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Virtual Patients for Assessment of Clinical Reasoning

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av **Elenita Forsberg**

Huvudhandledare:

Professor Uno Fors
Institutionen för data och systemvetenskap
Stockholms Universitet

Opponent:

Professor Charlotte Ringsted
Dept. of Anesthesia
University of Toronto
Canada

Bihandledare:

Docent Kristina Ziegert
Sektionen för hälsa och samhälle
Högskolan i Halmstad

Betygsnämnd:

Professor Kirsten Hofgaard Lycke
Dept. of Educational Research
Oslo Universitet
Norge

Bihandledare:

Professor Håkan Hult
Institutionen för klinisk vetenskap,
intervention och teknik
Karolinska Institutet

Professor Pernilla Nilsson
Sektionen för lärutbildning
Högskolan i Halmstad

Docent Margaretha Bachrach-Lindström
Institutionen för medicin och hälsa
Linköpings Universitet

ABSTRACT

In healthcare education it is essential for the students to develop and achieve clinical reasoning skills. Clinical reasoning is complex to teach and learn, and effective assessment methods are also lacking. Virtual Patients (VPs) are interactive computer simulations of real-life clinical scenarios for the purpose of healthcare training, education and assessment. Many VP systems are focused on clinical reasoning and have the possibility to track every interaction from the user and therefore have been suggested to be used for assessment.

The overall aim of the thesis was to explore the potential of using VPs for assessment of clinical reasoning in postgraduate paediatric nursing education.

Study I evaluated the applicability of VPs for the postgraduate paediatric nursing field and students' acceptance for using VPs for assessment. Study II aimed to identify how clinically experienced paediatric nurses through clinical reasoning solve complex paediatric VP cases. The study was also aimed to give information about how clinical reasoning might be assessed in VP-based exams for postgraduate paediatric nurse students. Study III evaluated a novel scoring and grading model for VP-based exams. Study IV explored whether formative VP-based assessments in connection with self-evaluations had an impact on postgraduate paediatric nursing students' development of clinical reasoning abilities and the learners' discovery of their progression.

The findings showed that it was possible to develop and implement VP cases that reflected specific tasks for paediatric nursing. Students and experienced paediatric nurses found the cases realistic and engaging. Both groups also thought using VPs was an innovative and interactive way to be assessed and that VP cases can be used to assess clinical reasoning. The novel scoring and grading model developed for summative VP-based exams could be used to assess the clinical reasoning process and the clinical decision-making. The model has opportunities to give negative points if not protecting patient safety or doing unnecessary things, which was good. In study III, one group of students performed a VP-based exam in three consecutive courses and a clear progress was detected: 53% of the students passed the first exam, 63% at the second and in the last, 84% of the students passed the exam. The most common reason for deduction of points was due to students asking too many interview questions or ordering too many laboratory tests. In study IV, when VPs were used for formative assessments; the findings showed that students' understanding of the concept of clinical reasoning, awareness of what to focus on in clinical practice and grasp of the level of clinical competence they would require in future professional practice was improved. The students reported a perceived progression of clinical reasoning ability during the courses (from uncertainty about the competence to self-efficacy).

In conclusion, the results of the Thesis indicate that VPs seem to have excellent opportunities to assess clinical reasoning skills. Even though the four studies have been performed within the area of postgraduate paediatric nursing care, most of the results are most certainly applicable and transferable to many other areas within healthcare education.

Key words: assessment, formative assessment, clinical reasoning, health care education postgraduate paediatric nursing, scoring rubrics, scoring and grading, assessment model, self-evaluations, virtual patients

DEPARTMENT OF CLINICAL SCIENCES, INTERVENTION
AND TECHNOLOGY
Karolinska Institutet, Stockholm, Sweden

**VIRTUAL PATIENTS FOR
ASSESSMENT OF CLINICAL
REASONING**

Elenita Forsberg



**Karolinska
Institutet**

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LIST OF PUBLICATIONS

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- II. **Forsberg, E.,** Ziegert, K., Hult, H., & Fors, U. (2014). Clinical reasoning in nursing, a think-aloud study using virtual patients – A base for an innovative assessment. *Nurse Education Today*, *34*:538-542.
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“The doors we open and close each day decide the lives we live”

Flora Whitemore

1 INTRODUCTION

In healthcare education many courses have learning goals which specify that learners should be able to demonstrate competence in aspects of patient problem solving such as clinical reasoning and clinical decision making. These skills are difficult to learn and teach (Delany & Golding, 2014), and effective assessment methods are also lacking (Cook & Triola, 2009). To prepare students for complex clinical situations and to learn reasoning effectively the students must learn to understand how to pay attention to relevant cues and how these cues lead to clinical decisions. How we design assessment packages, makes a difference and the chosen methods will influence the students' learning (Al-Kadri, Al-Moamary, Roberts & van der Vleuten, 2012; Schuwirth & van der Vleuten, 2010). Integrating learning of clinical reasoning in Virtual Patient (VP)-based assessments might bring benefits for the students and help them develop these essential skills needed for their future professions within health care.

This thesis explores the use of Virtual Patients (VPs) for assessment in postgraduate paediatric nursing education, with the starting point to investigate students' acceptance of VPs as assessment tools, VP-based assessments' impact on development of clinical reasoning skills and how a VP-based exam might be designed, scored and graded.

The initial reason for starting my research was an urge to find an assessment method that assessed clinical reasoning in an effective way and that also promoted learning. It was also important to find an assessment that works in distance-based courses, and thus the solution should preferably be web-based. In 2006 Halmstad University decided to offer postgraduate specialist paediatric nursing as a web-based course; in the same year, as a teacher and course director for the paediatric nurse programme I attended a work-shop on distance learning tools at Karolinska Institutet in Stockholm, at which professor Uno Fors presented the VP system Web-SP (Web-based Simulation of Patients) and its use in healthcare education. At that time the use of VPs in education had increased and initial studies had identified VPs as realistic and engaging learning tools (Zary, Johnson, Boberg & Fors, 2006). In 2007, I joined a collaborative project between Karolinska Institutet, Gothenburg University and Halmstad University for the project *Innovative assessment within medicine and healthcare*, funded by NSHU (Swedish agency for Networks and Cooperation in Higher Education). I also learned that there was a lack of published scientific studies regarding the use and benefits of VPs in nursing education and regarding VPs used as an assessment tool. The NSHU VP project subsequently resulted in the first study of my thesis.

2 BACKGROUND

2.1 CLINICAL REASONING

Clinical reasoning is a cognitive process by which knowledge and experience is applied to clinical situations to develop solutions (Carr, 2004). All health care professionals use clinical reasoning to reach clinical decisions, even though the final goal of their respective types of decisions may differ.

“Nurses’ clinical reasoning can be defined as the cognitive processes and strategies that nurses use to understand the significance of patient data, to identify and diagnose actual or potential patient problems, to make clinical decisions to assist in problem resolution, and to achieve positive patient outcomes” (Fonteyn & Ritter 2008, p. 236).

However it is important to note that nurses and physicians need to be competent in many other areas besides clinical reasoning, for example communication skills and performing physical exams. But in terms of clinical decision making, clinical reasoning seems to be a crucial skill. Clinical reasoning is the way clinicians think about the problem, it is the process that take part before the clinical judgments, when finally deciding what is wrong with the patient and deciding what to do (Banning, 2008; Levett-Jones et al., 2010; Simmons, Launza, Fonteyn, Hicks & Holm, 2003; Smith Higuchi & Donald, 2002; Tanner, 2006).

Clinical reasoning is very important to learn and develop. Today’s health care necessitates the effective use of clinical reasoning in complex care situations for rapid assessments of patient care needs. There is a correlation between effective use of clinical reasoning skills and positive patient outcomes meaning that lack of clinical reasoning skills may lead to worse outcomes (Levett-Jones et al., 2010). Several studies (Göransson, Ehnfors, Fonteyn & Ehrenberg, 2008; Göransson, Ehrenberg, Marklund & Ehnfors, 2006; Jacques, Harrisson, McLaws & Kilborne, 2006; Thompson et al., 2008) reported an association between limited knowledge of clinical reasoning among nurses and actual or potential negative impact on patient safety.

Clinical reasoning is difficult to teach and learn because of its complexity. It can also be hard for students to comprehend, because it is difficult to make the clinical reasoning visible and accessible (Delany & Golding, 2014). Clinical reasoning ability depends, among other things, on earlier experience of similar patient situations; experience can also lead to the acquisition of tacit knowledge, which is important for pattern recognition (Simmons et al., 2003; Smith Higuchi & Donald, 2002). To have the ability to see patterns in different situations, to recognize the symptoms of the patient and be able to link those with a specific problem are important for the clinical reasoning process. An experienced nurse seems to immediately know what significant data to catch, will be able to draw conclusions, decide, plan and implement appropriate care for the patients in an automatic way (Smith Higuchi & Donald, 2002). According to Smith Higuchi and Donald (2002) clinical reasoning is a learnt skill. Acquiring competence in clinical reasoning skills is dependent on clinical experience, something the novice students may not have or having difficulty getting during their clinical

training. Students' work-based education may be rather limited; today patients spend less time in hospital and a lot of patient care takes place in patients' own home. Therefore, it can be difficult for students to see a range of patient cases during clinical training.

Levett-Jones et al. (2010) developed a model for clinical reasoning. The model provides a structure suitable for problem-based learning and/ or self-directed learning and has therefore been proposed to be applied in classroom teaching or appropriate for computer-based learning. The model is linked to the "five rights" of clinical reasoning namely "the ability to collect the right cues and take the right action for the right patient at the right time and for the right reason" (Levett-Jones et al., 2010, p.517).

Collecting the "right cues" is a reference to the ability to pick up on the available patient information. Judgement about the "right patient" refers to the ability to identify and prioritise the patient who is in need of care immediately and "right time" refers to the ability to identify risks to patients in time to intervene and take the appropriate clinical actions in the right sequence. "Right action" relates to the nurse's behaviour after the clinical decision, has been made, for example which part of the care plan takes priority. The "right reason" is not only a reference to a sound clinical reasoning process, but also takes into account ethical, legal and professional standards (Levett-Jones et al., 2010).

For nursing students, it requires the ability to identify, synthesise and apply their knowledge in complex clinical situations; it is therefore essential for healthcare educators to develop methods and tools to support and promote development of students' clinical reasoning ability and evaluate regularly their skills in this area.

2.2 NURSING EDUCATION IN SWEDEN

In Sweden, before applying for postgraduate Diploma in Specialist Nursing Paediatric care (60 higher education credits [ECTS], one year) the students need to have a Bachelors' degree in nursing (180 ECTS, three years) and most Swedish universities also require registered nurse (RN) experience for at least one year before admission to postgraduate studies (Ohlén, Furaker, Jakobsson, Bergh & Hermansson, 2011).

The specialist educational programme include learning goals such as demonstrated clinical reasoning abilities and skills in paediatric care. The diploma gives formal and real competency to work as a paediatric nurse in different paediatric settings or in child- and school health care centres with responsibility for the general vaccination programme.

2.3 VIRTUAL PATIENTS

Virtual Patients are defined as "interactive computer simulations of real-life clinical scenarios for the purpose of healthcare and medical training, education or assessment" (Ellaway, Poulton, Fors, McGee & Albright, 2008, p.170). VPs have been used successfully in medical and healthcare education for a number of years (Ellaway et al., 2008). The VP system used (Web-SP) was initially developed at Karolinska Institutet and used worldwide

in several universities in different healthcare educations (Zary et al., 2006; Zary, Johnson & Fors, 2009). Like most VP systems, Web-SP's features include an introduction to the case, patient interview questions, physical examinations, laboratory and imaging tests and features for suggesting appropriate diagnosis and treatment, the justification for decisions about diagnosis and treatment and a feedback section (Bergin & Fors, 2003). Since 2010 Web-SP has included a semi-automatic assessment module which allows the examiner to define required or recommended patient interview questions, physical examinations and laboratory and imaging tests in order to score learner's performance. The examiner also has the option of creating follow-up questions (Forsberg, Georg, Ziegert & Fors, 2011).

VPs have been found to improve learning and be superior to traditional teaching methods for clinical reasoning like paper based cases (Botezatu, Hult, Kassaey Tessma & Fors, 2010b). Based on the fact that VP systems are focused on clinical reasoning and have the potential to track every interaction of the user (Botezatu, Hult, Kassaey Tessma & Fors, 2010a;2010b; Forsberg et al., 2011), VPs have been recommended to use for assessment of clinical reasoning (Cook & Triola, 2009).

Virtual patient systems

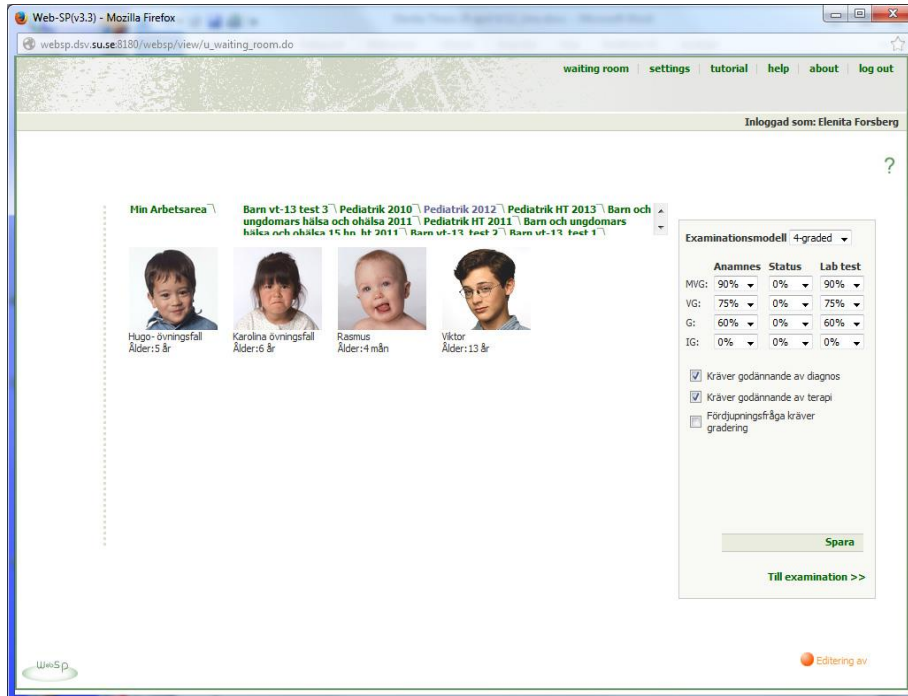
As mentioned in the introduction the initial reason for starting my research was an urge to find an assessment method that assessed clinical reasoning in an effective way and as well as working well in distance-based courses, and thus the solution should preferably be web-based.

Desirable options were that the system would be interactive to stimulate a student-activating learning process, suit nursing care, and be free of charge. The system should also provide templates to facilitate case creation and editing, enable both educators and learners to easily implement cases, as well as to offer update opportunities (Ellaway et al., 2008).

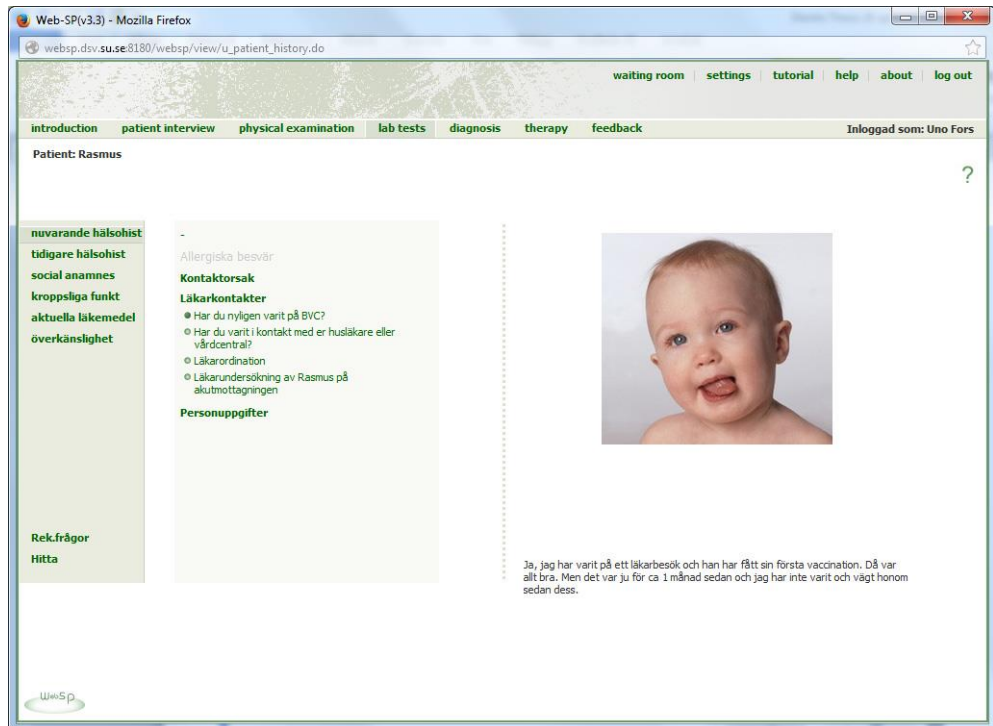
At the time for initiating my studies, a number of different VP systems were available for the purpose such as Web-SP, Open Labyrinth, CASUS, CAMPUS etc. (MedBiquitous, 2014). However, as the aim of my studies was to use VPs for assessment, a system with opportunity to measure and score students actions was requested. Web-SP is the only available VP system in Swedish, and since 2010 Web-SP consist a semi-automatic assessment module and therefore seemed to be the best choice for the research in my thesis.

The VP system used in this Thesis

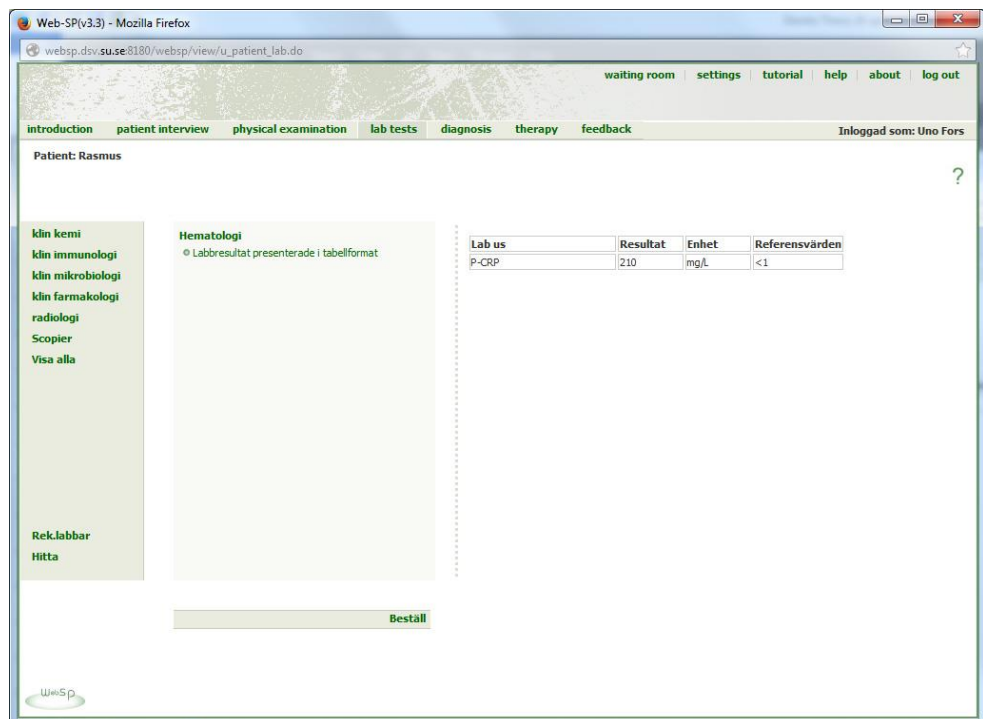
The Web-SP system contains a number of features, including "waiting room" where the teacher can select which cases that should be used in a course, *patient interview*, physical exam (not used in the Thesis), *lab/imaging tests*, *diagnosis* and justification, *therapy* and justification, automatic *feedback* and an *assessment module*, see Screenshots 1-7 below.



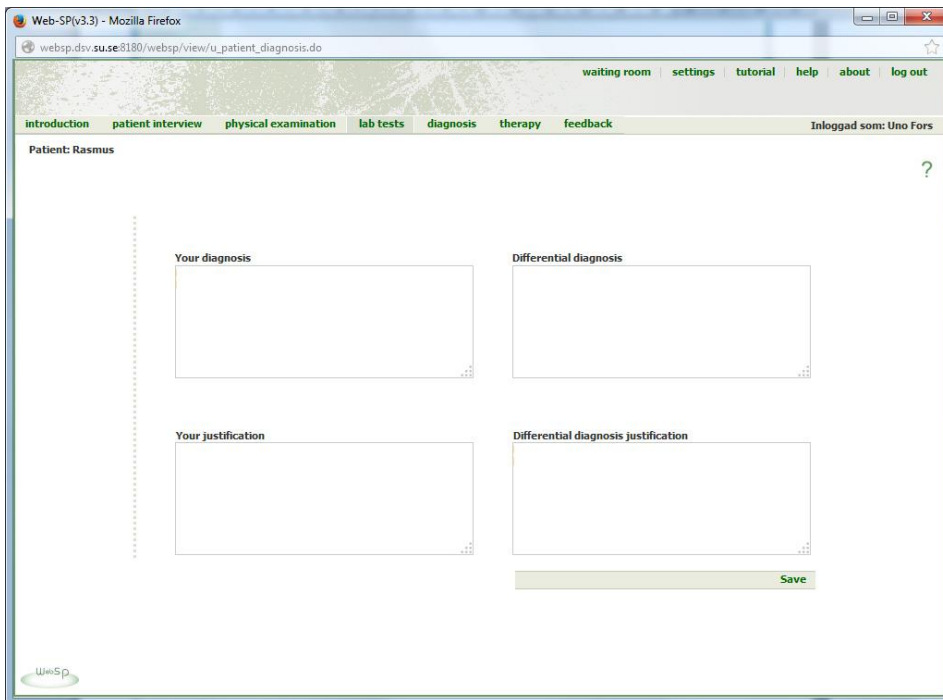
Screenshot 1. A view of the VP cases in the "waiting room" to be used for assessment in the course of paediatric, including a part where the examiner can assign an appropriate assessment model for the course.



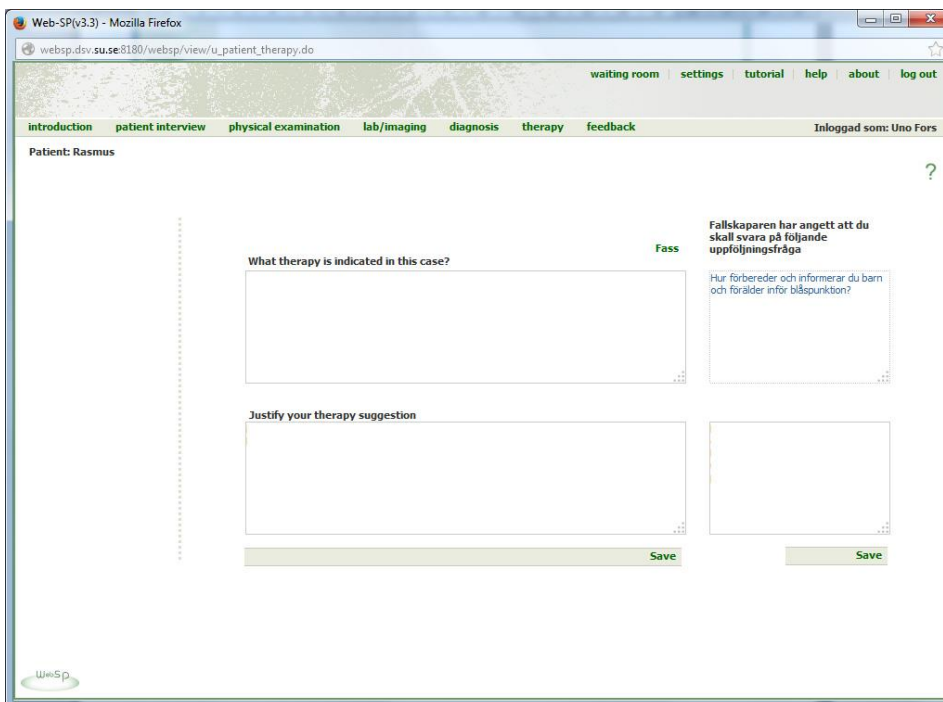
Screenshot 2. The patient interview component (or asking the parent in paediatric cases).



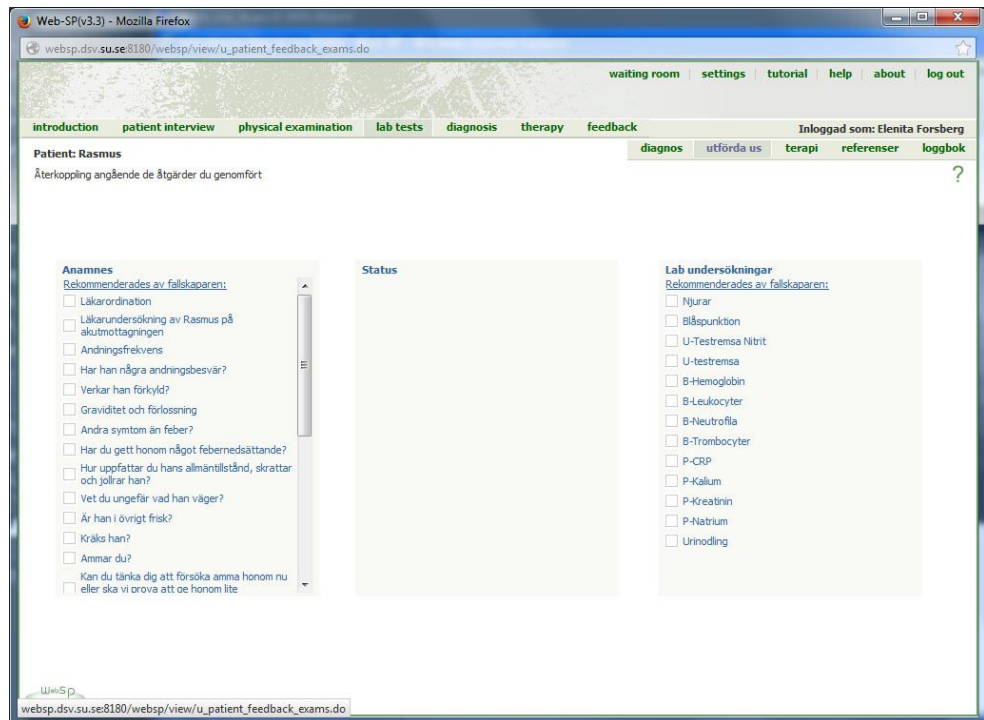
Screenshot 3. The lab test component, where several lab/imaging tests can be ordered.



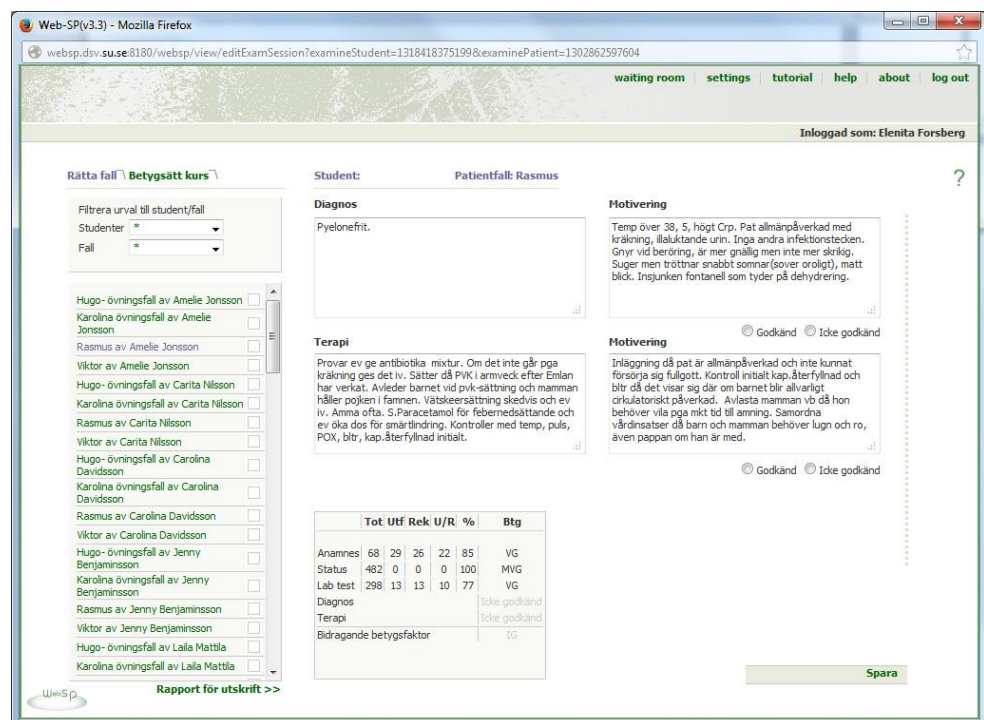
Screenshot 4. The diagnosis component, where the student suggest diagnosis and differentials with justifications.



Screenshot 5. The therapy component, where the student suggest appropriate medical and nursing care with justifications and answer the follow-up question (on the right).



Screenshot 6. Automatically generated checklist that matched and compared the students' activity in the system.



Screenshot 7. A view of the semi-automatic assessment module and a student's result in one of the VP cases.

2.4 ASSESSMENT

In healthcare education, it is important to not only assess theoretical knowledge, but also to assess the competencies and skills that are essential for the professional role such as clinical reasoning and decision making, in order to ensure that students are prepared for future professional duties. This is especially important in assessments linked to licensing or certification of registered healthcare professionals. In designing assessments certain principles should be taken into consideration such as goals of assessments, what to assess, how to assess, the tests' reliability and validity, educational impact, cost-effectiveness and acceptability (Al-Kadri et al., 2012; Epstein, 2007; van der Vleuten et al., 2012;; Schuwirth & van der Vleuten, 2010; van der Vleuten, Schuwirth, Scheele, Driessen & Currie, 2010; van der Vleuten & Schuwirth, 2005; van der Vleuten, 1996).

Goals of assessments

How we design assessment packages have educational impacts. Even the best assessment method is useless if learners and examiners will not accept it. We also have to consider the cost-effectiveness of the exam (Schuwirth & van der Vleuten, 2010). For example what is the goal of the work-placed based assessment, can it be assessed in a more cost – or resource effective way. The assessment could be formative: designed to guide future learning, give individuals feedback on their performance and promote reflection, or summative: intended to assess and grade students for certification. Assessment drives learning, but not always in a positive way (Al-Kadri, et al., 2012). Summative assessments have strong focus on grading students and the constructor/examiners of the test may not have considered the tests benefits for learning. There has been a shift in the thinking of assessment, from assessment *of* learning to assessment *for* learning (Schuwirth & van der Vleuten, 2011). Therefore, an assessment should preferably be a learning activity. A well designed assessment can provide opportunities to steer and foster the learning of each student at the maximum of his/her ability.

There have been discussions on the use of more formative assessment models in health care education to promote deep learning (van der Vleuten et al., 2012). Feedback is important in formative assessments but research show that students ignore much of it, and it seems that some form of intervention is needed to force students to take part in the feedback information (van der Vleuten et al., 2010).

What to assess

All exams must use a method that is appropriate to the learning goals to be assessed and test knowledge and skills at an appropriate level. It is not uncommon to find tasks that are intended to assess postgraduate students' factual knowledge being used at undergraduate level (Wass & Archer, 2011).

One exam form cannot measure everything (van der Vleuten et al., 2012), so there needs to be various forms of assessments in a healthcare program, where there exist several types of knowledge and skills that needs to be mastered by a clinician.

To design exams for assessing clinical competence (including clinical reasoning) various taxonomies can be used.

Miller's pyramid (Figure 1) for assessing clinical competence (Miller, 1990) sets out a structure for categorising methods of assessment. *Knows*, is at the lowest level of the pyramid; the student should demonstrate factual knowledge, for example in a written test. At the next level, *knows how*, the student should show the ability to use knowledge in a specific context, for example, in clinical reasoning to solve a patient problem. The third level, *shows how*, requires that the student be able to perform appropriately in a simulated environment. To assess the *does* level, which requires the student to demonstrate clinical competence, a workplace-based exam is needed. This framework suggests that a VP-based assessment of clinical reasoning should target the second and third level of Miller's pyramid.

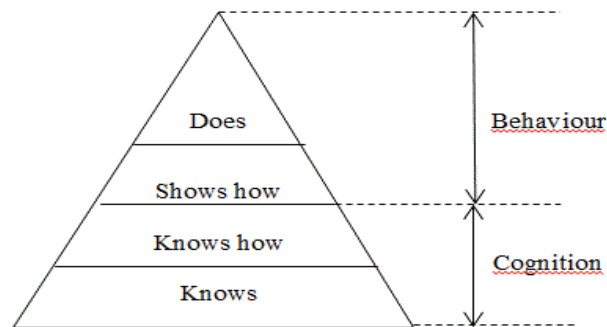


Figure 1. Miller's pyramid of clinical competence (Miller 1990).

The Bologna Directives emphasise consistency of course objectives, teaching methods and examinations and recommend the Structure of the Observed Learning Outcome (SOLO) taxonomy (Biggs & Tang, 2007), (Figure 2) as the criterion by which students' knowledge should be assessed.

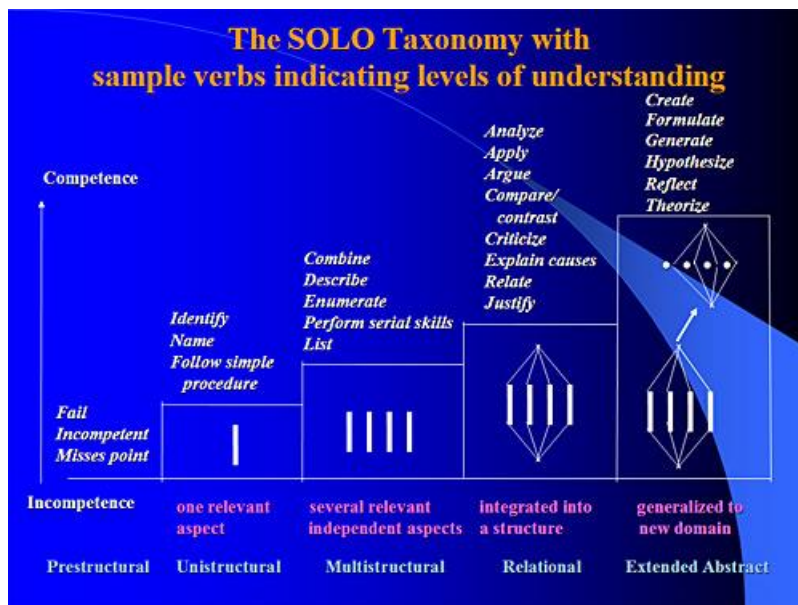


Figure 2. The SOLO-taxonomy (reprinted with permission from John Biggs)

The SOLO-taxonomy consists of five stages, the first stage *prestructural* involves that the learners only have grasped one or few aspects of the task but have not understood. At the second, *unistructural* stage, learners have grasped some aspects of the task, without fully understanding them. By the next stage, the *multistructural* stage, they have grasped several aspects of the task, but not yet related them to each other; this happens at the fourth or *relational* stage, when learners can demonstrate that they can integrate the various aspects of the task. At the last stage, *extended abstract*, learners should be able to generalise and transfer their knowledge to another context.

In postgraduate paediatric nurse education assessment should be designed to provide for the assessment of the higher levels of this taxonomy and to assess students' functional knowledge. This is due to the fact that specialist nurses should be able to work as experts in their domain, and thus need to be assessed on more advanced levels of the SOLO-taxonomy. Functional knowledge is knowledge *of how to do* something; a student with functional knowledge is able to demonstrate that he or she has learned and can integrate academic knowledge with professional skills and use them in real life context to solve problems.

An exams validity and reliability

Validity refers to how effectively the test has measured what it was intended to measure. For designing an assessment different facet of validity should be considered. Validity can only be evaluated retrospectively, after the performed assessment not at the planning phase (Wass & Archer, 2011). Reliability refers to if you have measured in a proper way and reliability has been defined "as the reproducibility of assessment data or scores, over time or occasions (Downing, 2004). Generalisability is one approach that measure test reproducibility. For

example to match reliability a students' mark could be compared if similar judged of different examiners.

So, an appropriate assessment should assess the important competencies a clinical nurse need in her/his clinical duties (like clinical reasoning), not only assess things that are easy to assess (like factual knowledge).

How to assess

Finding a model that can differentiate excellent students from good students, and from those whose performance is only satisfactory presents a problem when devising scoring and grading schemes for any exam. The use of rubrics can improve the reliability of the scoring and this also seems to help students to improve their exam performance (Jonsson & Svingby, 2007). Several scoring and grading methods have been proposed for VP-based exams, but none have yet been shown to be reliable (Botezatu et al., 2010a; Fors & Gunning, 2014; Oliven, Nave, Gilad & Barch, 2011; Perron et al., 2009; Waldmann, Gulich & Zeitler, 2008).

Cook and Triola (2009) have pointed out the difficulty of finding an effective way to assess healthcare students' ability to use clinical reasoning to make a diagnosis and plan treatment. It is not only important to arrive at an accurate diagnosis, it is also necessary to assess which steps students are taking to get there (e.g. which interview questions they have asked or what laboratory tests were ordered). In a previous study, experienced nurses argued that students should not get a high score if they had asked every possible patient interview questions or ordered all available laboratory tests (Forsberg, Ziegert, Hult & Fors, 2014), calling for a model that also controls such issues.

Challenges with assessments

Assessment of clinical reasoning in nursing is complex and prior to my studies; effective and efficient assessment methods are lacking. The most commonly used assessment methods today are combinations of paper-based exams and observation by clinical teachers. There are problems with both of these examination methods. Workplace-based exams are resource and time consuming and may also be subjective. Paper-based exams make it difficult to evaluate the clinical reasoning process. VP systems focus on clinical reasoning and have the potential to track every interaction with a user and have therefore been suggested as a method of assessing clinical reasoning.

At the start of the research project, there were few published studies on use of VPs in nursing education or of VPs used for assessments in any context. There have recently been calls for the development of valid and reliable methods of scoring and grading VP-based exams. Furthermore, in universities there is continuing debate about how to make more use of formative assessments to facilitate higher-level student learning. Universities have also noted that students are being assessed at too low a level and that methods for assessing higher-order thinking skills should be developed.

3 AIM

The overall aim of the thesis was to gain a deeper understanding of the potential of using VP-based exams for assessing clinical reasoning in postgraduate paediatric nursing education.

The specific aims of the four studies were determined as follows:

- I. To examine postgraduate paediatric nursing students' opinions on the use of VPs for assessing clinical reasoning skills, and assess their performance on a VP-based exam.
- II. To identify how clinically experienced paediatric nurses solved complex paediatric VP cases using clinical reasoning. The study also aimed to give information about how clinical reasoning might be assessed in VP-based exams for postgraduate paediatric nursing students.
- III. To develop and evaluate a novel scoring and grading model for VP-based exams.
- IV. To explore whether formative VP-based assessments in connection with self-evaluations had an impact on the development of postgraduate paediatric nursing students' clinical reasoning abilities and their perception of progress in this domain.

4 METHODS

4.1 DESIGN

This thesis consist of four sub-studies and has a descriptive and exploratory design using quantitative and qualitative approaches to gain a deeper understanding of the use of VP-based exams for assessment of clinical reasoning in healthcare education. The choice of methods was based on the fact that the area was more or less unexplored previously, calling for an explorative approach. Descriptive methods are often successfully used when exploring new fields (Polit & Beck, 2014). To receive a broader understanding, three perspectives were applied:

- *A learner perspective* to examine students' opinions of the use of VPs for assessment and the impact of VP-based exams on their development of clinical reasoning skills.
- *A professional perspective*, VP-based exams should be consistent with expected professional clinical competence.
- *An educational perspective*, investigate how VP-based exams can support student-centred learning and the future of the profession and explore how VP-based exams in an effective reliable way can differentiate students for the required qualification for licensing.

A quantitative approach was chosen in studies I and III in order to describe students' opinions of the use of VPs for assessment and evaluate their performance in the VP-based exams. A qualitative approach was chosen in studies II and IV to identify the experienced nurses' clinical reasoning while solving VP cases (for later use in study III as a base for developing a new scoring and grading model) and to explore formative VP-based exams impact on students' development and achievement of clinical reasoning abilities.

Using both quantitative and qualitative methods may complement each other and to start from the three perspectives; *learner -*, *professional -* and *an educational perspective* can contribute to a broader understanding of the research field.

Table 1 presents an overview of the main designs, approaches, participants and methods of the sub-studies in the thesis.

Study	I	II	III	IV
Year of data collection	2008	2011	2011-2012	2013
Design/ Approaches	Intervention study/ Students acceptance of VP-based exams and their performance on a VP-based exam.	Descriptive/ Description of experienced paediatric nurses clinical reasoning using VPs.	Experimental/ Evaluation of a new scoring and grading model for VP-based exams.	Exploratory / Assessment of progression of clinical reasoning through formative VP-based assessments.
Selection/Sample	Cohort I, 38 postgraduate paediatric nursing students in semester 4/4 Cohort II, 26 postgraduate paediatric nursing students in semester 1/4	30 postgraduate paediatric nurses in 15 Think Aloud sessions	19 postgraduate paediatric nursing students in three courses in the one year programme	14 postgraduate paediatric nursing students in semester 1/2
Method of data collection	Questionnaires The students' free text answers in the VP-based exams	Recorded Think Aloud session and follow-up interview	Summative VP-based exams with a scoring and grading model applied. Received data from semi-automatic assessment module in Web-SP and free text answers.	Formative VP-based exams, in connection with self-evaluations. Transcribed text from the self-evaluations.
Method of data analysis	Descriptive quantitative analysis. SPSS and text analysis. Assessment of the exam.	Manifest and latent content analysis.	Descriptive quantitative analysis.	Deductive content analysis.

Table 1. Overview of the design, approaches, participants and methods in the thesis

4.2 PARTICIPANTS

The four studies were performed between the years 2008 to 2013.

The participants consisted of postgraduate paediatric nursing students at Halmstad University in Sweden. In study I there were 64 students participating, in study III there were 19 and in study IV the number of subjects were 14. All students were females except for one male student in study III, (this is the unfortunate situation in Sweden, where almost all nursing students are female).

All students in the study were participating in courses, where VP-based exams were applied as a routine assessment method. This means that the subjects in the three studies consisted of all available students, and not sub-selected groups. However, all students were informed of that the assessment data also should be used as the base for scientific studies.

In study II the participants were postgraduate paediatric nurses (n=30) employed at Departments of Paediatrics in Hospitals at Halmstad, Helsingborg, Stockholm (KS and HS) and Varberg, and nurses employed at children's and school health care centres in Halland and Skåne in Sweden. Head nurses and advanced clinical teachers in paediatric wards were contacted and asked to suggest appropriate participants. The inclusion criteria were possession of Registered Nurse (RN) status with a postgraduate diploma in Specialist Nursing in Paediatric care and least one year of postgraduate paediatric nursing experience. There was a purpose and convenience samples with intention of maximum variation in paediatric care. All nurses were females with a median age of 41 years (range 29-55). They had been RNs for a median of 13.5 years (range 6-35) and median postgraduate experience of paediatric nursing was 8 years (range 0-30).

4.3 VP SYSTEM APPLIED

In all four studies the VP system Web-SP was used. All the VP cases used for training, assessments and the think-aloud sessions in this research were created, developed and implemented in Web-SP by the author of the thesis. Some of the paediatric VP cases were based on patient data from postgraduate paediatric nursing students' clinical internship or on written descriptions of anonymised cases provided by clinicians (head nurses and physicians). All the VP cases are based on authentic patient cases, and were deliberately chosen to represent different conditions, genders, ages, and family structures; they were validated by a senior paediatrician.

Before the exams, the students received verbal and written information about the Web-SP and were instructed on how to use Web-SP. In order to solve the VPs they were required to obtain patient interview questions, obtain and interpret physical exams, order appropriate laboratory tests and finally in the free text part suggest diagnosis and treatments and formulate justifications for it, as well answered the follow-up question. The suggestion for treatments should include both medicine and nursing care, with an emphasis on nursing. Before the exams they had also access to train on other cases in Web-SP. All groups of

students had had the possibility to contact teacher during the exam by telephone and/ or e-mail.

4.4 PROCEDURES FOR THE STUDIES

Procedures for study I

Two student groups participated in the study. The first group consisted of 38 students from a paediatric nursing course in their fourth (last) semester of a two-year (half-time) distance-based educational program for postgraduate paediatric nursing. As a learning activity, the students were asked to create paediatric cases in paper format, describing actual clinical patient scenarios they had encountered during their internship at the department of paediatrics, in the semester before the study. Twelve cases proved suitable for development and implementation in Web-SP. These VP cases were later used for assessment of the participants in their last semester. The class was divided into three groups and a final exam was delivered, comprising four VP cases to be solved individually; one child surgery case; one paediatric infection case and two child medicine cases (one easier and one more complex case). The cases were selected so that no student received case he or she had contributed. The students could choose to take exam at any time during a given week and were instructed not to spend more than three hours on the four VP cases.

The second group consisted of 26 students from a neonatal course in the first semester of a two-year (half-time) distance-based educational program for postgraduate paediatric nursing. As a course director and teacher on the course the author of the thesis developed four neonatal cases for Web-SP. The VP exam in neonatal was also home-based and took place at a specific time and date; students were given three hours to solve four VP cases individually.

To grade the exam, the teacher estimated if the student had achieved at least 70% of correctness (in the total of the four VP cases) in the free text part (suggested diagnosis and treatments with justifications), which was the limit for passing the exam.

Instrument

A questionnaire with responses on a six-point Likert scale and an additional two open-ended questions to elicit free text comments was developed for this study. The questionnaire was based on the protocol described by Zary et al. (2006). The first questionnaire consisted of 22 and the second of 23 questions (one question in the first questionnaire was divided into two in the second). The questionnaire covered both background data about the nursing students' previous experience of computerised cases and specific questions about the Web-SP system and its use in assessment. Answers were given by ticking one of six boxes labelled 1 to 6, where 1 represented "do not agree at all" and 6 is "totally agree". The two open-ended questions asked for comments about the best and worst aspects of Web-SP.

Procedures for study II

The Think-Aloud (TA) method of describing cognitive processes using verbalisation (Newell & Simon, 1972) was applied to investigate how experienced clinical paediatric

nurses' reasoned on paediatric VP cases and how they reached clinical decision. The TA method is often used to capture data on nurses' clinical reasoning thinking (Simmons et al., 2003). It was also intended to use the data to validate the VP cases and provide information about which issues were suitable for assessment using a VP-based exam for nursing students.

VP cases in Web-SP, covering different sub disciplines of paediatrics were used in the TA sessions. The experienced clinical paediatric nurses (n=30) worked in pairs to solve two to three VP cases over a maximum period of one and a half hours, including an introduction to Web-SP. They were asked to think aloud during problem-solving process with the VPs. A short structured interview was administered at the end of the TA sessions. The TA sessions and the follow-up interviews were recorded. The author of the thesis was an observer during the TA sessions, reminding the nurses to think aloud and dealing with technical problems.

For the follow-up interviews an interview protocol was developed including questions such as;

- What was it in the VP case that made you coming up to that clinical decision?
- Describe how you identify the problems and how you analyse the case.
- Are your suggested interventions evidence based?
- Describe advantages and disadvantages with Web-SP.
- Do you think something is missing in the VP case or in the feedback section?
- Do you think Web-SP is suitable for an assessment of clinical reasoning?

Procedures for study III

A new scoring and grading assessment model for VP-based exams was developed (Figure 3) based on my previous studies (Forsberg et al., 2011; Forsberg et al., 2014) and particularly influenced by the model used by Botezatu et al. (2010a). In comparison with the scoring model in Botezatu et al. (2010a) the new model also measure the clinical reasoning process according students indicated patient interview questions, the nursing care, answers at follow-up questions and have a time limit.

Item	Positive score	Score	Negative score	Score	Max
Patient interview incl. physical examination	Pass with special distinction	+3	More than 50% of the total recommended or less than 30% of recommended	-1	3
	Pass with credit	+2			
	Pass	+1			
	Fail	0			
Labs and imaging	Pass with special distinction	+3	More than 50% of the total recommended or less than 30% of recommended	-1	3
	Pass with credit	+2			
	Pass	+1			
	Fail	0			
Diagnosis	Positive diagnosis	+1	Potentially life-threatening decision Motivation contradicts diagnosis	-2 -1	3
	With adequate discussion	+1			
	Differential diagnosis	+0.5			
	With adequate discussion	+0.5			
Treatment	Positive treatment (med.)	+1	Wrong decision that delays patient recovery or causes illness An effectively focused clinical process is missing	-2 -1	6
	With adequate discussion	+1			
	Positive treatment (nurs. care)	+2			
	With adequate discussion	+2			
Follow-up question		+2			2
<i>Total</i>					17
If the student took more time than three hours to solve the VP-cases he/she received -1 for the total sum of the four cases.					

Figure 3. The scoring and grading model used in study III. Note: In the child and healthcare course assessment, lab and imaging tests were not included because this is not performed at these healthcare centres in Sweden, and so the maximum score for each case was 14 points. For the scoring and grading assessment model, the scores for each case were calculated and the final figure expressed as a percentage of the total score given for the final examination grade.

Instrument

The scoring and grading model was validated by administering two summative VP-based exams comprising four VP cases to 18 students on a distance-based postgraduate course in paediatric nursing. Application of the preliminary scoring and grading model to these exams revealed a number of problems with the model. As a result changes were made. The score for failing a case was changed from -1 to 0. The deduction for choosing too many actions (more than 50% of the total number of recommended interactions) or less than 30% of the total recommended interactions, the deduction was adjusted from -2 points to -1.

Before applying the scoring and grading model for the VP-based exams, an experienced group of teachers discussed the scoring and grading model further for facets of validity (Wass & Archer, 2011).

The scoring and grading assessment model chosen assess the clinical reasoning process and the clinical decision-making on the basis of data from the semi-automatic assessment module

and the free text answers in the boxes for diagnosis and treatments, with justifications and the follow-up questions (screenshot 1 and 7). Students receive negative points for actions that endanger patient safety or for unnecessary actions that are not in accordance with resource-efficient healthcare. Points are also deducted for exceeding the time limit.

In order to take advantage of the semi-automatic assessment module, the teachers agreed which specific interview questions, physical exam procedures and laboratory and imaging tests would be defined as “recommended” for each VP case. The teachers also agreed definitions of correct diagnosis and treatment regimens, including optimal justification for these. It was decided to test a four-grade scale, with the intention of subsequently developing this into a seven-grade scale consistent with the Bologna directives. In nursing education in Sweden two- or three- grade scales are most common, but students have asked for a more differentiated grading than simply pass and fail.

The same grading system was used for all three VP-based exams in study III. The grades were awarded as follows, 90–100% points available: “Pass with special distinction”; 75–89%: “Pass with credit”; 60–74%: “Pass”; and <60%: “Fail”. A student’s score was calculated by dividing the total score for the four VP cases by the sum of the maximum scores for the individual cases and multiplying by 100 to give a percentage score for the exam, e.g. a score of 78% would result in the award of the grade “Pass with credit”.

Twelve different VP cases covering different sub-disciplines in paediatrics were implemented in Web-SP for the assessments in three courses. The first course in the postgraduate paediatric nursing programme was Health and Ill Health related to Children and Adolescents (15 credits), and the first exam took place after 10 weeks; the students received two VP cases in Child health care (a two-month-old baby starving at the breast and an 18-month-old girl with suspected gluten intolerance) and two VP cases from School health care (a six-year old boy with obesity and a youngster with growth hormone deficiency). The second course was Neonatology (7.5 credits) and the students performed the exam at the end of the first semester, they received four VP cases (a preterm with respiratory distress syndrome [RDS], and a preterm with hyperbilirubinemia, a new-born with a heart failure and a three days old girl with low blood glucose). In addition, during the first semester the students have a course in Pain Management related to Children and Adolescents (7.5 credits); knowledge from the Pain Management course was assessed in the Neonatology exam and in the exam for the last course at the end of second semester. The last course was Paediatrics and Paediatric Nursing Care (30 credits) and the third VP-based exam took place at the end of second semester and the students received four VP cases consisted of a four-month-old boy with pyelonephritis, a six year old girl with an anaphylaxis condition, a seven year old boy with suspected appendicitis and a teenager with suspected diabetes.

Because the VP-based exams replaced previous paper-based exams, the examiner (the author of the thesis) assessed the students using the Halmstad University rating system for health care education which uses binary pass or fail grades. For the purposes of this study, the data collected during the exams were reanalysed using the newly developed scoring and grading

assessment model. Results of assessment using the new model did not influence grades awarded under the Halmstad University system.

Procedures for study IV

A reflective tool was developed to investigate whether formative VP-based assessments in connection with self-evaluations have an impact on postgraduate paediatric students' clinical reasoning ability. Kolb's model of the Learning cycle (Kolb, 1984) (Figure 4) was used as a model for the design of the study and the design of the self-evaluations. This model is chosen because the Learning cycle provides a structured description of the learning process, which was applied in this study to describe how use of VPs influenced students' clinical reasoning. Before their first assessment the students received verbal and written information about the formative assessments, the Web-SP system, the self-evaluations and the definition of clinical reasoning.

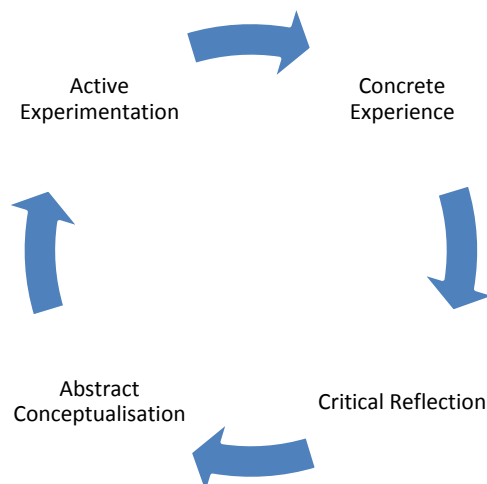


Figure 4. Kolb's model of the Learning cycle

Kolb's model of the Learning cycle involves four stages.

1. An individual has a *concrete experience* which forms the basis of further learning, in this study the concrete experience is the student's performance in the formative VP-based assessments.
2. The student reflects on the concrete experience (*critical reflection*) including analysing feelings and links with existing knowledge and experiences; in this study the self-evaluations were used to facilitate this.
3. *Abstract conceptualisation*, the student draws conclusions from the experience and formulates concepts.
4. The student uses what has been learned in a process of *active experimentation* trying out new methods or solutions in similar or new situations. Then the cycle start again, with experience gained during experimentation treated as *concrete experience*.

The self-evaluations related to the learning experience of the completed VP cases; students were asked to reflect on how the clinical reasoning process felt, what they have learnt and how this new knowledge would be useful in the future in a professional context. Students were asked to describe what they found especially difficult, important or interesting.

4.5 DATA COLLECTION

In study I, the students were asked to complete the questionnaire on experience and opinions of using VPs for assessment (anonymously) after they had taken participating in a VP-based assessment. The questionnaire was completed by 35 out of 38 students in the first cohort and 19 out of 26 students in the second cohort. The Web-SP log-files were used to track the students' interactions as they tackled the four VP cases individually; the students' answers regarding diagnosis, suggested care procedures and the justifications for these were used to assess performance.

In study II, 30 experienced clinical paediatric nurses worked in pairs to solve two to three VP cases in their paediatric speciality, thinking aloud during the problem-solving process. A short structured interview was administered at the end of the TA sessions. The 15 TA sessions and the follow-up interviews were tape recorded and transcribed verbatim.

In study III, 19 postgraduate paediatric nursing students participated in three summative VP-based exams comprising four VP cases each; the cases were selected according to course content. The students performed the exams at a specific time and date, at home or at the university and were given a maximum of three hours to complete the assessment.

The scoring and grading assessment model was applied and data on 228 (19 students x 3 exams x 4 VP cases) VP cases were assessed.

In study IV, 14 postgraduate paediatric nursing students participated in three formative VP-based assessments, with two VP cases to solve in each assessment. Students completed the assessment at the university or at home, at a specific date and time; they were given a maximum of three hours to complete it. After they had completed the formative assessment but before completing the self-evaluation the students were asked to complete the feedback section and look at the recommended interactions in Web-SP to get a picture of their current skills and aspects of clinical reasoning they had not yet mastered.

The self-evaluations were completed on a computer, printed out and handled in anonymously. Completion of the self-evaluations was voluntary, 14, 11 and 12 students respectively from the group answered the self-evaluations. As the self-evaluations were anonymous, it was not possible to follow student's progress individually.

4.6 DATA ANALYSIS

Quantitative analyses

The questionnaires for study I provided data on ordinal scales and were analysed with descriptive statistics using SPSS v. 16.0. A significance threshold of $p < 0.05$ was specified. Text analysis was used to evaluate answers to the two open-ended questions. A group comparison was not the aim of the study, but out of curiosity a Mann-Whitney U test was used to compare the mean ranks of the two groups.

The scoring and grading model was applied to data in Study III and the results were expressed descriptively in text and tables (please see tables 5 and 6 and text in the section for findings).

Qualitative analyses

Inductive and deductive content analyses were used for studies II and IV respectively. Qualitative content analysis is used to interpret texts and to analyse and describe similarities and differences in human experiences. An inductive approach involves an unprejudiced analysis of text while a deductive approach is based on a theoretical framework (Denzin & Lincoln, 1994).

All the TA sessions and follow-up interviews for study II were transcribed. Manifest and latent content analysis were used to analyse the text. Manifest content analysis analyses what the text says – obvious meanings - and adheres closely to the literal meaning of the text. Latent content analysis explores the underlying meaning of the text (Graneheim & Lundman, 2004). We followed the content analysis procedures described by Graneheim and Lundman (2004). The text was read as a whole to get a first impression of the data. Then the text was re-read with an inductive approach. Sentences describing the nurses' clinical reasoning and clinical decision making were marked. The marked text was then reduced and coded (Table 2). Codes with similar content were grouped together and categories were formulated. A theme emerged from the latent analysis.

Extracts from the TA-sessions and the follow up interviews	Condensing	Category
<i>“it may be meningitis or it could be pyelonephritis or it may be that he is just vomiting because of the fever? We need to know more”</i>	Formulate suggestions for diagnosis, but need to test it first	Hypothesis-oriented
<p><i>“I'm thinking, don't you put down a tube and tube-feed these small children? He is four months. I thought, can you not give him some of that Semper fluid replacement?</i></p> <p><i>I'm a little unsure about this, but I think you can. Now I'm not sure when you say that. I do not think there is an age limit. I do not know how long they need to stay in hospital, a few days perhaps. But they do not have to be within 10 days of antibiotics, do they?</i></p>	Unsure how to treat the child, to general level, because of the fact that the nurses were working at a very specialized paediatric ward	Experience is of importance

Table 2. Examples of coding by condensing text in study II

For study IV, all text material from the self-evaluations was coded, then transcribed and organised in a table giving details of each exam, question and informants. Deductive content analysis (Hsieh & Shannon, 2005) was used to focus on descriptions of the process of learning clinical reasoning skills using VPs, structuring the analysis according to Kolb's learning cycle (Kolb, 1984). The first step in the analysis was to read all text to get an overall understanding of the data. The text was then re-read and sentences describing feelings of uncertainty or confidence in clinical reasoning, learning from completed VP cases and treatment plans contingent on additional knowledge were marked. These sentences were retained in context in order to avoid losing their meaning and were used for coding (Table 3). Codes with similar content were grouped together and categories formulated. The categorisation was discussed further with the supervisors and an external teacher and a theme was formulated.

Extracts from the self-evaluations	Condensing	Category
<i>Using the VP cases make it is easier to obtain a detailed picture of the clinical reasoning and to find out in which area I need to improve my knowledge</i>	Visible what knowledge is missing	Lack of knowledge
<i>I felt unsure in the beginning related to my inexperience</i>	Unsureness related to no experience	Uncertainty

Table 3. Examples of coding by condensing text in study IV

4.7 PRE-UNDERSTANDING OF THE CONTEXT

The author of the thesis has a diploma in postgraduate Specialist Nursing in Paediatric Care and 17 years' experience as a paediatric nurse in different paediatric departments. The author also has a diploma in teaching for nursing and has completed courses in teaching for higher education and courses in distance learning; since 1998 the author has worked as a teacher and course director for postgraduate paediatric nursing education in two different universities in Sweden. The author's experiences from the clinic and in the academy have been of great importance for creating the VP cases and a scoring and grading assessment model.

4.8 ETHICAL CONSIDERATIONS

Studies II - IV were approved by the Ethical board of Karolinska Institutet, Stockholm, Sweden (2011/5:1, 2010/1996-31/5). Study I was a part of the project, *Innovative examinations in medicine and healthcare*, financed by NSHU (Agency for Networks and Cooperation in Higher Education). Study I investigated educational issues of current concern with the aim of improving assessment methods for nursing courses. This work falls under the category of normal course improvement and thus did not require a special ethical research permit in Sweden. Study I was also mentioned in the ethical application and was approved.

For study II, information about confidentiality and the voluntary nature of participation was given verbally and in writing and it was explained that participants could withdraw from the study at any time without explanation. Written informed consent was obtained from all participants before data collection. There was no dependent relationship between authors and participants.

The VP-based assessments in study I, III and IV were a part of the improved courses, all students were required to participate in the exams, but completion of the questionnaire in study I and the self-evaluation in study IV was voluntary. For study III, data collected during university exams were re-analysed using the newly developed scoring and grading assessment model. This new model did not influence the grade awarded under the university examination system.

In all studies the participants were informed about the aim of the study and told that the findings might be published and were this to happen, the results would be presented in such a way that the identity of the participants would not be detectable.

The questionnaires used in study I were printed out and then completed anonymously, by the students before being handled in and subsequently coded. The self-evaluations in study IV were answered on the computer, printed out and handled in anonymously and then coded.

All data in the course of this research has been treated confidentially and in an ethical manner according to 1964 Helsinki declaration of the World Medical Association (The Swedish Medical research Council, 2003; Polit & Beck, 2014).

The majority of the photographs in the Web-SP cases were bought from a commercial photo-bank and were allowed to be used for these purposes. Some photos of the children are taken of the students in study I, but they have received written informed consent from the parents. This form of consent was approved by lawyers at Halmstad University. Further on, the VP cases are more or less based on real patient data, but all data were anonymised before they were received by the author and implemented in Web-SP.

5 MAIN FINDINGS

This thesis explored the use of VPs for assessment in postgraduate paediatric nursing. The research evaluated applicability of VPs to the postgraduate paediatric nursing domain and students' acceptance of the use of VPs for assessment. The clinical reasoning process used by experienced paediatric nurses to solve VP cases was explored and formed the basis of a scoring and grading assessment model. Research was done to evaluate this newly constructed model including the use of a specially developed semi-automatic assessment module for Web-SP and investigations into the best way to assess the clinical reasoning process and clinical decisions, and how to score and grade VP-based exams. Finally to address a request that assessments should also be a learning opportunity and encourage student-centred learning, the development of clinical reasoning was tracked through formative VP-based assessments in connection with self-evaluations. The main findings are presented from three perspectives; the learner's perspective, a professional perspective and an educational perspective.

The learner's perspective (studies I, IV)

The findings showed that it was possible to develop and implement VP cases that reflect specific tasks relevant to postgraduate paediatric nursing. The students found the cases realistic and engaging, they also thought using VP cases was a good way to practice their clinical skills (Table 4). They were curious to find out whether they had reached the patient solution described in the feedback section. The feedback was viewed as an important aid to improving clinical reasoning. The use of VPs for assessment of clinical reasoning was very well accepted by students (Table 4). They thought it was an up-to-date assessment method. However some students in study I thought that the VP-based assessment was rather too medically oriented, and a few students thought using the VP system was too abstract for exam use (IV). They missed having the opportunity physically to see the patient, perform the physical exams and ask the questions however they liked.

The time limit for the exams and the VP-technology format were a source of stress for some students. They sometimes used more time than allowed (in studies I, III and IV) as well as commented upon that the system could show glitches under some circumstances (study I, III and IV).

Question no.	Question	Median
3	I think my nursing education has given me enough knowledge and skills to solve the cases	4
4	I think these cases contained enough information to reach a diagnosis and/or nursing problem	5
5	I felt that these cases were realistic	6
6	I would have appreciated more help to use the Web-SP system	4
7	To work with the cases increased my self confidence in solving clinical problems	5
8	To use virtual cases like these is a good way to assess the ability to solve clinical problems	5
9	I think this exam was a good learning experience	5
10	I think the case presentations were believable	5
11	I think the web-based cases were enough challenging	5
12	To work with the VP cases was a good way to <i>practice</i> clinical problem solving	6
13	To work with the VP cases was a good way to <i>assess</i> clinical problem solving	5
14	I think Web-SP was easy to use	4
15	I think it was fun to use Web-SP	5
16	I think that Web-SP cases should be used also in other courses	5
17	I think that Web-SP should be used for assessment	5
18	I think that I got enough time to solve the number of cases in my exam	5
22	My overall opinion about Web-SP	5

Table 4. Students' opinions on the use of the Web-SP system. Median values of a 6-graded scale from 1-6, where 1 is "do not agree at all" and 6 is "totally agree".

Another learner perspective is related to students' progression. When VPs were used for formative assessments and in connection with self-evaluations, the postgraduate paediatric nursing students reported that they thought their clinical reasoning ability had improved during the courses. The first assessment took place at the very beginning of the educational programme, and after it the students reported feelings of uncertainty about how to solve the VP cases and felt that gaps in their knowledge had been exposed. The uncertainty was attributed to students' lack of experience in child health care. The students were able to use the insight into their lack of knowledge as an opportunity; the assessment had made them aware of what they needed to focus on, what they needed to study more and attend to during work-place education. The students' awareness of improvements in their clinical reasoning was obvious. They explained that they felt more confident and were more certain of how to solve the VP cases. Finally, after the third exam they described a sense of self-efficacy, reporting that they now had the ability to use clinical reasoning in new unexpected clinical situations.

A professional perspective (II)

The thinking aloud procedure used by the experienced paediatric nurses when they were solving the VP cases revealed that they found the cases very realistic and engaging and suitable for the child health and paediatric field. Their clinical reasoning demonstrated that their strategy for solving the cases was based on hypothesis testing; they used the thinking strategy from the nursing process and demonstrated a very specific clinical competence. It was apparent that previous clinical experience was important in the clinical decision making. The more experienced the nurses were the fewer patient interview questions they asked. Nurses also quickly become specialists, if they were asked to solve a case relating to a new work context uncertainty was observed. The nurses also thought that VP-based exams might be an innovative and interactive way to be assessed and VPs had potential as a model for assessing clinical reasoning and clinical decision making; however, they suggested that students should not receive high score if they selected too many actions in the VP system. The experienced nurses could also see advantages to the use of VPs in paediatric care setting for example for new employer or as a regular test to ensure patient safety.

An educational perspective (I, II, III, IV)

Together the findings from the four studies validated the VP cases as suitable for postgraduate paediatric nursing education. Studies demonstrated that the cases were motivating and were constructed similarly to real-life patient cases. The VPs were very well accepted as method for assessing clinical reasoning. In the first study, 64 postgraduate paediatric nursing students received a summative VP-based exam including four VP cases only the free text responses for the diagnosis and treatment with justifications were assessed. The teacher estimated whether the student had achieved a 70 % correct solution. The results showed that most students reached the correct diagnosis and made adequate clinical decisions, but there was considerable variability in ability to justify clinical decisions using clinical reasoning.

The aim of the second study was to explore the clinical reasoning used by experienced paediatric nurses tackling VP cases in order to identify what could be assessed in a VP-based exams and how to score and grade such an exam. In summary the results showed three categories were important for clinical reasoning; the experienced nurses were hypothesis-oriented, they had very specific knowledge and experience was also important. Hypothesis-testing and pattern recognition involved several actions in the VP system. The transcriptions of the TA-sessions and follow-up interviews and Web-SP interactions proved very valuable for the development of the scoring and grading assessment model for VP-based exams which was used in the third study. Consideration has been taken when developing the scoring model, according to that the postgraduate paediatric nursing education should assess basic paediatric nurses skills based on course literature.

The scoring and grading model developed for summative VP-based exams in postgraduate paediatric care education seems to be valid and reliable; it measures what it claims to measure; and the criteria of reliability that the measurement is accurate in terms of that regardless of which examiner who corrects the exam, it will give the same results. Both the

clinical reasoning and the clinical decision-making were considered and the model gave negative scores for not maintaining patient safety or taking unnecessary actions. Most deductions were made for asking too many patient interview questions or ordering too many laboratory tests.

From a teaching perspective it was helpful to be able to track a student's clinical reasoning and follow the student's progress through the three exams taken during the one year educational programme. The students show progress: 53% of students passed the first exam, 63% the second and 84% passed the last exam. The VP system and the scoring rubrics appeared to facilitate improved exam performance; free text responses on suggested diagnosis and treatments with justifications suggested that students' clinical reasoning ability improved from one exam to the next. No student was awarded the highest grade, "pass with special distinction" and very few students were awarded a "pass with credit" (Table 5). The scoring model meant that points should be deducted if students had indicated potentially life-threatening diagnoses (-2 points) or if the motivation contradicted the diagnosis (-1 point). For this reason, two students received negative points in the first and second exam, with none in the last exam.

The students should also receive a points deduction if they indicated erroneous decisions that delay the recovery of the patient, or might cause further illness (-2 points) or if an effectively focused clinical process was missing in the student's answer (-1 point). In total, seven students received a deduction in the first and second exam, with none in the last exam. The time used for the exam could also result in a deduction of points if the students had used more than three hours to solve the four VP cases in the exam. In 31 out of the 57 (19 students x 3 exams = 57) exam results, one point was deducted for this reason. Five students received a deduction in all three exams. Three students performed all three exams without any point deduction for having exceeded the time limit.

Grade	Exam 1 Number of students	Exam 2 Number of students	Exam 3 Number of students
Pass with special distinction	0	0	0
Pass with credit	2	3	1
Pass	8	9	15
Fail	9	7	3

Table 5. Grading results of the VP-based exams for the class using the scoring and grading model. The scores for each case were calculated and the final figure expressed as a percentage of the total score given for the final examination grade.

However, no progress was observed in students' performance on other the aspects of clinical reasoning, selection of patient interview questions, physical exams and lab and imaging tests. The results from the semi-automatic assessment module were quite similar in the three exams (Table 6). The findings from the scoring and grading model used for this part also indicated that no student really improved their ability in the clinical reasoning process. The

semi-automatic assessment module facilitated the scoring and the teachers' efforts but needs to be further developed in order to control better for unnecessary actions. According to the new scoring and grading model (Figure 3), the students should have one point deducted if they indicated more than 50% of the total recommended actions or less than 30% of the total recommended. Two students received no deduction in any of the exams. In total, 38 out of the 228 VP cases in study III (19 students x 4 VP cases/exam x 3 exams= 228) had a deduction of points. Of these, 32 of the 228 cases received a deduction due to the fact that they had indicated too many patient interview questions or physical exams and in 6 cases; the results were deducted because the students had indicated too few.

In total, 50 out of the 152 VP cases (labs and imaging were not used in the first exam) received a deduction of points. In 38 of the cases, points were deducted due to the students indicating too many lab tests and imaging tests and in 12 cases; the results were deducted due to too few.

Semi- automatic assessment module	Exam 1 Number of students	Exam 2 Number of students	Exam 3 Number of students
Pass with special distinction	0	0	0
Pass with credit	4	8	2
Pass	13	9	13
Fail	2	2	4

Table 6. Data from the semi- automatic assessment module. The Web-SP system showed a percentage sum for each case. All percentage figures in the four VP cases were added and then divided by four. This final figure was used to grade the exam.

The self-evaluation was a reflective tool consisting of four questions about how clinical reasoning felt, what the students felt they had learned and how they could make use of this new knowledge professionally in the future. Analysis of the self-evaluations revealed several factors of potential relevance to the design of student-centred assessment. The introduction of VPs, the provision of a clear definition of clinical reasoning and early exposure to an exam delivered many surprising benefits. The use of formative VP-based assessments in connection with reflective tools early in the education resulted in improvements in students' understanding of the concept of clinical reasoning, increased their awareness of what to focus on in clinical practice and gave them a better understanding of expected clinical competence. Through the three assessments, students' perceptions of their clinical reasoning ability improved from uncertainty about the competence to self-efficacy. A theme emerged from the findings; formative VP-based assessments in connection with self-evaluations show the progress in students' perceived clinical reasoning ability.

6 DISCUSSION

It is essential that healthcare professionals develop it is essential to have developed clinical reasoning during their education and have achieved a satisfactory level of competence before being accredited. Assessment of clinical reasoning skills is complex and effective assessment methods are lacking.

The overall aim of the thesis was to explore the potential use of VPs for assessment of clinical reasoning in postgraduate specialist paediatric nursing education. Both quantitative (study I and III) and qualitative (study II and IV) methods were used to identify, analyse and describe

- students' and experienced nurses' opinions of the use of VPs for assessment;
- how experienced nurses think and arrive at clinical decisions when solving VP cases;
- how VPs and the semi-automatic assessment module in Web-SP can be used to evaluate the clinical reasoning process;
- a method of scoring and grading VP-based exams;
- the impact of formative and summative VP-based exams on students' clinical reasoning skills.

6.1 METHODOLOGICAL CONSIDERATIONS

Sample sizes

The participants in the empirical studies presented in this thesis were 97 postgraduate paediatric nursing students drawn from four classes of at Halmstad University and 30 clinically experienced paediatric nurses from five different hospitals and five different child- and school healthcare centres in Sweden. The number of students in each class was however rather low which could be seen as a limitation. To the best of my knowledge, Halmstad University is the only university in Sweden using VPs in postgraduate paediatric nursing education and thus *all* possible students available in Sweden were used in these studies. Therefore, no more students could have been incorporated in the studies. Additionally, the quantitative data obtained did not show any major issues based on the relatively small samples.

In study II the nurses were recruited with a certain purpose, meaning that they should represent as many sub-domains as possible as well as different types of hospitals (university hospitals, other major hospitals as well as smaller clinics). Further on, since these nurses were working at clinics nearby Halmstad (where I work at the University, Helsingborg (where I live) and Stockholm (where I am a PhD student) it might be considered as a convenience sample. However the samples of the selected nurses seem suitable for the purpose, since they actually represented a rather broad variation of hospitals and nursing domains.

Ethical considerations

The dependency between the author of the thesis and the students might be discussed since I have been both a teacher, and examiner and a researcher. However, I have been clear to separate the role as a researcher from the role as an examiner for the courses. The students' participation in the questionnaires and self-evaluations were voluntary, and all students were informed about that their willingness to participate in the studies would not influence the grading of any real exam. So the possible risk of that students might have felt a "pressure" to participate in the studies is considered to be very low.

Credibility, transferability, conformability and dependability

For evaluating qualitative studies' trustworthiness four criteria have been proposed; credibility, transferability, conformability and dependability (Polit & Beck, 2014).

The criterion of *credibility* is achieved through clearly described methods, data collection procedures and data analyses using content analysis. The implementations in the studies corresponded with the aims, the data collection and analyses were structured and the data collection was in agreement with the informants. The recruited nurses in study II had varying paediatric care experiences, which was good. The study was based on recorded think-aloud sessions with nurses working in pairs and complemented by follow-up interviews to secure that all possible issues had been covered. Credibility also relates to how well categories and themes cover the data (Granheim & Lundman, 2004). To strengthen the credibility of the analysis in study II and IV the data were analysed independently by the author of the thesis and one of the co-supervisors. Afterwards, the categorizations were compared and discussed further with all supervisors until agreement was reached. In study IV an external teacher colleague participated in the analysis process and her contributing views were included in the discussion. Quotations from the data in both studies have been used to strengthen the results that it is based on the investigated material.

The most central parts of all four studies have also been submitted, peer-reviewed, accepted and presented at a number of research conferences, which also provide a source for the credibility of the results (see peer-reviewed, accepted conference abstract at the beginning of this thesis).

Dependability was ensured due to the fact that the same researcher conducted all TA-sessions included the follow-up interviews in study II and collected the self-evaluations in study IV, verbatim all transcripts and performed the analysis in both studies.

Conformability was ensured due that the supervisors represent different perspectives and knowledge areas and have been involved in the discussions regarding the formulation of result categories and themes in order to ensure conformity of the data.

Transferability; a clear description of the participants, data collection and data analysis facilitate transferability, but it is for the reader to judge whether these findings would generalise to other contexts.

Validity and reliability

The response rate for the questionnaire used in study I and the self-evaluations in study IV were high, 54 out of 64 (84%) and 37 out of 42 (88%), respectively. The scoring and grading model for VP-based exams developed for study III, was used to evaluate 228 VP case managements, which is considered to be a high number in this type of studies (cf. with the study by Fors and Gunning (2014), which had only 154 VP exams as a base for their study of scoring and grading rubrics).

The questionnaire used to examine students' opinion of the use of VPs for assessment in study I was based on work by Zary et al. (2006). A similar questionnaire had been used previously to evaluate dental and medical students' opinions of the use of VPs in learning and assessment studies (Zary et al., 2006; 2009) and the questionnaire was adapted to make it suitable for the nursing domain and to address our objectives. Unfortunately we did not discover on the occasion of first use that one question in the questionnaire actually asked about two different things. This was corrected at the second time. In the questionnaire used, there was also one of the questions set up in an opposite manner: a low figure was good, opposite the others where a high figure was a good result. However, this does not seem to have harmed the results in any major way. The median data in the study for the Halmstad University students (Forsberg et al., 2011) were very similar with the other examined nursing student group at Karolinska Institutet in the same study. Thus, the questionnaire seems to have good validity, reliability and possibilities for generalisation.

The scoring and grading assessment model used in study III was based on the model used by Botezatu et al. (2010a) which also used negative scoring for unnecessary actions. The model was subjected to a validation process. Validity can only be evaluated retrospectively, after data from assessments have been analysed (Wass & Archer, 2011). Before the scoring and grading model was applied to VP-based exams in study III, it was discussed by an experienced group of teachers who addressed a series of questions:

- “What is the test's face value?
- Does it match up with the educational intentions?
- Does the test include a representative sample of the subject matter?
- Does the test differentiate at the level of ability expected of candidates at that stage in training?
- Does the test predict future performance and level of competency?
- Does the test produce the desired educational outcome?”

(Wass & Archer, 2011, p.235)

The experienced teacher group concluded that the test measured what it was intended to do and answer yes to the above questions. In conclusion, the scoring and grading assessment model is valid in the sense that it measures what it claims to measure and reliable in that the score will be similar regardless of whom marks the exam.

6.2 DISCUSSION OF THE FINDINGS

Students and experienced paediatric nurses opinions of VPs for assessment

As have been mentioned before, a good method for assessment should be acceptable for both students and experts (Schuwirth & van der Vleuten, 2010).

In 2007 when Web-SP was introduced into the postgraduate paediatric nursing education at Halmstad University, the technology was novel to the author. There were no paediatric VP cases available.

In study I, the first of the two student groups participated in the creation of paediatric VP cases as a learning activity. The aim of study I was not to compare the groups, but out of curiosity a Mann-Whitney U-test, was used to test the hypothesis that the first group (cohort one) would exhibit a more positive attitude to the use of VPs because of their involvement in developing cases for the VP system. There were only two items on which significant group differences in the median ranking were found. The group not involved in creating the VP cases (cohort two) thought they had made more use of their education in solving the VP cases in the assessment than cohort one. There are obvious explanations for this result, cohort two was at the beginning of the education programme at the time of the assessment and was tested on a specific area of neonatology, whereas cohort one was at the end of the education and was tested on cases covering the whole paediatric field. So this difference is natural. The other issue was more puzzling, due to the answers on the first question: cohort one found the VP cases were less challenging than group two did, but this might also be due to the fact that they had more experience in using VPs than cohort two (since cohort one developed VP cases on their own, they received more experience in using VPs).

Further on, the findings in study I show that it was possible to create VP cases for the nursing domain since the postgraduate paediatric nursing students found the cases very realistic and engaging. They also reported high marks for the idea of using VPs for assessment, which further strengthens the hypothesis that students accept VPs as an assessment tool. The findings agree well with a report of dental and medical students' opinions of VPs in (Zary et al., 2006; 2009). VPs have also been found to be engaging and useful for assessment purposes in other settings such as teacher education (Jonsson, 2008).

Regarding acceptance of experts, the experienced post graduate paediatric nurses in study II reported that they also were very well motivated by the VPs and thought they provided an innovative and interactive assessment method which was good fit with real-life clinical practice and the professional competence required in clinical practice. Both the students and the experienced nurses reported that it was engaging to read a real patient's story and be tested on one's knowledge; they were curious to discover whether their answers matched those in the feedback section of the VP system. Previous studies have also shown that students really appreciate the feedback in VP system (Botezatu et al., 2010b; Huwendik et al., 2009; Zary et al., 2009).

Supportive learning activity before VP-based exams

It was indicated in study (Forsberg et al., 2011) that it was a good idea to involve the students in creating the VP cases. But with the overall experience we have today in mind, it had been even better if the students have had administrator's right in Web-SP so that they could have developed their own cases directly into Web-SP, not as in this study, where the teacher actually developed the cases based on the input from the students. They had probably learnt more about the VP system and the clinical reasoning process if they had developed the cases on their own and it had facilitated the implementation of the cases. In study III the students showed progress in terms of results in the VP-based exams but no improvement in clinical reasoning-use of patient interview questions, physical exams and laboratory tests- was detected. To develop VP-cases force and train the students to think for example which patient interview questions are needed. This is in line with Heinke et al. (2013) were medical students who have been involved in developing OSCE (objective structured clinical examination) stations performed better in subsequent exams. So, learning activities like this can make the clinical reasoning become visible for the students, which is in accordance with the findings of Delany and Golding, (2014).

Scoring rubrics

A comparison of the VP-based exams in study I and III made it obvious that a defined marking scheme was needed; this would also be beneficial for students who would thus know what was expected. There was considerable variability in the ability of students in study I to justify their clinical decisions using clinical reasoning skills. In study III the students' showed improved performance; although the students had been verbally informed about the marking scheme earlier, it was not until before the third assessment that they were actually shown the marking scheme and it may be that access to the marking scheme helped drive improvement in their clinical reasoning ability. Jonsson and Svingby, (2007) reported that knowledge of the marking scheme can improve performance on an exam.

The experienced paediatric nurses contribution

It is obvious that cases used in an exam need to be valid and approved by experts. For validation of the VP cases for exams there was a good opportunity to have them tested by experienced paediatric nurses in study II. To be able to assess the clinical reasoning and clinical decision making for the specific domain, we need as educators to have knowledge of the underlying cognitive processes used by experienced nurses in realistic clinical patient cases (Smith Higuchi & Donald, 2002) for designing well suited exams that match desired educational outcomes. The nurses in study II, suggested very few adjustments of the construct and contents in the VPs before applying them for the exam in study III, which is interpreted as that the cases were clear and that the suggested important actions were OK. A few nurses lacked a number of patient interview questions and laboratory tests they believed as important, so they were added into the system. However, the nurses did not always have the same opinion of how acute the case depicted was; indicating the importance of that more than one clinician should be consulted before using VPs in high-stakes exams. But before applying the cases for the VP-based exams, the cases were also compared with the course

literature and validated by a paediatrician and other teachers in the paediatric field. In conclusion, the experienced paediatric nurses' additional answers in Web-SP have enriched the feedback section.

VP as an assessment tool

For assessing achieved clinical reasoning ability, effective assessment methods have been lacking. It is obviously important that students arrive at an accurate diagnosis, but it is also necessary to assess how they get there (Cook & Triola, 2009). Web-SP offers a unique opportunity to follow and judge the whole clinical reasoning process of a student (patient interview questions, physical exams, laboratory tests etc.) since the system shows exactly which actions and in which order the students have worked through a case. However, even if the semi-automatic assessment module is automatically suggesting scoring of the process, students could in the current version still receive a high grade if they had asked every possible patient interview questions or ordered all available laboratory tests, because the system cannot compensate for that. But our new scoring and grading model is taking this into consideration (including otherwise unwanted actions from the student). So, a new version of Web-SP should perhaps use this new scoring model than the current one.

Research has requested a way to score and grade VP-based exams in a valid and reliable way (Botezatu et al. 2010a; Fors & Gunning 2014; Oliven et al. 2011; Perron et al. 2009; Waldmann et al. 2008). The novel scoring and grading model in study III evaluates both the clinical reasoning and the clinical decision making and seems thus better than the current model in Web-SP, but this new model needs more studies before it can be suggested as totally reliable. Moreover, as indicated in other studies like Fors and Gunning (2014), different courses might need to focus on different issues of the clinical reasoning and decision process. For example, in a course on emergency care, the time and order of actions might have a higher importance than they might have in a course regarding dementia.

How to score and grade

The weighting of the scores and the set limitations for receiving deduction of points can be discussed. Before the exams, the teachers agreed on which specific interactions should be set as "recommended" in each specific case. The teachers also decided on correct diagnosis and treatment regimens, including optimal justification for these. However, there is always a possibility that other teachers may have recommended other interactions or judged students free text answer differently or weighted the scores otherwise. Further research is thus needed regarding how to solve this issue.

Another question is if students actually should receive negative points for exceeding the time limit or for doing unwanted things? For paper based exams, you have a time limit for the exam and in real life there also a time limit to examine the patient and make a clinical decision. Today's care situation necessitates the effective use of clinical reasoning, so it is believed that negative points should be given in students exceeds the allotted time.

In real (clinical) life, serious professional malpractice or negligence results in a warning or withdrawal of one's licence to practice as a RN; we therefore consider negative scoring for

issues related to patient safety to be justified. The results in study III showed an improvement in clinical decision making in terms of the free text justifications and no students received negative points in the last exam, however no improvement in clinical reasoning was observed. The focus of each exam was quite different and it takes time to gain experience and learn how to ask questions effectively in order to arrive at a diagnosis and make clinical decisions.

Nursing students are not trained to use structured patient interview questions to reach a diagnosis in the way that medical students are. As mentioned previously, this is something which should be taken into consideration in the development of educational programmes; nursing students should be supported by providing learning activities which will train them to use patient interview questions. According to Göransson et al., (2006; 2008) nurses in emergency rooms have shown limited skills in clinical reasoning - every second fictive patient was misjudged in these studies. So, the students need to learn rules that examine how cues shape clinical decisions and how the cues relate to the outcomes (Benner, 1993; Tanner, 2006). Decisions about ordering labs and X-rays are usually made by physicians, and postgraduate paediatric nursing students' skills in this area are only evaluated on a very basic level in current exams; with this in mind the threshold for negative scoring were rather generous in comparison with those used by Botezatu et al. (2010a) in the assessment of medical students.

VP as an assessment tool for clinical reasoning

As have been pointed out by van der Vleuten et al. (2012), one exam cannot measure everything. VP-based exams cannot assess the complete clinical competence, the “does” level (Miller, 1990). For example, the actual performance of measuring the blood pressure of a patient, need to be assessed using a work-place assessment or an OSCE exam. VPs offer a much greater opportunity than paper-based exams to judge clinical reasoning and clinical decision making. Due to the fact that VP-systems can track every interaction in the system and that the semi-automatic assessment module in Web-SP assess the learners performance, the students could show what they intended to do with the patient (target Millers' third shows how level). The students had in accordance with the highest level in the SOLO taxonomy, opportunities to demonstrate abilities of generating hypothesis, show how to analysis it and justify their actions in an effective way compared to paper- and work-based assessments. Thus, VP-based exams can assess the requested higher order thinking and have possibilities to offer more patient cases to solve in an exam than a work-place based assessment can do. Comparing the use of paper-based patient cases in courses to the use of VPs, VPs seem to involve students more in higher critical thinking (Huang, Rynolds & Chandler, 2007). VP-based exams are also much less expensive and resource-intensive than OSCEs.

In studies III and IV, provided an opportunity to observe the same students and test their knowledge repeatedly during the whole educational programme respectively during their first semester. This gave the students opportunity to assess their own development (metacognition), whilst as an examiner the author of the thesis was able to track the development of students' clinical reasoning skills.

It is a challenging for the students to synthesize all data, and apply their knowledge to solve the rather complex VP cases. According the model of the "five rights" of clinical reasoning in Levett-Jones et al. (2010), the students should develop and achieve the abilities to collect the right cue, identify and prioritise patient who are in immediately need of care (right patient). The students should also be able to undertake interventions at the right time and in the right sequence. In the semi-automatic assessment module in Web-SP it is not possible to define the priority of the order of interactions to be performed, or which patients should be taken care first, (but you can do this manually using the Log-files of Web-SP). However, you have the possibility to use the follow-up question in the VP case and ask for how the students should triage the patient. So there are other possibilities that can be used even in the current version of Web-SP.

Moreover, you can also ask the students to read all introductions for the cases in the VP-based exams and then ask them to triage and take care of the VPs in priority order. Some studies (e.g. Jacques et al., 206; Thompson et al., 2008) have identified that nurses too often do not respond with the right action upon documented deviations from normal cases. In Web-SP, the students have possibilities to demonstrate achieved skills of right action through suggested care with justifications in the free text part. If they had considered the VP case and processed all data in a proper way they have good chances to demonstrate achieved ability of the right reason expressed throughout the interactions in the VP system and in the free text part.

Benefits of formative VP-based assessments

The aim of study III was to evaluate a scoring and grading model applied for three summative assessments. One of the findings was that the students show progress in their results, even if the last exam was the most complex, as consisted of a wide breadth of paediatric VPs. The question arouse if VPs in connection with a tool for reflection could visualize progression of clinical reasoning skills. The self-evaluations (as a part of a tool for reflection) were inspired of Kolb's learning cycle used in study IV seems to have supported the students' reflective thinking in a good direction, which is in line with findings by van der Vleuten et al. (2010). Furthermore, to introduce the definition of clinical reasoning and expose the students to VP-based exams early in their courses showed benefits, but to expose them for the early assessments in the courses in a way deviates from the curriculum. Before the first assessment (which took place in the very beginning of the one year educational programme) the students have received only one lecture in child health care and no one of the students have experiences from Child- or school health care. The findings in study IV showed a gain of students' own identification of the concept of clinical reasoning, awareness of what to focus on during clinical practice and visualised the expected clinical competence for the future profession. This is in accordance with Schuwirth and van der Vleuten (2011; 2012) who described progress tests in medical schools where the idea of the test was that the students should be assessed as a way to motivate them to study, as opposed to studying for exams.

Additionally, half of the students in the class had never worked at paediatric wards as RNs. But still in the last formative VP-based exam which consisted of two paediatric cases from the emergency room, the majority of the students reported self-efficacy in clinical reasoning and increased confidence in their ability to make use of clinical reasoning in new, unexpected clinical situations. This was very interesting and since the students have had no lectures about sick children before the formative assessment, it was a positive finding. According to Fencil and Scheel (2005) using teaching strategies where the students are involved in their learning process, can improve students' self-efficacy. Self-efficacy is believed to increase a student's ability to be successful at a task (Bandura, 1995). Several studies (Goldenburg, Andrusyszyn & Iwasiw, 2005; Gordon & Buckley, 2009; Tuttle, 2009) have proved that simulation training leads to progression of self-efficacy in clinical reasoning. But perceived and expressed self-efficacy says not much about factual knowledge and ability, so further research is needed to investigate this further.

Study IV, focused on students' reflections using Kolb's learning cycle to structure their descriptions of the experience of clinical reasoning what they learnt and how that new knowledge could be applied. The assessments validated students' progress through the courses and the assessments thus became an engine for student learning. From an educator's perspective the result improved our understanding of how assessment design can influence the development of clinical reasoning skills and awareness of clinical competence requirements. Even if the study was based on a limited sample of postgraduate paediatric nursing students it generated data that provides a basis for a new pedagogical approach in postgraduate paediatric nursing education. The study provided new pedagogical insights into the role that VP-based formative assessments can play in development of clinical reasoning abilities and appreciation of the clinical competence required in professional practice. This is in line with Nilsson (2014, p. 4) "To achieve effective teaching and learning activities where students' achievement and attitudes are stimulated, aspects such as the teachers' knowledge of *what makes a difference in students' learning* and adapting teaching to students' needs are crucial".

Generalisation of the results to other settings

The studies in the thesis are limited by being conducted with rather small groups of postgraduate paediatric care nursing students. Further experimental studies of the scoring and grading model for VP-based exams might contribute to even more valid and reliable tests in the future. Moreover, further exploratory studies of the impact of VP-based assessments can have on students' development and achievement of clinical reasoning ability, will probably also contribute to a greater understanding for how to design assessment packages to support student learning.

However, even though the four studies in the thesis have been performed within the area of postgraduate paediatric nursing, most of the results are most certainly applicable and possible to transfer to many other areas within healthcare education like medicine, dentistry, physiotherapy and so on. Additionally, the templates in Web-SP can be changed to on e.g. diagnosis for nursing care or other specific disciplines. In presentations at research

conferences, people have seen great possibilities and a transferability of the use of VPs in completely other settings, like for teacher education, law education or using in the finance world (Allodi, Linikko & Fors, 2012; Fors & Skoglund, 2013; Jonsson, 2008).

7 CONCLUSIONS

The overall purpose of the thesis was to gain a deeper understanding of the potential of using VPs for assessment of clinical reasoning in healthcare education.

- It is possible to develop and implement VP cases that reflected specific tasks for postgraduate paediatric nursing.
- The use of VPs to assess clinical reasoning was very well accepted by postgraduate paediatric nursing students.
- Both postgraduate paediatric nursing students and experienced postgraduate paediatric nurses found the VP cases realistic and engaging.
- It was possible to identify the experienced postgraduate paediatric nurses clinical reasoning process while solving the VP cases and thinking aloud and use the outcomes for developing a scoring and grading model for VP-based exams.
- Experienced postgraduate paediatric nurses thought using VPs was an innovative and interactive way to be assessed and saw potential for use in the care setting for training, introducing the field for new employers or to refresh one's knowledge.
- The scoring and grading model developed as part of this research appears to be suitable for assessments of postgraduate paediatric nursing students; it assessed both clinical reasoning and the clinical decision making, but further research is needed to test its validity and reliability.
- The semi-automatic assessment module facilitates the scoring and the teachers' efforts but needs to be further developed in order to control better for unnecessary actions.
- Early use of formative VP-based assessments in connection with reflective tools led to improvements in students' understanding of the concept of clinical reasoning, awareness of what to focus on in clinical practice and grasp of the level of clinical competence.
- Students' perceived clinical reasoning ability improved from uncertainty to self-efficacy when using regular VP-based assessments in connection with a reflective tool.
- VPs seem to have excellent opportunities to assess clinical reasoning skills in postgraduate paediatric nursing and most of the results are most certainly applicable and transferable to many other areas within healthcare education.

8 FURTHER IMPLICATIONS AND RESEARCH

The findings presented in this thesis indicated that the postgraduate paediatric nursing students seemed to have limited clinical reasoning skills, especially regarding choosing appropriate patient interview questions. A hypothesis is that a more extensive use of VPs for learning could improve their understanding and development of such skills. For a sustainable VP-based assessment, the specific VP-system used (in this case Web-SP) should probably be further developed. Moreover, the scoring and grading models for VPs in assessment need further research to better meet the criteria for validity and reliability.

Overall implications of the findings:

- Involve students in creating and implementing VP cases.
- Use VPs in the physical class room to support discussion of clinical reasoning and particularly to train students in the use of patient interview questions.
- For assessment purposes a function to turn off the system after the time allocated for an examination has elapsed is needed. A warning could be implemented in the VP system to inform the student about the number of minutes left before the end of the exam.
- The semi-automatic assessment module requires further development to improve the way unnecessary actions are handled.
- For summative assessments the technical stability of Web-SP must be assured.
- Develop a national final exam for postgraduate paediatric nursing and implement VP-based assessments instead for paper-based exams.

Further research should address

To ensure validity and reliability for future VP-based exams, repeating tests of the scoring and grading assessment model for VP-based exams are needed. For developing and suggesting a national final VP-based exam in postgraduate paediatric nursing education we need to investigate how educators at other universities within postgraduate paediatric nursing would measure the VP-based assessments and explore their view of the novel scoring and grading model. It would also be interesting to evaluate the scoring model in other professions.

For a deeper understanding of which benefits and impacts the VP-based assessments had during the education for the professional thinking; follow-up interviews with students could be performed and/or compare two different cohorts of postgraduate paediatric nursing students in a final assessment, where one cohort has received VP-based cases during the education and the other cohort has went through a “traditional education”.

To deepen the understanding of students’ sense of improved self-efficacy after performed formative VP-based assessments it would be interesting to compare the individual progression of perceived clinical reasoning ability in the self-evaluations with actually scored results in VP-based exams. A randomized design will be used to measured students’ self-efficacy with psychometric tests.

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10 SAMMANFATTNING (SUMMARY IN SWEDISH)

Det övergripande syftet med forskningsprojektet var att få en ökad kunskap och förståelse över att använda Virtuella Patienter (VP) i examination för att bedöma specialistsjuksköterskestudenters kliniska resonemang inom hälso- och sjukvård för barn och ungdom.

Examinationen är en del av läroprocessen och bör därför utformas så att den tränar och förbereder för den kommande yrkesfunktionen. Sjuksköterskeutbildningar på grund- och avancerad nivå är akademiska yrkesutbildningar som kräver kunskaper som kvalitetssäkrar professionell kompetens. Centralt i vårdutbildningar är att studenten utvecklar förmågan till kliniskt resonemang och kliniskt beslutsfattande. Det saknas idag effektiva examinationsmetoder för att examinera kliniskt resonemang. Virtuella Patienter är ett interaktivt datorprogram som simulerar faktiska kliniska scenarier. Eftersom studentens interaktioner med de simulerade patientfallet kan följas i detalj har det föreslagits att VP kan användas för examination.

Studie I, har utvärderat VPs tillämplighet för specialistutbildningen inom Hälso- och sjukvård för barn och ungdomar samt studenternas acceptans för att använda VP för examination. Studie II har identifierat hur kliniskt erfarna barnsjuksköterskor genom kliniskt resonemang löser komplexa pediatrik VP fall. Studien syftade också till att ge information om hur det kliniska resonemanget skulle kunna bedömas i en VP baserad examination för barnsjuksköterskestudenter. Studie III utvärderade en ny poäng- och betygmodell för VP baserad examination. Studie IV undersökte om formativa VP baserade examinationer tillsammans med användande av ett reflektionsverktyg i form av självutvärderingar kan påverka barnsjuksköterskestudenternas utveckling av kliniska resonemang och att de kan se sin egen progression.

Resultaten visade att det var möjligt att utveckla och implementera VP fall som reflekterade barnsjuksköterskans verksamhetsområde. Resultatet visade hög acceptans för att använda VP i examinations sammanhang. Studenterna tyckte fallen var realistiska och engagerande och ett bra sätt att examinera deras kliniska färdigheter på. Det framgick även att de erfarna barnsjuksköterskorna tyckte det var en lärande, innovativ och interaktiv examinationsform där ens egen kunskap/kunskapsbrist blev synlig för en själv och de såg många användningsområden för personal inom vård.

Den nya poäng- och betygmodellen som utvecklats för summativa VP baserade examinationer bedömer både kliniskt resonemang och kliniskt beslutsfattande. Modellen har möjligheter att ge minus poäng om föreslagen diagnos eller åtgärder innebär risk för patientsäkerheten eller att studenten utför onödiga interventioner. Samma studentgrupp i specialistutbildningen inom hälso- och sjukvård för barn och ungdom genomförde VP baserade examinationer i tre kurser i följd. Studenternas resultat visade en tydlig utveckling: 53 % av studenterna fick godkänt på den första examinationen, 63 % på den andra och 84 % av studenterna fick godkänt på den sista examinationen. Den vanligaste orsaken till

poängavdrag berodde på att studenterna hade ställt för många anamnesfrågor eller beställt för många laboratorieprov. När VP användes för tre formativa examinationer under den första terminen i barnsjuksköterskeutbildningen och studenterna fick i samband med examinationerna genomföra en självvärdering uttryckte studenterna en upplevd progression av kliniskt resonemang under kurserna. Deras upplevda kliniska resonemang, dvs. förmåga att lösa VP fall, förändrades från osäkerhet till self-efficacy.

Resultatet visar att VP har goda möjligheter att examinera kliniskt resonemang. Även om studierna inom avhandlingen har genomförts inom specialistutbildningen för hälso- och sjukvård för barn och ungdom kan de flesta resultaten överföras och tillämpas inom andra medicin- och vårdutbildningar.

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