a skill, and then consciously use that skill. Eventually, the skill can be performed without consciously being thought through, and the learner is then said to have unconscious competence (Flower, 1999; Ahlberg, 2005; Skarman, 2011).

Skills competence is shown by consciously knowing facts and having understanding, but also by conscious and unconscious practical knowledge and practical wisdom (Gustavsson, 2002; Flower, 1999; Ahlberg, 2005; Skarman, 2011).

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Figure 1. Learning as change in the state of knowledge and consciousness. A processed model from Flower (1999).
Learning manual and procedural skills requires time to develop experience. Regular repetition with feedback on what has been done forms the basis for skills learning. In practical, manual learning the sense of touch, including proprioception, provides feedback on performed actions. Learning can therefore occur outside the realm of consciousness, the fourth stage in Figure 1. To become aware of manual and procedural learning, the use of video recording might incorporate competence into consciousness, the third stage in Figure 1. The actions will be performed on a conscious level and understanding can grow out of action (Skarman, 2011). Accordingly, techne would be the origin of the skills learning process and the start of learning theoretical knowledge, episteme. Säljö (2000) says that clinical skills learning can be said to have a theoretical scientific basis mainly in socio-cultural and cognitive perspectives.

**Experiential learning**

Experienced knowledge is defined as a combination of theoretical and tacit knowledge, practical wisdom, intuition, experience and personal maturity (McCutcheon and Pincombe, 2001). Edmond (2001) expresses about the same opinion when he suggests that practice requires thought, feeling and action. Marton and Tsui (2004) point out that the learner develops an ability to discern similarities through variations. Observations of variations of a phenomenon in learning lead to experience-based knowledge. Experience is obtained largely through the use of senses; so-called embodied knowledge. To gain knowledge via the senses requires practice and repetition. Sensory information creates memories in implicit functional systems in the brain, and these memories are used automatically without outside conscious control, whereas the explicit systems create conscious memories. These systems work parallel to each other, sometimes being supportive and sometimes competitive (Squire, 2004). In the unconscious system, sensory input is compared with previously stored images of experiences (Björklund 2009). It is found that memories require engagement to be stored.
Experiential learning is the process of making meaning of experiences. The learner uses patterns from previous experiences (Hård af Segerstad, 2007). Learning can appear as a change in the learner’s knowledge in relation to experience (Mayer, 2010). The experiential learning theory, developed by Kolb (1984) has a holistic integrative perspective on learning that combines experience, perception, cognition and behaviour. He believes that learning occurs through reflection on doing. Kolb’s experiential learning model (Figure 2) includes a four-phase cycle of learning, consisting of concrete experience, reflective observation, abstract conceptualisation and active experimentation (Hartley, 2010). Social interaction and emotional aspects are not taken into account in this model (Hård af Segerstad, 2007).

Learners in the experimentation phase are highly active through trial and error practice, whereas in the step-by-step approach the learner takes a more passive role (Ringsted, 2009). Many errors are characterised in the initial stages of learning and Ringsted states that learning from error has received...
increasing attention in skills training. She hopes that clinical training centres might be places where learners can train in an experiential way, allowing them to make the errors that are necessary for embedding the skills in the long-term memory.

**Situated learning**

Situated learning is an approach to learning in which knowledge is constructed in practice and the learning context is important in this construction of knowledge. Lave’s understanding of situated learning is based on viewing learning as situated in communities of practice. The concept of situatedness is based on knowledge theory, which states that the world is socially constructed (Lave, 1991). This kind of knowledge is something you use in action and as a resource in problem-solving (Säljö, 2000). Wenger (1998) developed the concept of communities of practice theory which covers a wide variety of practices, such as social and cultural practice. Situated learning can be seen as a way of becoming a member of a community of practice (Johnson, 2004). The focus is context, relations and activity rather than isolated tasks and performances. Johnson (2008) believes that knowledge is created in situated practice and that the whole practice situation is simulated, not certain skills. What happens in the learning process is ability development and allowing a person to act with new intellectual and physical tools (Säljö, 2000).

A current notion is that motor learning must take place in a context in which the individual solves the functional tasks in interaction with the environment (Shumway-Cook and Woollacott, 2012). New insights about the importance of learning motor skills in an authentic environment can be related to situated learning, with focus on how learning occurs when interacting in social situations in the environment (Skøien et al., 2009; Johnson, 2007; Lave and Wenger, 1991).
Motor learning

Motor learning is defined as learning new movements or modifying movements. This learning has been described as processes associated with training and experience, leading to changes in the ability to create efficient movement functions. Motor learning is now considered to mean more than motor processes. Learning is developed through a coherent set of processes related to sensation, cognition and motor function (Shumway-Cook and Woollacott, 2012). Elliott et al. (2011) also express this view, stating that learned and controlled movements are based on an internal structure that contains, for example, sensory, motor and cognitive information about an external act as a movement. We perceive through our senses. When learning manual skills we explore objects by touch, using tactile sense with support from visual and audio perception. The relationship between sensor, motor and environment can be described as in Figure 3 (Swartling Widerström, 2005).

![Diagram of Motor Learning](image-url)

Figure 3. Relation between sensory motor integration and environment. Modified from Bader-Johansson (1991, p. 20) in Swartling Widerström (2005, p. 75) and translated.
Figure 3 shows that humans perceive (perception) themselves through the senses (sensor) and environment. Sensory perceptions are interpreted (cognition) and the muscles (motor) will work depending on the decision of movements or stands. Motor function will continuously be corrected or changed (feedback) based on perception and cognitive interpretation.

During the learning process, motor and sensory input is stored in different memory places (Nyberg, 2009). When learning manual skills, tactile sensory perception will be stored in a specific haptic tactile sensory memory. This perception is an automatic response outside cognitive control. Via the short term memory the perception comes to working memory where the tactile sensory perception is processed, organised and integrated with other sensory perceptions as e.g. visual and auditory perceptions and prior knowledge from long-term memory. The sensory experience has now become conscious and is stored in long-term memory. Even if the long-term memory has an unlimited capacity, new knowledge must be rehearsed if the knowledge is not to fade away.

How much attention a task demands depends on the level of training one has received in performing the task. If one has little training, the task requires a high degree of attention control. With much training the performance can be automated. The control is reduced. The ability to simultaneously pay attention to different stimuli is limited and the consequence is selective attention. The more complex and attention-consuming the task, the greater is the selective attention (Floyer-Lea and Matthews, 2004; Nyberg, 2009).

Motor learning is essential in clinical skills training. Learning through the perceptions of the senses contains an interpreting element in regulating movements or positions (Figure 3). The sensory system gets new information from the motor activity through perception and interpretation. High fidelity simulators are equipped with haptic devices to get tactile feedback, images for visual feedback and audio feedback from ‘patients’ voices’.
**Embodied learning**

Somatic or embodied knowing is experiential knowledge that involves the senses, perception and the mind, and body action and reaction (Matthews 1998). During the 1900s, research in adult learning aroused interest in practical knowledge. Polanyi (1966/1998) suggested that practical activities have a tacit dimension. Through tradition and experience we know how to carry out practical activities. New learning appears based on tacit background knowledge. Ryle (1949) believed that persons know things as “knowing that”, and how to perform as “knowing how”. Knowing how is both the ability to do but also to understand what you do. The thought must be there during the process (Gustavsson, 2002).

A holistic phenomenological view of humans was a reaction to the dual thinking way in the philosophy presented by Descartes (1596 – 1650). Examples of dualism can be body and soul, theory and practice, cognitive and affective, and man and woman (Swartling Widerström, 2005). In the 1800s, philosophers investigated how another view of the human body could be understood according to learning. In the view of pragmatism, Dewey (1916) believed that dual thinking was removed by action and experience making.

The French philosopher and psychologist Merleau-Ponty (1908 – 1961) criticised the traditional concept of experience as cognitive and suggested that the base for experience is a tacit bodily knowing. A central idea argued by Merleau-Ponty (1945/2009) was that knowledge is associated with the human body, as the brain and senses are parts of the body (Bengtsson, 2001; Gustavsson, 2002).

Merleau-Ponty (1945/2009), when describing the mind and the body, said that we do not **have** a body, we **are** bodies. He compared the body with a work of art when the painting conveys the content through colours or a musical composition through tones. The body conveys its message through gestures, imitating, movements and posture (Duesund, 1996). The body is experienced through perception about ourselves and the environment.
Theoretical Framework

We know more than we can say. This refers to Polanyi (1891 – 1976) and his theory of tacit knowledge. Polanyi says that tacit knowledge as background knowledge is there as “a tacit bodily knowing”. It can be exemplified by the process of developing motion skills as it is impossible to explain how to maintain balance on a bicycle or stay afloat when swimming (Polanyi, 1966).

When embodied knowledge has occurred after repeated training, the focus of the action has moved from the performer to the object of action (Silén, 2006). An object can be a kind of tool, and when this is mastered the focus moves further to the object for the tool, such as the patient’s arm and then to the person. The tool will become like part of the body and the ability to feel through it emerges. The ability to use the tool has become tacit (Leder, 1990). Merleau-Ponty (1945/2009) uses the example of the blind man’s stick to illustrate this. The man experiences the world around through the stick, which has become an integrated part of his body. When an instrument has become internalised in the body, focus is on the object for the instrument, such as the arm.

Dreyfus (2004) describes a qualitative difference between a beginner who lacks experience and an expert who has experience of being able to act professionally. He and his brother (Dreyfus and Dreyfus, 1986) developed a model of adult skill acquisition, which is described as having five stages: novice, advanced beginner, competent performer, proficient performer and expert. Benner (1984) based her studies of nurses’ competence development on these stages. In the novice stage of skill acquisition, she found that the learner is dependent on rules but will eventually become more contextually aware and use more experienced knowledge. Tacit knowledge is described as characteristic of an expert. The expert acts intuitively, especially in critical situations, from memories of earlier, similar situations that have been experienced, and he or she cannot always explain why. Experienced experts cannot directly transfer knowledge to less experienced colleagues. The knowledge must first become conscious for the learner, and made visible in action.

In their research into learning, Marton and Booth (1997) studied how students solved a proposed problem. The students came up with a solution and were
quite sure that the solution was adequate, but they could not explain how they solved the problem. Marton and Booth found that the students had demonstrated intuitive understanding.

Experience from training with simulator devices may provide sufficient confidence in how to act, and consequently change the focus to the object. Several studies have been performed to investigate how clinical skills from simulated training can be transferred to clinical settings. Different kinds of learning activities might promote self-confidence. When students feel confidence in a learning group, a seminar or in working teams in clinical practice, the focus of attention moves from themselves to the object of the activity, and this occurs in problem-solving, clinical reasoning and different kinds of performances. Behaviour and presented knowledge are essential to develop professional competence from unconscious incompetence to unconscious competence (Figure 1) or to move through the stages from novice to expert (Dreyfus, 2004), or for a reflective practitioner (Schön, 1987), when giving feedback on actions. Reflection and feedback are frequently used to help the students become conscious of their areas of incompetence and competence.

**Peer learning**

Peer learning or peer-assisted learning has been recognised for a long time in clinical practice as an educational method where the students experience mutual benefits as teachers and learners (Weidner and Popp, 2007). A peer can be a fellow student, a colleague, or a person from the same course or school. In the literature, peer learning is referred to as to peer tutoring, peer teaching, peer group learning, peer consulting etc. (Lincoln and McAllister, 1993).

The pedagogic origins of peer learning are derived from theories of cognitive development by Piaget and Vygotsky. Learning is facilitated through social interaction and new strategies, and knowledge comes from working with others. In the theory of social constructivism, learning is viewed as a social phenomenon. Social interaction and collaboration, together with cognitive
processes, are essential in constructing new knowledge (Baldry Currens and Bithell, 2003). Encouraging students to reflect on learning experiences increases their confidence and enables them to develop an understanding of their own and others’ learning (Goldsmith et al., 2006).

According to Boud (1999) peer learning refers to the use of teaching and learning strategies in which students learn with and from each other. He emphasises the use of reciprocal learning instead of peer teaching and argues for assessing peer learning because of the emphasis on generic learning outcomes. Peer learning fosters certain aspects of lifelong learning skills such as collaboration, teamwork, critical inquiry, reflection and communication skills. Roberts (2008) has found that friendship is an important aspect of peer learning, and that friendship fosters learning. He argues that students adopt a reciprocal teaching role in terms of demonstrating clinical skills to each other.

Positive outcomes of peer learning that have emerged in several studies include decreased levels of pressure, embarrassment and anxiety (Weidner and Popp, 2007). It has been found that through confirmation and acceptance of ideas from their peers, students experience reduced anxiety when entering an unknown clinical placement and gained confidence (Baldry Currens and Bithell, 2003; Goldsmith et al., 2006).

Ladyshewsky (2010) states that peer learning may lead to significant gains in learning. He enhances peer coaching as a learning strategy to promote learning and professional development. Peer feedback can be used to describe communication processes and is seen as a powerful formative assessment strategy. Peer learning is reported as effective and efficient. An encouraging dialog between students is found to enhance learning. Ruth-Sahd (2011) proposes in a study that student dyads create a supportive learning environment and that cooperative learning encourages teamwork, which improves patient outcome. Another benefit of working in pairs is the opportunity to observe each other. Elliott et al. (2011) report that research involving observational practice shows that as much is learned by observation as is learned by physical practice. He refers to the mirror neuron system, which can be seen as providing the basis for imitation and observational learning, as well as social mirroring.
AIM

The general aim of this thesis was to contribute to a deeper understanding of students’ perceptions of learning in computer simulation skills training, and show how to relate this understanding to the educational design of simulated skills training in the studies.

Research questions

What is characteristic of a stimulated learning situation for simulated skills training? (Study I)

How do students perceive that they learn manual clinical skills when simulation is used in skills training? (Study II)

What do students think about their learning in simulated skills training? (Study II)
METHODS

The research field of medical education has a variety of approaches. Positivism is the most common paradigm, but interest in the qualitative approach has increased (Harris, 2002; Bunniss and Kelly, 2010). In the simulation field, most research takes the form of effectiveness and description studies.

This thesis examines students’ views of learning clinical skills in a simulated context. In study I, second year nursing students were asked to answer questionnaires before simulated skills training, directly after, and after the examination of clinical skills. In study II, third year nursing students were interviewed directly after the simulation skills training about their perceptions and thoughts on learning clinical skills through simulation. The students performed the simulation procedure in pairs and they were video-recorded. The video was used for stimulated recall during the interviews.

Study context and design

To achieve the aim of this thesis, two studies were performed on learning manual and procedural clinical skills in simulation skills training: one about students’ perceptions of learning features and the other about students’ experiences of their learning in simulation skills training. The students studied at the Faculty of Health Sciences, Linköping University. Since 1986, problem-based learning, PBL, is a principal educational approach (Barrows and Tamblyn, 1980; Kjellgren et al., 1993; Schmidt, 1993; Silén, 2001). Focus has changed from teacher-led education to the students’ learning perspective, and this is now the trend in most higher education. Some of the main ideas of PBL are that students take responsibility for their own learning and that learning processes are based on authentic patient scenarios to reflect upon and to enhance motivation and meaning (Marton and Booth, 1997; Silén, 2003; Murray et al., 2008).
Over a period of about thirty years, clinical skills training centres have been developed all over the world (Bradley and Postlethwaite, 2003), and in 2008 the Clinicum centre was established at the Faculty of Health Sciences, offering different types of skills training.

The studies were designed for nursing educational settings at Clinicum: study I in Norrköping and study II in Linköping. In study I the use of an intravenous catheter simulator in skills learning was studied. This catheterisation is a basic skill in nursing and the study contributed with two CathSim® programs in ordinary catheterisation skills training.

The research design in study I was an intervention study over time (Figure 4). Throughout the study, the students followed their normal curriculum in the third semester. The students practiced intravenous catheterisation, both on plastic arm models, and with the CathSim program. The study was designed to follow the students during the first 14 weeks. The semester started with theory and skills training. To create a meaningful learning context for the vein catheterisation skills training, the students were presented with a scenario. A female patient had a femoral fracture, and the doctor prescribed intravenous alleviation of pain and glucose infusion before the operation. The students had to prepare for what to do in the skills training of peripheral vein catheterisation. Before the clinical practice at the end of the semester, the students were given an examination on intravenous catheterisation skills. Three questionnaires were answered; before and after the skills training, and after the skills examination, respectively.

Based on the research question, the characteristic elements of a stimulating learning situation design were identified, based on the phases, preparation, realisation and follow-up (Figure 4). To investigate the students’ perceptions and attitudes to the current simulation, they answered questionnaires before the simulation training, after the training, and after the examination. During the preparation phase the students reflected on their experiences, pre-understanding and learning needs. The realisation phase included the skills training procedure, and involved students asking questions and practising with the simulator. In the follow-up phase, the students were made aware of
what they knew and what they did not know. Their learning was confirmed by feedback and examination.

Figure 4. Design of study I

In study II a new simulator, UrecathVision™, was used for training urethral catheterisation skills. A qualitative research approach was chosen to investigate the students’ perceptions. They were interviewed about their learning in simulated skills training (Figure 5). The simulation session was video-recorded and the video was used for stimulated recall in subsequent individual interviews. The students’ learning was thus studied by observation, interview and stimulated recall.
Participants and data collection

Both the CathSim and UrecathVision simulators were suitable for clinical skills training in nursing and medical education. We decided to recruit nursing students in both studies. The Bachelor nursing program comprises six semesters over the course of three years.

Study I

In study I the selection of participants had to take into account the limited supply of simulators. The nursing students were recruited on the first day of the third semester, the second year. All the students volunteered by signing a list, and they were allotted an anonymous number. In the regular intravenous catheterisation skills training sessions, a maximum of 24 students had the
Methods

opportunity to train in pairs, with an additional option of using two CathSim simulators. Twenty-one women and three men were selected at random by the course leader by drawing lots from the total of 55 students. The students’ ages were between 21 and 45 years, with a mean age of 27.7 years and a median of 23 years. Twelve of the 24 students were between 21 and 25 years old. The range of age in the whole group was 20 to 45 years. So, the selected group was representative in age.

Three questionnaires were developed to collect the students’ opinions about the value of using the CathSim program for intravenous catheterisation skills training. The first questionnaire was answered by 53 students before the skills training session. The students were asked about expectations, prior experience, and demographic data. The single open question was about their expectations of what would be learned. The second questionnaire was given immediately after the skills training to 22 students in the intervention group. The students were asked about the fulfilment of their expectations. The four open questions asked about what the students learned by using CathSim, their perspective on CathSim as a learning tool in skills training, and the features and limitations of CathSim skills training. The third questionnaire was given immediately after the skills examination and concerned the fulfilment of expectations in terms of curricular goals. The three open questions asked about the features and limitations of CathSim as a learning tool in skills training. The questions with statements were formulated using Likert-type scales in a range of 1-6, from not at all to in a high degree, or do not agree to fully agree. The questionnaires were tested in a pilot study of a small group of nine students during the previous third semester course. The second questionnaire was then revised with two additional questions about the anatomy resource and feedback functions.

Study II

In study II, nursing students were recruited by e-mail in their sixth and last semester. Ten third year students were selected because they had experience from clinical practice, and our assumption was that they had previously had
the opportunity to catheterise real patients. All students were female. Their ages were between 21 and 47 years with a mean value of 26.5 years and a median of 24 years. Two of the students had experience of catheterisation prior to their nursing education. Nine students had catheterised patients once or more, while two had done so more than three times, in clinical practice. Two students had used a simulator earlier in their education. All but one had used simulation devices outside the educational context, for example computer games. According to Denzin and Lincoln (2000), it was a purposeful sampling as the students shared certain characteristics. They were nursing students in the same phase of education and they had different degrees of experience of learning and performing urethral catheterisation.

The individual interviews were unstructured, with question areas, and with the opportunity to follow up interesting answers with new questions (Kvale, 2007). Question areas for the interviews were: Watch your performance and describe what you thought and experienced. In what ways could the simulator facilitate your learning of catheter insertion? What were the advantages and weaknesses? How do you evaluate your learning through the senses, such as touch, sight and hearing in this type of skill training?

The videos were the basis for the interviews and were used for stimulated recall (Haglund, 2003; Lyle, 2003; Polit and Beck 2008). Immediately after the skill training with the simulator the two students were interviewed by the author (EJ). Both students attended, but only one student at a time was interviewed. Besides answering open-ended questions the students could give comments on their performance. Both the interviewer and the interviewee could stop the video using a remote control and the student could add comments such as “then I thought I felt ...” The two students could talk to each other and make comments also in this part.

Stimulated recall is widely used in educational research. Video recording can be used to make it easier for the participant to remember thoughts during a subsequent interview. Lyle (2003) suggests that stimulated recall is a valuable tool for investigating cognitive processes. The value is enhanced if the participant is interviewed shortly after recording, so that the participant can use the short-term working memory. The participants in study II were urged
to “think aloud”, which Lyle (2003) argue assists the participant’s recall. Stimulated recall is seen as a valuable educational tool to achieve objectives such as reviewing prior experiences and learning through reflection. Haglund (2003) emphasises the value of this method since the recorded video brings a combination of interactive ideas and thoughts that are created in the interview situation.

Simulation skills training

Learning in skills training was investigated through two kinds of simulations. In study I the students practised intravenous catheterisation both on low fidelity plastic arm models as usual, and with the high fidelity CathSim program. After an introduction by the supervisor, the students trained together for one hour, two at a time, at each CathSim simulator. In the second hour, they practised intravenous catheterisation on the plastic arm models. The session finished with time for common reflection. During the following seven weeks, the students were able to practise with CathSim and the plastic arm models in the skills lab on their own before the skills examination and their clinical practice.

The CathSim® simulator was developed in Maryland (MD), USA, by Immersion (www.immersion.com). Two sets of CathSim® simulators were used for the intravenous catheterisation skills training. CathSim® is designed to provide an interactive learning experience using 3-D computer graphics, high fidelity sound, and haptic tactile feedback. The student can feel a slight resistance when the needle and catheter insertion from the input device enters the skin, and then the vein lumen (Figure 6). CathSim® allows for cognitive and motor skills to be practised and can represent a variety of patient types with a range of possible complications as might be encountered in real life (Barker, 1999; Merril and Barker, 1996). The simulator demonstrates acceptable construct and content validities (Reznek et al., 2002).
In study II, two nursing students, dressed in nursing uniforms, individually performed urethral catheterisation with the simulation program UrecathVision™. Before starting they were given verbal information about the simulation process and they answered some background questions in a written form. The simulation program included questions for reflection both before and after the simulation. The students answered these questions orally. The peer student assisted in the catheterisation procedure and acted as a discussion partner. The training was video-recorded to capture comments and events relevant to the study. The camera was on during the whole training session, which lasted for 15 - 20 minutes per student. The students were asked to think aloud and talk to each other.

The simulation program UrecathVision™ is still in a developmental phase at Melerit Medical AB in Linköping, Sweden (www.meleritmedical.com). The Faculty of Health Sciences has been involved in the development, and the simulator used in Study II was a prototype. UrecathVision™ is a portable
computer-based simulator for providing training in the skill of urethral catheterisation. To prepare the students, the program starts by presenting some modules explaining different procedures, using multimedia techniques such as text and images about disinfecting and donning sterile gloves, preparation of the equipment and cleansing the genital area. These preparations are learned using a combination of reading and interactive exercises on the simulator screen. For some of the tasks there are instruction videos. While the user is inserting the catheter, the performance can be followed on the computer screen (Figure 7). Anatomic features are visualised as anatomic cross-section images and updated according to the actions taken. The resistance felt in the catheter is a function of the pathological conditions. The quality of the performance is measured and presented after the catheterisation procedure is completed (Jöud et al. 2010; www.meleritmedical.com).

Figure 7. Simulation skills training with UrecathVision
Methods

Data analysis

Study I had a descriptive approach and three questionnaires were used. Data from the questionnaires were analysed through descriptive statistics using SPSS 14.0 through frequencies and percentages (Polit and Beck, 2008). The within group comparison before and after the simulation and after the examination were evaluated using a Wilcoxon signed rank test (Siegel and Castellan, 1988). A p-value ≤ 0.05 was considered statistically significant. Similar answers to open questions were collected in categories and described with quotations. The categories were further analysed and resulted in learning features.

Study II used qualitative content analysis (Graneheim and Lundman, 2004). Data was collected from interviews to find categories and themes with rich information. An inductive analysis process contains two phases and starts by focusing on manifest content until categories have become identified. The latent phase is when categories are interpreted into themes.

The interviews were tape-recorded and transcribed verbatim. Video recordings were watched through and interviews were read several times to obtain a sense of the whole. Then the text about the students’ experiences and thoughts was extracted in meaning units that were condensed. The condensed meaning units were abstracted and labelled with codes. The codes were compared and sorted into categories and themes (Figure 8). A category refers to a descriptive level and can be seen as the manifest content. Creating themes is a way to identify underlying similar meanings from the categories. Themes were on an interpretative level with latent content. All authors in the study project were involved in the analysis and agreed, after discussion, about the themes described. In the construction of themes a theoretical model of learning aspects by Marton and Booth (1997) was used. They suggest that experience of learning is constituted of what you learn and how you learn. What you learn is the content that is being learned. How you learn, in this model, is divided into how the act of learning is performed, and what refers to the type of capabilities the learner is trying to develop and master, i.e. the student’s intention when learning.
<table>
<thead>
<tr>
<th>Meaning unit</th>
<th>Condensed meaning unit</th>
<th>Code</th>
<th>Category</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>“It was good that I also saw the anatomy at the same time and saw the consequences of what I did” (1)</td>
<td>Saw the anatomy and the consequences of what I did</td>
<td>Can see the anatomy and the consequences of the act</td>
<td>Oppurtunities to see anatomy</td>
<td>Simulator contribution to the students’ learning</td>
</tr>
<tr>
<td>“According to these anatomical images it works in the opposite direction as there will be two bends instead (5)”</td>
<td>According to the anatomical images it works in a different way than we have learned</td>
<td>Anatomical images provide an understanding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“It was fun to see because now we could actually see where the sphincters were. You can see the anatomy very well” (6)</td>
<td>Could see where the sphincters were. Can see the anatomy</td>
<td>Can see the anatomy where the sphincters were</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“I tried to pull carefully because I thought that it would come out then, but actually it did not. There was resistance, so it was very good felt like an advanced technique” (1)</td>
<td>Tried to pull and it was resistance</td>
<td>Can test and feel the resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“What happens if I bend to this angle, why is there resistance now? If I bend it upwards, it is a lot smoother” (1)</td>
<td>What happens? Why is it resistance and why is it smoother?</td>
<td>Explore different kinds of resistance</td>
<td>Oppurtunities to feel resistance</td>
<td></td>
</tr>
<tr>
<td>“One felt that there was some resistance. It takes a while before it comes down and you have to press hard. But there is resistance from the start in reality too” (7)</td>
<td>One felt resistance and you have to press hard. Resistance in reality too</td>
<td>Feel resistance. Hard pressure. In reality too</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8. An example of meaning units, condensed meaning units, codes, categories and a theme.
Ethical considerations

The students in both studies were informed of the purpose and the anticipated benefits of the current study and that they could withdraw from the study without giving any explanation. The participants gave informed consent. They had a free choice to consent or decline to participate voluntarily. The questionnaires were coded to ensure anonymity. The students knew that the interviewer was not a nurse, so they could carry out the catheterisation in the knowledge that they were not being assessed. With reference to the local research ethics committee, no formal ethical approval was required as this kind of educational research does not fall under the Swedish legislation for research ethics.

Trustworthiness

Shenton (2004) discusses how to ensure trustworthiness in qualitative research and he refers to Guba (1981), who proposes four criteria that he believes should be considered to ensure a trustworthy study. By addressing similar issues, naturalistic investigations can be compared with positivist investigations in using the concept of credibility in preference to internal validity, transferability in preference to external validity/generalisability, dependability in preference to reliability and confirmability in preference to objectivity.

Credibility is a concept that is used in qualitative studies, and replaces the concept of internal validity (Graneheim and Lundman 2004; Meyrick 2006). Lincoln and Guba (1986) argue that ensuring credibility is one of the most important factors in establishing trustworthiness. Credibility deals with how congruent the findings are with reality and how believable they are to others. To ensure credibility in study II, data was collected both from what happened during the simulation, using the video record, and also in the form of the students’ experiences and thoughts about what was happening during their performance in the subsequent interviews. In judging how well the categories covered data and how similarities within and differences between categories were made, agreement among the co-authors and other co-researchers was
Methods

sought. Another way to approach credibility is to show representative quotations from the transcribed text.

Transferability and the concepts of external validity and generalisability relate to how findings can be transferable to other settings. Generalisability in positivist work demonstrates that the result can be applied to a wider population (Shenton, 2004). In qualitative projects, findings are specific to a small number of individuals and it is impossible to demonstrate that the findings are applicable to other populations. To facilitate transferability, Graneheim and Lundman (2004) argue that culture and context should be fully described as well as the selection and characteristics of participants, data collection and the analysis process. In study II these considerations were taken into account in facilitating transferability. Authors can reflect on findings and give suggestions, but it is the reader who decides if the findings are transferable to another context. Lincoln and Guba (1986) suggest that it is the responsibility of the investigator to ensure that sufficient contextual information is provided to enable the reader to make such a transfer. A rich description of the findings with quotations will also enhance transferability.

Dependability is another aspect of trustworthiness in preference to reliability in positivist research. The process within the study should be reported in detail to enable another researcher to repeat the work, not necessarily with the same results (Shenton, 2004). Interviewing is a process in which interviewers get new insights that can influence follow-up questions (Graneheim and Lundman, 2004). To enable readers of the report to develop an understanding of the methods and their effectiveness, the text should describe research design and its implementation, details of data gathering, and give a reflective appraisal of the project. Dependability is strengthened by the transparency of the analysis and by whether other researchers can follow the trail and come to a similar solution and comparable conclusions (Shenton, 2004). In study II, the author and co-authors discussed the analysis several times during the process. Research seminars have also been a forum for discussions on how the analysis process has been understood.

Confirmability is a concern of the qualitative investigator that is comparable to objectivity. It must be ensured as far as possible that the findings are the result
of the experiences and ideas of the informants, rather than the preferences of the researcher (Shenton, 2004). Triangulation via use of different methods and different types of informants can promote such confirmability by providing different perspectives. In study II, observations and interviews with stimulated recall can be seen as a type of triangulation. The interviewer was not a nurse, which was a strength in terms of confirmability.
RESULTS

Perceptions of learning in simulation skills training have been identified through nursing students’ responses to questionnaires and by listening to their opinions and experiences in the two studies.

Study I

Before the CathSim skills training the students had high expectations of using CathSim. They thought that CathSim would provide a more realistic experience than training with a plastic arm model. Immediately after the skills training these expectations were fulfilled. About seven weeks after the skills examination, the students were less convinced that CathSim was such a valuable tool in intravenous catheterisation. Their main objection was that the input device did not mimic reality since the needle insertion was not realistic: “A strange way of gripping the input device” (Student 2), “Impersonal not to have an arm to hold” (Student 4), “There was no arm in which to insert the needle” (Student 19). Other perceptions were that the students missed a holistic perspective and the opportunity to practise communication and empathy skills.

However, one result of the study was that CathSim was found to be useful in the students’ learning process as a complement to use of plastic arm models, and several simulation functions were still considered helpful. Thanks to variations in the cases, students became aware of differences between patients’ conditions and veins and they were able to perceive sensations, such as resistance in the vein wall. Sensory experiences, such as tactile feedback, were regarded as a valuable part of the simulation: “You could feel how ’soft’ it was and how difficult it can be to find a suitable vein” (Student 23). Other feedback functions appreciated by the students included various questions in the assessment form and reactions from the simulated patients: “You could hear an ouch!” (Student 2). The visualisation of a specific area of the anatomy was considered valuable in learning how to insert the needle. The students learned
Results

practical techniques such as which needle to choose and how to carry out intravenous catheterisation in the proper order. Students thought it was easy to use the simulation program and to repeat certain steps. CathSim skill training was regarded as helpful in developing confidence in relation to intravenous catheterisation: “I don’t have to be so cowardly about inserting the needle” (Student 19).

Overall, the students liked the way the program was structured. Other comments about features of CathSim skills training were: “If you can save people from injuries by practising with simulation, it’s a ‘must’ I think” (Student 2), and “It was more fun with CathSim than with the plastic arm” (Student 11).

The most prominent learning features in computer simulation skills training were motivation, realism, variation, meaningfulness, feedback, reflection and confidence. Motivational factors were expressed as realistic tactile, visual and auditory sensations and a variation of patient conditions, veins and degree of difficulty. Realistic sensations and different patient cases were also provided to give a meaningful context. Feedback from the CathSim program from an assessment form, from the patients via sensory experiences, and from the peer student, along with time for reflection, created confidence in the specific situation. Other important features of the system were that it offered a safe environment, repeated practice, active and independent learning, interactive multimedia, and a simulation tool that was easy to use.

Study II

The analysis resulted in three main themes: what the students learn, how the students learn and how the simulator contributes to the students’ learning by providing certain opportunities. The students learned manual skills and how to perform the procedure from a situational perspective, and how to behave from a professional perspective. They learned by preparing, watching, practising and reflecting. The simulator contributed by providing opportunities to prepare for skills training, to see the anatomy, to feel
Results

resistance, and by allowing students to become aware of their performance ability (Figure 9).

Figure 9. What students experienced and how they felt about their learning using simulated skill training.

What the students learn

The students practised manual skills by holding, pressuring and coming into contact with the material. By feeling different kinds of resistance they learned to modify touch and pressure: “It becomes very, very resistant, so you have to press pretty hard” (6). Some students tried to use tweezers when inserting the catheter, but using the fingers was experienced as giving better tactile feedback: “With the tweezers, I can’t feel how hard I am pressing” (8). The students experienced that this kind of learning in simulation training mostly focuses on techniques: “I view this exercise as mostly technical, to practise manual dexterity with syringes” (1).
The students learned to perform the procedure. They thought that it was more important to be trained in procedural and technical skills than to focus on the patient: “I focused only on how to do it, not on the patient” (5). Some students were more experienced. They used a structured procedure and they performed and described one thing at a time. Other students gradually remembered the things to do, but they could be in the wrong order. The procedure was not fixed in their mind and they were not confident in the situation: “To carry out all the steps, that is what you feel you need to practise the most” (5).

From the professional perspective, the students’ behaviour was characteristic of nurses. In watching the video-recording, the students saw how they moved and how they managed disinfected equipment: “When I wear the clothes, I start to think that I am a nurse and I am going to do this;” if I was wearing normal clothes it might seem less serious” (2). They felt that they should not contaminate disinfected equipment: “I am standing with my hands together so that I do not touch anything else” (4).

How the students learn

The students learned catheterisation skills by preparing before performing the procedure: “I can imagine that the patient becomes more anxious if you are not well prepared” (7). They prepared themselves by watching instruction videos and images in the simulation program. They found that the images of patients’ faces in different scenarios gave the feeling of a real situation: “It provides an image of a real patient” (2).

The students found that it was important to see what they were doing. The cross-section image on the screen helped the students learn the catheterisation procedure: “You have to take it really easy and watch to make sure that it is actually inserted” (10). The students carried out the catheterisation in pairs and could watch each other’s performance. They found that they could learn from each other: “Did you feel that watching me do it wrong helped you to do it right the next time?” (1).
Results

The students thought that the simulation gave the opportunity to repeat, test and practise many times and that it allowed them to make mistakes in a safe environment: “In this situation it is OK to make mistakes” (2). When the students had the opportunity to repeat the practice they felt more confident: “I have of course noticed that there are things I need to practise to feel more confident” (4). Practising with the simulator gave the opportunity to test how to perform the catheterisation in different ways without the anxiety of harming anyone: “You learn by doing something wrong too, and here it is OK to make mistakes, so it is useful” (1). The students liked to practise with a peer. They found that they thought differently and that they complemented each other: “It is good to work in pairs. We think in different ways and we complement each other very well” (6).

The simulated situation gave opportunities for reflection on the students’ own skills: “I’ve been thinking about how I perform” (8). The students felt that it was valuable to have someone to reflect with during the procedure: “It is good for students to work in pairs so you have someone to discuss with. We talk to each other and we can share our thoughts and ask each other questions” (7).

Contributions of the UrecathVision™ simulator to the students’ learning of catheterisation skills

The experience was that instructional videos and images were helpful in the simulation skill training: “… and there is this demonstration video if you feel that you need a reminder of how to do it” (2). The patient scenarios served as background information: “We received some background information about his problem. Then it felt more like a real person” (7).

In the catheterisation procedure the students looked at the images on the screen, and seeing the anatomy was an appreciated feature of the simulation programme. They could see what happened and follow the consequences of their actions. This experience helped the students to gain a deeper understanding of the anatomy involved in the catheterisation procedure: “It was good that I also saw the anatomy at the same time and saw the consequences of what I did” (1).
The students appreciated the tactile feedback when they injected anaesthetic fluid and inserted the catheter, and they could understand that the feedback varied according to the patient case they had chosen: “One felt that there was some resistance. It takes a while before it (the anaesthetic) comes down and you have to press hard. But there is resistance from the start in reality too” (7).

The simulator was equipped with an assessment module to measure the quality of performance continuously. The students found this motivated them to discover the results of the assessment of their catheterisation performance ability: “I got rather high scores and then I felt pretty good; it was a confirmation of what I can do” (7).
DISCUSSION

This thesis contributes to existing research by strengthening the value of using simulation techniques in health care education. It contributes because it answers the question ‘How is simulation effective?’ posed by Hatala (2011), but also because it contains students’ perspectives, studied with a qualitative approach. Student acquisition of clinical skills is regarded as a valuable research focus in health sciences education. Most of the literature today has analysed learning from various external perspectives, test scores and other outcome measures, while the studies in this thesis focus on the student viewpoint, which is fairly uncommon. Previous studies use mainly quantitative research methods, whereas one of the two studies in this thesis also relied on qualitative methods. Our findings derived from analysis of the learners’ perspective can be emphasised as additional validity evidence.

For the students at the beginning of their second year, CathSim was found to be useful in learning intravenous catheterisation as a complement to use of arm models. At the end of the third year, students learned clinical skills with support from simulation skills training with UrecathVision in developing manual skills ability, procedural performance, and professional behaviour. The simulator was seen as a facilitator in learning clinical skills.

Results

Based on students’ learning of manual skills, performance skills and professional behaviour, the results from the two studies highlight different perspectives on learning features and experiences in simulation skills training. These are presented in figure 10. The figure illustrates the student in the centre with feelings of motivation, meaningfulness and confidence as central features in learning clinical skills with simulators. The next two circles show what the students learn and how they learn clinical skills. These features can be taken into account by creating educational conditions for variation, realism, feedback and
reflection. Educational conditions that support the students’ learning of clinical skills, are: a safe environment, providing the opportunity for repeated practice, providing active and independent learning, using interactive multimedia, and providing a simulation tool that is easy to use. The outer circle shows how the simulators in these studies can support the learning process of acquiring manual and procedural clinical skills by providing opportunities to prepare for skills training, to see the anatomy, to feel resistance to catheter insertion and to become aware of performance ability.

Figure 10. The ‘onion model’ of layers showing conditions for learning in skills training through simulation.
Kneebone and Nestel (2011) have illustrated layered learning with concentric layers in a similar onion-like model to figure 10. The core is the learner’s interaction with a patient. In figure 10 the core is the skills learning student, with what and how the student learns in layers. The outer layers represent educational support in a skills training centre or clinical setting with the simulator contribution to the skills learning process.

**Student**

*Conditions for student’s learning*

According to the students’ opinions and experiences the results have shown that learning features such as *motivation, meaningfulness* and *confidence* are central to learning clinical skills through simulation.

Motivation is crucial to learning in terms of shared ownership of the learning task. Some students in the studies wanted to test and perform the catheterisation procedure in their own way in order to become more motivated. They wanted to challenge their experienced knowledge with the combination of theoretical, *episteme*, and practical, *techne*, knowledge, and practical wisdom, *phronesis*. At the same time the performance assessment was found to motivate the students to perform catheterisation with high scores. They experienced the assessment and examination as confirmation of their skill ability. Alsin et al. (2009) say that there are two different ways of thinking about learning and knowledge - as performance or competence. In the performance model, knowledge is predictable and easy to assess, while the competence model is not predictable and gives students opportunities to choose how to learn. The competence model seems consistent with the way the nursing students learn, while the basis for assessment in the two simulators in this thesis refers to the performance model. This fact is worth being aware of, especially since there is often a mix of the two models, which can make the students confused.
Patient scenarios were described as motivational and meaningful. An authentic realistic environment motivated the students and it assisted them in their construction of knowledge. Choices of material and procedures were described as meaningful, as was the fact that the students in study II were dressed in nursing uniforms to encourage seriousness. Situated learning in clinical settings is favoured, and simulation in skills centres or in clinical environments might bridge the gap between university and health care (Khan et al., 2011).

The students experienced confidence when they could learn in an active and independent way. A safe and non-threatening environment as well as working with a peer was considered to develop confidence. Confidence in action leads to less focus on how to do something than on the intention of the action (Silén, 2006).

**What the students learn in simulation skills training**

Prominent features of what the students learn were *manual skills, performing the procedure* and *behaving like a professional*. The students expressed that they were more serious when they were dressed in nursing uniforms. An authentic, realistic environment positively affected their attitude towards the content, what they learned.

In these studies, manual skills and dexterity were characterised by ‘techniques’, ‘sensory experiences’, ‘modifying touch and pressure’ and ‘how to hold’. Motor learning emerges from processes related to sensation, cognition and motor function (Shumway-Cook and Woollacott, 2012). In learning manual skills, novice students are focused on single techniques, which are shown in the studies. Some students in the sixth semester managed to be aware of the patient and the environment. They could be seen as advanced beginners (Dreyfus, 2004). When one has little training the task requires a high degree of attention control. With more training, manual skills can be automated and the control can be reduced (Floyer-Lea and Matthews, 2004).
Discussion

In performing a procedure the students learn procedural and technical skills. That was regarded as the most important aspect of the skills training. The students felt that their focus was on carrying out the procedure in the correct manner. They thought that they needed to practise technical skills first to be sure of the catheterisation procedure. The task was not automatic yet, but they were secure in handling disinfected material. It was familiar to them.

Professional behaviour develops continuously and will become tacit embodied knowledge. It is difficult to explain this knowledge because the behaviour has become unconscious competence (Figure 1). One student expressed the view that she felt like a novice in the catheterisation procedure, but at the same time she saw herself as a graduated nurse. Even if you are a competent skilled professional, you become a novice when learning new things. The video recording in study II made it possible for the students to see that they behaved like professional nurses. This behaviour had become embodied. It is an example of how the body conveys its message through gestures, imitations, movements and posture (Duesund, 1996).

How the students learn in simulation skills training

The findings showed that the students learned skills by preparing, watching, practising and reflecting. To prepare for the skills training, the students started with reflection for action. In study I, questions were answered about previous experiences and theoretical knowledge, learning needs and expectations. In study II the students responded orally to questions intended to encourage reflection, similar to study I. The students became acquainted with the material for the catheterisation procedure and the environmental context, and they also prepared themselves by watching instructional videos and images and discussed the procedure with their peers.

It was important for the students to see what they were doing. Both visual and tactile senses give input to the perception, which is interpreted and memorised (Figure 3). As the procedure was performed in pairs, the students could watch each other. Elliott et al. (2011) claim that, with the mirror system, skills are learned by watching skill performance as well as in social mirroring.
The students appreciated that they could see what happened inside the body on the screen. However, the observation was divided between the computer screen and the syringe or the catheter. It was difficult for the students to have contact with the patient when they were busy watching the screen. In skills training, visual input supports the tactile sense and a conflict occurs, especially for novices. Moreover, in study I there was no arm into which to insert the intravenous catheter. The students missed having an arm to hold and the feeling of managing the syringe. On the other hand, the students appreciated the anatomical images. Several students realised that they had to revise their previous understanding of the actual anatomy. In both studies, the anatomical images were a valuable benefit of the simulation and resulted in a deeper understanding of the anatomy.

It is necessary to practise a skill in order to perform an automated procedure. The students appreciated the opportunity to practise many times on their own or together with a peer without harming anyone, in a safe environment. Repeated practice resulted in a feeling of confidence. When the students are more experienced they manage to think and do several things at the same time. The reality of the situation can gradually be increased by introducing different kinds of distractions. Johnson (2004) describes the difference between a student and an expert in a clinical setting, where the expert noticed how colleagues came and went, and other things that happened, but the student was not aware of these things. The learning process takes both cognitive and motor forms with sensory experiences. People perceive themselves through their senses and the environment (Swartling Widerström, 2005). During the skills training, the realisation phase in the design of study I (Figure 4), the students had an inquiring attitude, asking what, why and how, and how does it work? In practising, the students also learn by sensory experiences. They make their own choices and learn from their mistakes (Ringsted, 2009). Learning from an inquiring approach might be associated with experiential learning. Kolb (1934) stated that learning can start in any of the four phases in the cycle of learning (Figure 2). Learners who want to take an inquiring role through practice might start with active experimentation, giving them concrete practical experience to reflect upon and create new theoretical knowledge, abstract conceptualisation. In simulating clinical skills training it...
must then be possible for the learners to start in the experimentation phase without learning from initial teaching modules in simulators. At the same time it must be possible to go back to previous phases if needed.

Both studies were designed for reflection in, on and for action (Schön, 1984). Working in pairs promotes reflection. The students thought that it was valuable to have a peer to reflect with during the procedure. By reflecting, the students became aware of their behaviour, how they used their hands, and how they performed the procedure.

**Education**

*Educational conditions for student’s learning in simulation skills training*

Significant educational conditions to enhance learning features in simulation were variation, realism, feedback and reflection. The students appreciated variation in patient cases and the degree of difficulty. The patient cases served as a meaningful context, but at the same time it was difficult to relate to the patient during the skills training. According to Benner (1984) it is hard for a novice to focus on different things at the same time. Variation is regarded as a driving force for learning since the student learns by comparison (Marton and Booth, 1997). Kneebone et al. (2002) state that one important learning purpose in skills training is to enhance motivational factors, e.g. variations. To increase realism, simulators have been combined with real people, so called hybrid simulation. Our simulation studies presented learning features such as experiences of realism and feedback. An authentic context influenced how the students learned. A realistic context encourages seriousness in professional behaviour. Working in pairs was described by the students as valuable for reflection and for obtaining a different kind of feedback. Practising with a simulator was experienced as the joy of discovery. Having fun is a highly motivational factor for learning (Chauvet and Hofmeyer, 2007). The students got feedback from the assessment form, audio reactions from the presented
patients in study I, and from their tactile as well as visual senses. Feedback from the instructor in study I was highly appreciated by the students.

Several studies highlight that reflection is important in simulation skills training (Kneebone at al., 2002; Bradley and Postlethwaite, 2003; Ker, 2003; Maran and Glavin, 2003; Jeffries, 2005; Alinier et al., 2006). In study I, the time for reflection was too limited although answering the questions could be seen as reflection. In study II, reflection was an inherent part of the UrecathVision program. Active and independent learning in a safe environment is said to promote confidence. Repeated practice was another important learning feature for developing more confidence in a clinical setting, which is in line with other studies (Issenberg et al., 2005; Baillie and Curzio, 2009). The students appreciated interactive multimedia as a resource for refreshing theory and practical skills.

**Simulator contribution to learning by providing opportunities**

The simulators helped students to learn clinical skills by providing opportunities to prepare for skills training, to see actual anatomy, to feel resistance to catheter insertion and to become aware of performance ability.

Although more clinical skills centres are being built, many argue that simulators for skills training should be placed in a clinical environment to allow situated learning (Lave, 1991). This would help in maintaining the skills of professionals as well as training students in clinical placements. Besides learning skills with the help of a simulator, a clinical environment provides additional opportunities in learning clinical skills. For a more experienced learner this would be optimal, while for a novice learner with limited ability to pay attention to different stimuli, having access to different simulators at a skills training centre would be preferable.

The simulator provides multimedia instructions and images of patients’ faces in various scenarios. Varied patient cases and the degree of difficulty were regarded by the students as meaningful contributions for preparation.
Discussion

However, the students expressed the view that they had not been given a holistic perspective or the opportunity to practise communication. A new approach might be to use hybrid simulation with a combination of simulator and simulated patient because many simulators today are only representations of body parts with focus on the equipment and techniques (Kneebone and Nestel, 2011).

The simulators helped with visual feedback such as cross-sectional and anatomical images, with tactile feedback through haptics, and with audio feedback in the form of patient sounds. The students also thought that they gained a better understanding of anatomy. Several studies claim that the simulator ought to be appropriately integrated into the curriculum to ensure it is used regularly (Rystedt and Lindström, 2001; Issenberg et al., 2005; Schiavenato, 2009).

Methods

In order to gain a broad insight into the students’ perceptions of learning, two methods of data collection were used in the studies; questionnaires and interviews. The questionnaires in study I were designed by the research group and the questions were tested and revised in a pilot group. There was no problem to understand the questions.

Even though the design of the studies incorporated phases both before and after the simulation realisation phase, not enough time was spent on these. The real simulation performance was what the students thought they were supposed to concentrate on. In future studies and in education, more time is recommended to be spent on the before and after phases. Being aware of previous knowledge and experiences allows the skills training situation to be more cognitively contextualised, which might support motivation, meaningful learning and confidence. Moreover, in both studies, it was found that allowing more time in getting acquainted with the simulators in the arranged setting would have helped the students. As it was, they were much occupied with how to use the simulator.
In study I, twenty-two students participated in the study. It was a small number, due to the limited number of simulators and a desire to use regular skills training. One question area in the third questionnaire, 4 questions, was asked about how the simulator might facilitate reaching the curricular goals for clinical practice. The students thought that this simulator could not help them to learn how to organise actions, to explain and value choices of materials and procedures, value and explain why and how the student approach, touch and talk with patients and to be sensitive to the patients’ experiences. This area expresses planning for action and clarifying values in how to approach and communicate with a patient. The simulator did not have these functions. This clarifies a need for alignment between goals, learning activities and assessment. Hybrid simulation might be one way to meet the needs of meeting a patient (Kneebone and Nestel, 2011).

Both simulators were equipped with haptics, which was greatly appreciated by the students. In study I there was resistance when inserting the needle through the skin and then through the vein wall. In study two there was resistance when injecting anaesthesia, inserting the urethral catheter, and the students felt that the catheter could not come out after the inflation ‘cuff’ was filled. Even though the students in study II were occupied with how the simulator worked, many of them seemed to be more aware of curricular goals, the patient, and a holistic approach, than the students in study I. This may have been the case because some students in the latter part of education had come to the second stage in their professional development, advanced beginner (Dreyfus and Dreyfus, 1986), while the students in study I were still novices in stage 1, and thus were more occupied with the task.

The follow-up phase in study I, the examination of intravenous catheterisation skills, made the students aware of their competence. Their abilities were confirmed. Also in study II the students thought that different kinds of feedback helped them to become aware of their theoretical knowledge, practical skills and practical wisdom. They received confirmation of these, especially from the video record.

Limitations of study I might be that the students only used the simulator once. Extra scheduled simulation resources would have been offered for training.
with CathSim between the simulated skills training and examination to have current experience of practising with the simulator. Limitations of study II might be that the students were self-selected volunteers from the last semester. Although they may have been too similar, they had different experiences from various clinical placements. As mentioned, we could have let the students become more familiar with the simulator in advance. Both simulators have been further developed. The new CathSim now has a pad into which the needle is inserted. The new UrecathVision has become much smaller. It can be used as it is or can be inserted into a body model. The students in study II missed the legs. Their absence was considered unrealistic. Another limitation of CathSim skills training was that the input device did not imitate reality, but it has now been developed and changed. The catheterisation process in study I was seen as too controlled when using a stepwise procedure. This reaction was also expressed in study II. Suggestions for further development might be to create functions for moving both forward and reverse in the simulation procedure.

Simulation skills training in the clinical skills centre presents a clinical situation as if it were real. A realistic and authentic environment was considered by the students to benefit how they experienced the seriousness of the situation. The students were dressed in nursing clothes, and it was surprising that they highlighted this point so much. It made the situation more realistic and it gave the students the feeling of being a nurse. The findings show the importance of a realistic setting even when using body part simulators. The students learned together and constructed their knowledge in practising clinical skills as situated learning (Lave, 1991).

Educational designs in the studies

The studies that form the basis of this thesis were designed from an educational perspective. Thus, the designs of both studies can be used in education for skills training. In study I the design (Figure 4) was based on the aim of identifying learning features in simulated skills training. The 22 second-year students' opinions were studied over time. The way to integrate
simulation skills training into the regular curriculum is supported by previous studies (Rystedt and Lindström, 2001; Glavin and Maran, 2003; Issenberg et al., 2003, 2005; Seropian et al., 2004b; Schiavenato, 2009; Aggarwal et al., 2012). A group of eight students at a time trained together in pairs using a simulator and plastic arm models. After the skills training, the time for reflection could have been extended to give the students an opportunity to become more aware of what they did and did not know. However, the period spent on answering the questions could be seen as a time for reflection. The model of becoming conscious of competence and incompetence can be a resource in students’ reflection (Figure 1). The students trained using a scenario with the purpose of creating a meaningful context (Marton and Booth, 1997), but they did not use it because the simulator provided its own patient cases, including photos and sensory feedback, which were regarded as more valuable in the learning process.

In study II, the design (Figure 5) was based on establishing how students perceive that they learn manual and procedural clinical skills with a simulator. This study was not integrated into the regular curriculum. The situation was arranged to be as realistic as possible with real equipment placed around the simulator. Johnson (2008) says that knowledge is created in situated practice and that the whole practice situation is simulated, not certain skills. The focus of simulation is context, relations and activity rather than isolated tasks and performances. The ten students in study II were encouraged to think aloud and talk to each other so their voices could be heard in the video. Some of the students were stressed by the camera. The students would probably have been more confident in the situation if they had practised in advance and become more familiar with the simulator. In the interview, the students seemed to be quite relaxed, perhaps because they knew that the interviewer was not a nurse. They did not feel that they were being assessed.

How can simulation be consistent with PBL?

A question about the consistency between simulation and PBL was raised in the educational health care programs at the Faculty of Health Sciences. New
Discussion

ideas about simulation were brought to the skills laboratory for all educational programs. The concern was whether simulation programs were too controlling and predictable when followed step by step, while PBL argues for personal responsibility and independent inquiry in the learning process (Silén, 2003). Both simulators used in the studies were structured the same way, with a teaching module, a learning module, a simulation module and an assessment module (Jouud et al., 2009). Considering the study designs, the preparation phase can be compared with the teaching and learning modules, the realisation phase with the simulation module and the follow up phase with the assessment module. The design with the phases before, during and after is in congruence with the PBL philosophy in becoming aware of previous knowledge and experiences, before, having an inquiring way of learning, during, and getting own awareness and confirmation, after.

Abrandt Dahlgren et al. (2009) emphasise certain characteristics of PBL, such as the shared ownership of the learning task, the learning content in a context, the social role of working together and the importance of reflection. In this thesis, the shared ownership can be seen as existing between the student and the simulation program. In congruence with PBL it seems that the design of the learning situation as well as construction of simulators has to take the shared ownership into account. The students might be a partner in the construction of the context as well as the simulator might have much variation to promote an interactive way of learning. The importance of learning in a context has been emphasised in both studies. In addition, the social role in the learning process, together with a peer, was appreciated by the students and gained reflection. According to the way of learning in PBL, techne is a starting point instead of the more traditional way of learning theoretical facts, episteme, and then knowledge is applied in practice, techne. The educational context in this thesis has been the skills training centre Clinicum. Even though the students were used to patient scenarios in base groups, it was difficult to relate the skills training to a patient. Perhaps hybrid simulations with peer students as a simulated patient with a simulator might be one way to create realistic situations.
Contributions and future research

The perspective in these studies on how learning occurs in simulated settings is rarely explored, although there is a call for more research from the fields of motor learning, neuroscience and psychology in order to obtain a deeper understanding of the learning processes (Tun and Kneebone, 2010). This thesis contributes to a student perspective related to learning theories with the purpose of how to design skills training in health care education with and without simulators.

The fields of motor learning, neuroscience and psychology have been touched in this thesis. More research is needed to understand what happens in clinical skills learning. How to learn manual and procedural skills through senses is a research field for urgent further investigation. Another field is how to develop skills training design, based on new learning research.

In this thesis the importance of learning manual skills through the senses has become evident. This might become an area for further exploration linked to simulation. The significance of experience, the attainment of automatic skills, embodied knowing, tacit knowledge and experiential learning, are other fields for future research on learning manual clinical skills through simulation.
CONCLUSIONS

Motivation is a prerequisite for learning, both internal and external. The students’ learning becomes enhanced if they experience the situation as meaningful. Variation is regarded as a driving force for learning as the student learns by comparison. To become aware of what the students know and not know, reflection together with others, with a peer or in a group serves as learning support. Realistic sensations are of great value since the learning process is both cognitive and motored. Sensation and cognitive feedback help the student to develop confidence and to become active and independent. The students learn clinical skills by preparing, watching, practising and reflecting.

In creating an environment that supports the learning process in skills training, certain factors is shown to be taken into account. They are seen as opportunities to prepare for the skills training by using interactive multimedia including patient scenarios to provide a sense of realism, getting acquainted with relevant material and dressed in professional clothes to behave like a professional and experience seriousness. In performing the procedure, the environment can support a sense of safety to minimise anxiety of hurting somebody. Learning together with others promotes visual input by watching others and being watched.

Simulation programs support students’ learning by providing different kinds of multimedia and patient scenarios in the preparation phase. By watching anatomic cross-section images, updated to the actions taken, the students get a new understanding of how it looks inside and how to perform the skill. High-fidelity simulators are equipped with sensory feedback as images and interactive videos, haptic equipment for tactile feedback and sounds with the purpose to simulate real life. The students felt that the opportunity of repeated practice gave them more confidence in a clinical setting.
When organising for simulation clinical skills training in health care education the findings in the two studies suggest following features to be aware of:

- Encouraging independent learning with and without a teacher, with a peer or in a group
- A realistic authentic environment and clothing to enhance seriousness
- Video recording the performance for reflection and feedback
- Using a realistic simulation device to enhance seriousness
- Peer learning for common reflection and feedback
- Repeated training, necessary for motor learning
- Assessment to provide feedback and to encourage seriousness

This thesis shows that with support from simulation skills training, students can develop manual skills ability, procedural performance and professional behaviour. They learn through their senses. The simulation tool in itself and the arrangement of the simulation situation may trigger optimal use of the senses. The experiences of performing, and conscious reflection on the performance, preferably with peer students, emerge as important in the learning process.
Färdighetsträning är en viktig del i utbildningen till olika professioner inom hälso- och sjukvård. Studenter har övt på varandra och på patienter i praktik i verksamhetsförlagd utbildning, VFU. Förändring av vårdens på grund av krav på ökad patientsäkerhet och etiska hänsynstaganden har lett till att tillgängligheten minskar. Samtidigt sker en teknisk utveckling, som innebär ökad datoranvändning och utveckling av datoriserade simulatorer. På senare år har kliniska träningscentra, KTC, bygatts upp för att ge större möjligheter till färdighetsträning för såväl studenter som personal.

Till att börja med var utvecklingen av simulatorer inriktad mot tekniska funktioner. Nu har den pedagogiska nytan alltmer kommit i fokus. Hittills har forskningen mest varit inriktad mot att mäta effekter av användningen av simulatorer vid färdighetsträning, för att se om simulatorer har något pedagogiskt värde.

Denna avhandling har en annan forskningsansats. Studierna har utgått från studenternas syn på vad och hur man lär sig i simulerad färdighetsträning och vad som är viktigt att tänka på i utbildningens planering av färdighetsträningen. Träning med simulatorer har visat sig underlätta motoriskt och kognitivt lärande. Frågan har ändrats från ”Är simulering effektiv?” till ”Hur är simulering effektiv?”

Det övergripande syftet med den här avhandlingen var att bidra till djupare förståelse av hur studenterna lär sig i simulerad färdighetsträning och hur denna förståelse kan relateras till hur studierna var upplagda.

Två studier genomfördes med sjuksköterskestudenter i termin 3 och termin 6 i Norrköping respektive Linköping. Studenterna i termin 3 övade venkateteriserings i ordinarie färdighetsträning. Tjugotvå av dessa studenter fick även öva med simulatorn CathSim®. Tio studenter i termin 6 övade urinvägskateriserings med UrecatVision™. Denna färdighetsträning erbjöds som ett extra tillfälle, utanför ordinarie schema, ett par i taget.

I studie II blev studenterna inspelade på video under färdighetsträningen. Förutom öppna frågor i den uppföljande intervjun användes videofilmen som hjälp att komma ihåg vad som hände och vad de tänkte, så kallad ”stimulated recall”. Intervjudata analyserades med kvalitativ innehållsanalys. Tre teman identifierades: vad studenten lär sig, hur studenten lär sig och hur simulatorn kan bidra till vad studenten lär sig.

När studenterna lärde sig färdigheter med hjälp av simulering menade de att motivation, meningsfullhet och tilltro till egen förmåga var viktiga faktorer att beakta. Studenterna lärde sig manuella färdigheter, att genomföra procedurer och ett professionellt beteende genom att förbereda sig, titta, öva och reflektera.

Från utbildningens sida, vid planeringen av färdighetsträning med simulator tyckte studenterna att det var viktigt att vara medveten om betydelsen av variation, att det var realistiskt, att studenten får återkoppling och möjlighet att reflektera. Det var viktigt att utbildningen ger förutsättningar för en trygg miljö, att repetera färdigheter, att vara aktiv och självständig, att använda interaktiva multimedia och att simuleringsverktyg är lätt att använda. Simulatorn bidrog med att ge möjlighet att förbereda sig, se anatomin, känna motstånd och att bli medveten om hur de presterar.

Vad sjuksköterskestudenterna har beskrivit hur och vad de lär sig, kan även gälla andra utbildningar, som planerar färdighetsträning i vården.
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