COMPUTER SIMULATIONS OF
THE CLINICAL ENCOUNTER
Perceptions and Emotional Aspects

Olivier Courteille

Stockholm 2008
"The question is not whether intelligent machines can have emotions, but whether
machines can be intelligent without any emotions."

- Marvin Minsky, *The Society of Mind*

"The extent to which emotional upsets can interfere with mental life is no news to
teachers. Students who are anxious, angry, or depressed don’t learn; people who are
caught in these states do not take in information efficiently or deal with it well. “

- Daniel Goleman, *Emotional Intelligence*
Dedication

I dedicate this thesis to the memory of my former co-supervisor and mentor, Associate Professor Rolf Bergin, who sadly passed away before this thesis was completed.

You already envisioned with passion the potential of interactive simulated patients at a time when multimedia was not yet there. Your pioneering vision ultimately gave birth to the ISP project.

The thoughtful scientific expertise and extremely generous support you selflessly provided me along the years, even up until the very last moments, have been for me the undisputable driving force that has lead to the fulfillment of the work presented in this thesis.
ABSTRACT

The aim of this thesis was to examine the issues surrounding affective learning, perceived effectiveness, student motivation and engagement in computer simulations of patient encounters. Offering a high degree of realism, authenticity and interactivity, the Interactive Simulation of Patients (ISP) system, a Virtual Patient (VP) environment, was found to be a good technological candidate for conducting this research.

Four studies were undertaken within the framework of this thesis:
Study I investigated if shared VP environments would enhance student learning and support collaborative learning. Study 2 evaluated the potential of ISP-like systems as possible tools for assessment of clinical reasoning and problem solving ability among medical students. Study 3 assessed medical students’ appraisals of a “mixed” virtual reality simulation for endoscopic surgery by exploring the potential benefits of this kind of contextualized learning experience. Study 4 aimed to extend the empirical findings from the previous studies and achieve a better understanding of students’ feelings of patient “presence” and reactions to a video-mediated VP encounter.

The results support a number of conclusions about ISP-like learning environments:
• They are perceived as compelling, innovative, realistic, and effective learning tools.
• They support active student involvement in clinical problem solving.
• They seem to motivate students due to their meaningful, authentic, and contextualized learning environment.
• They stimulate student engagement in the learning activity and have the potential to promote social interaction.
• They encourage critical thinking and enhance learning when the VP cases are solved in a collaborative setting.
• Extensive interactivity, natural conversational interface and video-filmed patient (actor) are key factors for the sense of presence and emotional involvement.
• They are able to present and simulate realistic patient encounters to an acceptable level of complexity and allow differentiation of student’s performance for assessment purposes.
• They might enhance contextualization and authenticity in mixed reality simulation.

The four studies demonstrated that high-fidelity computer simulations of the clinical encounter are good technological mediators to activate, motivate and engage students, resulting in possibilities of effective knowledge building, better understanding of the situated experience, increased confidence in clinical problem solving, and enhanced memory retention.

**Keywords:** Virtual patients; medical simulation; affective learning; computer mediated communication; experiential learning.
LIST OF PUBLICATIONS

This thesis is based on the following papers, which will be referred in the text by their Roman numerals:


IV. Courteille, O., Larsson, L-O. & Fors, U. Medical Students’ Perceptions, Observed Behaviors and Attitudes towards a Virtual Patient driven Computer-Mediated Learning Experience. *Submitted to Computers & Education*

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<th>Description</th>
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<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
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<tr>
<td>CAL</td>
<td>Computer Assisted Learning</td>
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<td>cf.</td>
<td><em>Confer, compare</em></td>
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<td>CI</td>
<td>Confidence Interval</td>
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<td>CMC</td>
<td>Computer Mediated Communication</td>
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<td>CSCL</td>
<td>Computer Supported Collaborative Learning</td>
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<tr>
<td>e.g.</td>
<td><em>Exempli gratia, for example</em></td>
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<tr>
<td>i.a.</td>
<td><em>inter alia, among other things</em></td>
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<tr>
<td>i.e.</td>
<td><em>Id est, that is</em></td>
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<tr>
<td>IQR</td>
<td>Interquartile range</td>
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<td>ISP</td>
<td>Interactive Simulation of Patients</td>
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<td>MR</td>
<td>Mixed Reality</td>
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<td>NLP</td>
<td>Natural Language Processing</td>
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<td>PBL</td>
<td>Problem Based Learning</td>
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<tr>
<td>R</td>
<td>Correlation Coefficient</td>
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<td>SE</td>
<td>Standard Error of the Mean</td>
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<td>SP</td>
<td>Standardized Patient</td>
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<td>VAS</td>
<td>Visual Analogue Scale</td>
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<td>VLE</td>
<td>Virtual Learning Environment</td>
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<td>VP</td>
<td>Virtual Patient</td>
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<td>VPE</td>
<td>Virtual Patient Encounter</td>
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<td>VR</td>
<td>Virtual Reality</td>
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1 INTRODUCTION

The panorama of patients at the university hospitals is changing. A former broad representation of various illnesses, with a spectrum from common illnesses with a more trivial treatment, to unusual illnesses demanding a highly specialized hospital care, is replaced with a narrow panorama of serious illnesses treated by highly qualified specialists. During the same time period the type of education has changed from a more passive type of education, where i.a. lectures are a prominent feature to a problem oriented educational setting where groups of students together should meet patients and patient related examples. These two factors contribute to that the number of patients – and the type of patients – can be insufficient in present medical education.

It is often argued that medical students learn best when regularly exposed to patients early. Consequently, case oriented learning in medicine and healthcare is now commonplace in medical education. However, where and how to introduce clinical cases in the education is under discussion. For example, some argue that education should be viewed as a two-stage process: after systematic knowledge has been internalized from literature, lectures, courses etc, it has to be consolidated by practically applying it within the context of concrete real life cases. Some others think that clinical cases should be introduced very early and/or that the curriculum should be integrated with no separation into clinical and preclinical courses.

The pedagogy of case-based education generally emphasizes active and situated learning. This is especially true for domains where diagnostic problem solving constitutes an essential element. Hence, the application of knowledge may be identified as a process of performing a thread of associations to solve concrete case-based problems. This can be achieved by applying the educational method called Problem Based Learning (PBL) in which students learn through finding meaningful solutions to contextualized problem sets.

However allowing students to learn for themselves by trial and error (the heuristic process) is often impossible in a conventional academic environment because of a combination of one or more constraints of time, space, location, finance and safety. The advent of computer simulations of real life situations has given teachers the means of providing students with learning environments that require thought and action as in the real world. In these situations the heuristic exploration provides the learning experience rather than the learning of descriptions, which the student may or may not relate to the real world in due course.

Moreover, knowledge within a particular domain can also be effectively contextualized by means of computerized case-based medical simulation in a PBL framework (Bradley & Postlethwaite, 2003).

Features of a learning environment do not act in isolation; other factors such as the concepts or skills to be learned, individual characteristics, the learning experience, and the interaction experience all play a role in shaping the learning process and its
outcomes. Unfortunately, until recent times the role of affective components on learning outcomes has been overlooked in the field of educational technology.

Designers and evaluators of case-based educational technology have many ideas concerning how computer simulation can facilitate learning. Having developed and assessed a certain amount of medical simulation systems at our department (LIME), we have been able to observe through the years that well designed simulation systems might motivate and engage students. Realistic and highly interactive problem-solving situations do not generate inert knowledge. Well-designed simulation systems can improve personal communication skills between non-equal individuals and also result in emotional involvement, important for learning.

Research in medical simulation has been mainly focused on the holistic level. It has been argued that trustworthy situations, authentic environments and realistic scenarios are key components for effective and enriched learning experience. However, we have little information concerning which of medical simulation’s features provide the most leverage for enhancing understanding, sharpen motivation and engage learners. We need therefore to understand the interplay between medical simulation’s features and affective learning outcomes. These latter have been reported by Kneebone (2007) as being one of the 4 key components of simulation-based learning.

Affective learning outcomes are being disclosed, are we then facing a new paradigm for Learning and Teaching in medical and healthcare simulation?
2 THEORETICAL BACKGROUND

2.1 COLLABORATIVE LEARNING

As learner-centered and constructivist approaches to education affect both the traditional and the online classroom, educators are beginning to take advantage of online collaborative tools that supplement and support their students' activities. These tools provide students with a space of their own where they can learn from each other, comment on each other's work and ideas, and better understand the thinking processes of their peers (Goodsell et al., 1992). Student motivation and satisfaction is increased by their involvement with a larger network of peers. Student motivation and satisfaction might increase by their involvement with a larger network of peers (Jansson, 2002).

Initial empirical studies have shown that collaborative learning is often more effective than learning alone, but not systematically (Slavin, 1983). Learning is perceived as the side effect of the effort that peers engage to build and maintain a (partly-)shared understanding of the problem-solving situation.

A virtual learning collaborative environment can become more than a social common area that allows students to meet with each other and their support network. Because of its essential characteristics, it can quickly become a dynamic "knowledge space" where information is contextualized in numerous ways and contributed to by the larger learning community. Since students have expertise of their own to share with the rest of the community, the opportunity to help build this environment and its content encourages more active participation in their subjects. This panel will include educators and others who are exploring the challenges and advantages presented by using these spaces during the course cycle, from theory to practice.

These theoretical notions, especially regarding learner identities, are supported by some concepts of virtual reality that emphasize its communicative and participatory nature. The collaborative learning environment promotes active mental engagement in the experience (Grabowski, 1990).

Despite the large body of literature on peer learning and teaching, there are few acknowledgments of how well CMC (Computer-Mediated Communication) may support collaborative learning. Although cognitive and social psychology have already provided much information about how students communicate and its relationship with collaborative learning, the context has usually been the traditional face-to-face setting with its paralinguistic cues to facilitate communication. What we do not yet know in published detail is how people learn collaboratively and how this collaborative learning relates to the communication in the CMC context. In addition, O'Malley (1995) calls for studies of collaborative learning that "focus more on the processes involved in successful peer interaction, rather than just on learning outcomes".
2.1.1 Experiential Learning and Active Knowledge

Knowledge may be considered as such yet be "inert" when there is evidence of learning (e.g., high examination score) and an inability to act appropriately in a real-life situation. To convert inert knowledge into active knowledge appears to require some process whereby the knowledge is realized. A powerful way of developing active knowledge acquisition is by the learner's cycle of experience where students are actively involved in the learning process. This concept of experiential learning involves the cycle of observation, reflection, experimental action and conceptualization, as indicated by Kolb's (1984) model. Experimental action is the basis of discovery, i.e., learning for oneself as opposed to prescriptive learning which typifies many academic environments.

“A good learning experience is one in which a student can master new knowledge and skills, critically examine assumptions and beliefs, and engage in an invigorating, collaborative quest for wisdom and personal, holistic development” (Eastmond & Ziegahn, 1995, p 59). It is argued that engagement is the most significant measure of whether communication is being achieved, as without any interaction between user and content learning will not take place (Sims, 1997). Contextual or learner-integrated approach enhances engagement through appropriate learner control options, providing an interactive environment both realistic and relevant to the learning environment. This favors for the learner-integrated philosophy designed to provide a true interactive environment in which effective communication occurs.

As framed by Laurillard (1997), curricula that provide real-life experiences should be valued more than curricula that merely provide descriptions of the experiences. Grabinger et al. (1997) note that: "By engaging in authentic activities that reflect the work environment for which they are being prepared, students have an opportunity to practice applying knowledge and skills to new problems, improving their ability to transfer their knowledge and skills to future challenges." This emphasizes the need to contextualize the learning experience, implying that task training should take place in the context of a realistic setting related to the clinical situation it is designed to reflect.

Motivation is a key issue whose effect upon learning is often under recognized. Motivated learners are enthusiastic, focused, and engaged. They are interested in and enjoy what they are doing, they try hard, and they persist over time. Malone (1981) proposed that the primary factors that make an activity intrinsically motivating are challenge, curiosity, and fantasy. Intrinsic motivation has also been reported as a strong factor for performance improvement (Bandura, 1997; Martens et al., 2004; Csikszentmihalyi et al., 2005). Moreover, research has shown that the learning curve can be substantially enhanced and shortened for motivated trainees (Bransford et al., 1999; Quinn, 2005; Hedman et al., 2006).

Csikszentmihalyi (1990) described the positive experience of being fully engaged in an activity as a state of “flow”. He defined flow as the state in which people are so involved in an activity that nothing else seems to matter (p. 4). Thus, flow represents an optimal state of performance at a task, a sense of enjoyment and control where an individual’s skills are matched to the challenges faced. The concept of flow provides
one perspective on the feelings of enjoyment and engagement that can be experienced by learners.

It is also important that participants do not feel peripheral or uncomfortable during the training exercise. The quality of the experience matters because it affects, either positively or negatively, the debriefing’s outcomes. A supportive learning climate should therefore be favored.

Students learn from the experience in such a way that they are cognitively or affectively changed (reflective process). Previous studies (e.g., Isbell & Wyer, 1999; Watson & Clark, 1984) have indicated that individuals who experience negative mood states tend to engage in automatic (unintentional) cognitive processes in which they encode and retrieve more negative that positive information on the target subject. Special attention should therefore be paid to the affective component of learning because of the impact of positive and negative emotional responses on learning outcomes (Garris, 2002). Appropriate intervention based upon students’ affective state would facilitate learning.

2.1.2 Social Interaction

Human communication is fundamentally social. From the time we are born, we begin reacting to the social cues in our environment and learning the appropriate rules for effective interaction, which include verbal behaviors such as intonation or word ordering, and also non-verbal behaviors such as posture, gestures, and facial expressions. These behaviors convey attitudes, identities, and emotions that color our communication. We often create substitute conventions for communication channels that don't naturally provide bandwidth for non-verbal cues, such as e-mail or online chat sessions.

Unfortunately, the majority of software interface design has focused primarily on the cognitive aspects of communication, overlooking most social aspects. However, recent research has demonstrated that human beings naturally react to social stimuli presented in an interactive context. Further, the reactions often follow the same conventions that people use with each other. Even the smallest cues, such as colors presented or word choice in messages, can trigger this automatic response. The presentation of an animated character with eyes and a mouth heightens the social expectations of and strength of responses to the character. Never assume that users expect a character's behavior to be less socially appropriate because they know it is artificial. Knowing this, it is important to consider the social aspects of interaction when designing character interaction. The Media Equation: How People Treat Computers, Televisions, and New Media as Real People and Places by Reeves & Nass (1996) is an excellent reference on current research in this area.

The way the technology is designed affects the form of the social interaction, but often in ways not predicted by the designer. Can the virtual actor/patient thus contribute to a better-perceived engagement of the simulated case experience and as a conveyer of emotions?
2.1.3 Emotional Involvement and Learning

Emotions are usually caused, then run through a process then have consequences. A widely accepted proposal has been made by Frijda (Frijda, 1987; Mesquita & Frijda, 1992) of an emotion as a set of stages, as follows:

Appraisal → context evaluation → action readiness → physiological change, expression, action

Numerous research studies support the claim that affect plays a critical role in decision-making and performance as it influences cognitive processes (see e.g., Damasio, 1994; Goleman, 1995; Picard, 1997). The following model shown in see Fig 2.1.3a doesn’t explain how learning works but rather provides a framework for thinking and posing questions about the role of emotions in learning. Affective valence, for instance, can be characterized by enjoyable/pleasant (positive effect on learning) versus boring/unpleasant (negative effect).

![Figure 2.1.3a – Emotion sets possibly relevant to learning](image)

A typical learning experience involves a range of emotions, cycling the student around the four quadrant cognitive-emotive space as they learn (see Fig 2.1.3b). It is important to recognize that a range of emotions occurs naturally in a real learning process, and it is not simply the case that the positive emotions are the good ones. In building a complete and correct mental model associated with a learning opportunity, the learner may experience multiple cycles until completion of the learning exercise.

It is generally agreed that the concepts of emotion and affect encompass a wide range of mental and physical phenomena: mental representations, states and responses of the autonomic nervous system, and behaviors, as well as subjective experiential qualities.

Numerous studies show that memory retention is enhanced when one is emotionally involved (James Forest, University Teaching, 1998). Hence, a number of studies have shown that being emotionally involved affects (positively) learning outcomes and understanding (Sansone & Morgan, 1992; Jansson, 2002; Oatley & Johnson-Laird, 1987). According to Clark Quinn (2005) “Learning is at its best when it is goal-oriented, contextual, interesting, challenging, and interactive.” This can be related to
Malone and Lepper’s taxonomy (Malone & Lepper, 1987) for intrinsically motivating educational environments (i.e. challenge, fantasy, curiosity and control). As reported earlier in chapter 2.1.1, motivation is a key ingredient in learning, and emotions play an important role in motivation.

We know that higher cognitive functions like perception, thinking and decision-making are affected by our emotions and affective states (Sansone & Morgan, 1992). Good learning engages emotion: Lepper & Cordova (1992) have reported a series of studies that suggested that making learning more enjoyable resulted in increased interest and learning. Jensen (1998) also declares that "Good learning engages feelings. Far from an add-on, emotions are a form of learning. This learning is just as critical as any other part of education"… "Emotions drive the threesome of attention, meaning, and memory". Experts in brain research remind also us of the important connection between emotion and cognitive development. Caine, R.N. & Caine, G. (October 1990) discussed in their work, entitled "Understanding a Brain Based Approach to Learning and Teaching", twelve principles of brain-based learning and the implications of those principles for educators. Two of their conclusions are the following: "A person's physical and emotional well-being are closely linked to the ability to think and to learn effectively". "Emotions and cognition cannot be separated. Emotions can be crucial to the storage of recall and information".

Emotions have thus a profound impact on our memory and learning. Sylwester, R. (1997) emphasizes that in his work "How emotions affect learning": "Emotion plays an important part in learning and schools need to focus on metacognitive activities that allow students to identify and deal with their own emotions and those of others. Emotionally stressful environments can inhibit learning.”

Emotional involvement is also an important part in the studies to become a health care professional and later on in everyday clinical work (Stolt, C.M., 2002). Therefore one should keep in mind that the motivation(s) of learner(s) has consequences for the learning outcome (Blankstein et al., 1989).

### 2.1.4 Emotional Mediated Experiences

Research questions about emotional mediated experiences are strongly connected to cognitive learning theories such as situated learning (Lave & Wenger, 1991), cognitive load theory (Sweller, 1988) and theory of multimedia learning (Mayer, 2001). The main question is: How do we create a learning environment that embraces emotion to enhance learning? Previous work has shown that different modalities of multimedia (including sound and other means) might induce or reduce emotions amongst the users/watchers (Courteille, 1989; Mayer & Moreno, 1998); the level of interaction being a significant factor. For instance, interfaces that motivate learners are realistic, easy to use, challenging and engaging. According to Donald Clark (2002), attention and memory are enhanced when the design of simulated interviews (e.g. interpersonal dialogue) relies on compelling close-ups shots and high realism. They arouse the emotional engagement of the learner (Van Vliet & Specht, 1998). On the other hand can an extreme emotional state decrease our capability to critically analyze the
information. This is particularly true with movies and TV advertisements. The psychological studies undertaken by Reeves & Nass (1999) about the human reaction to media and attributes presented in media even provides evidence that “media equals real life”.

Real patient cases are of course unsurpassed also for making students emotionally involved. As is pointed out earlier can media, however, in some cases accomplish an emotional involvement as in real life. The capacity of CSCs to accomplish emotional involvement has not been studied. It is reasonable to believe that different design and techniques in such systems will have different effects on the emotional involvement – and thereby on the learning outcome. The techniques and experiences from the movie and/or the advertisement business could probably be used in the study of emotional involvement also in medical education with CSCs.

Presence has been identified as one of the key factors for emotional mediated experiences (Johnson et al., 2000). It is characterized by high levels of arousal and intensive affect. Dede et al. (2002) argue that through situated learning, mediated and psychological immersion affects concentration, attention and understanding. In other words, it seems to shape the participants’ learning style. Hence, when enriched by embodied conversational agents, computer mediated communication is advocated for enhancing this sense of “presence” and increasing the feeling of immersion (Oatley & Johnson-Laird, 1987; Dede et al., 2002; Picard, 2000). More specifically, media studies like those performed by Reeves et al. (1999) have also demonstrated positive effects of screen size and message content on attention and arousal.

2.2 CASE-BASED MEDICAL EDUCATION

2.2.1 Problem-Based Learning

PBL is a learner centered pedagogical strategy, which started at McMaster University around 1970, and where the students themselves assume major responsibility for their learning. It is a method of teaching and learning that is used increasingly in medical and health care curricula worldwide. One major purpose of problem-based learning is the consolidation of learned knowledge by applying it within the context of concrete case-based problems (Barrows, 1994).

Most of the research on Problem-Based Learning has taken place in the past 20 years. It is argued that PBL is a method that will assist students towards achieving a specific set of competencies and is the method of choice for professional education because it is particularly suitable to support the conditions that influence adult learning.

According to Jonassen et al. (1993, p 235) authentic learning experiences are ‘those which are problem- or case-based, that immerse the learner in the situation requiring him or her to acquire skills or knowledge in order to solve the problem or manipulate the situation’.
The format of the problem simulates professional practice or a real life situation and can involve a real or standardized patient or a paper case. Other forms of media such as video, the Internet, and digitalized computer applications, like virtual worlds, allows for even more variability in format.

PBL has been described in a variety of ways that can be summarized as a complex mixture of general teaching philosophy, learning objectives and goals and faculty attitudes and values.

2.2.2 Effectiveness of PBL

There is general agreement that many students prefer the challenge, stimulation, and motivation offered by PBL and that development of critical thinking skills is an important component of medical education.

By utilizing cases and problems designed to match student perception of their future profession and their current knowledge, PBL serves as a powerful stimulus for their intrinsic motivation to learn (Dolmans, 1997; Koh, 2008).

Norman & Schmidt (2000) provided evidence that problem-based learning was more effective than conventional methods. Evidence indicates also that active participation in learning is more satisfying than passive transfer of information from the teacher to the student and that active learning leads to enhanced retention and recall (Bransford, Brown & Cocking, 1999).

Now PBL has evolved over time. According to Barrows (2000), authentic problem based-learning has emerged as an effective educational method for learners to carry out activities that are required in the real world (i.e. clinical practice). Students in PBL tracks report being more satisfied, less stressed, and more positive about their learning environment when compared to students from traditional tracks.

2.2.3 PBL and Collaborative Learning Issues

Computer supported collaborative learning (CSCL) has grown out of wider research into computer supported collaborative work (CSCW) and collaborative learning. Collaborative learning is defined as groups working together for a common purpose (Resta, 1995). The purpose of CSCL is to scaffold or support students in learning together effectively. They are based both on the promise that computer supported systems can support and facilitate group process and group dynamics in ways that are not achievable by face-to-face, but they are not designed to replace face-to-face communication. CSCL and CSCW systems typically tailored for use by multiple learners working at the same workstation or across networked machines. These systems can support communicating ideas and information, accessing information and documents, and providing feedback on problem-solving activities.
The research of CSCL and CSCW covers not only the techniques of the group work but also their social, psychological, organizational, and learning effects (Lehtinen et al., 1998; Yu, 2001; Teasley, 1993). It has been shown by Bergin et al. (2003) that the ISP system is a powerful tool to promote collaborative learning in clinical problem solving.

2.2.4 Medical Simulations in PBL Setting

Indeed, as reported previously, PBL can be seen as a more enjoyable and stimulating way to learn. We know that the use of technology in a meaningful way to facilitate exploration and collaboration is another critical component of engaging learning environments (Garris et al., 2002).

It is interesting to note that the use of computer technologies to support PBL Problems in a PBL-based medical course is usually structured around simulations of patient encounters. These can take the form of trained patient surrogates (human actors), otherwise known as 'standardised patients', or can be paper based (Koshmann et al., 1996). However, the existing literature on PBL has not considered much the emotional and psychological aspects of PBL with computer-based simulations.

2.3 COMPUTER SIMULATIONS IN EDUCATION

2.3.1 A New Educational Paradigm

Computer simulations are increasingly used by Higher Education Institutions as a method to enhance learning, training and assessment of competence (Issenberg et al., 2005). Being the spine of constructivist learning environments, simulations allow students to apply their practice and test their new knowledge to authentic, real-life situations. And this can be done in the classroom, online or wherever. Well-designed simulation systems can motivate and engage students. Students can thus work together to solve problems and share ideas (Norton & Sprague, 2001). Hence, Computer-based simulations of the clinical encounter can create a mindset that allows students to approach the problem as if it were a real-life clinical situation.

Simulations can also be flexible learning environments. Teachers can control the variables of the simulation and adjust them to meet the needs of different learning styles. As Schaef & Clarke (1997, p.2) point out in their study on the use of partially immersive virtual reality in tertiary education, "Virtual reality can be used to manipulate simulations". Thus, simulations can motivate students by providing with a challenge, relevancy, and security. Students who are motivated to learn will gain a better understanding and improve their critical thinking skills.
2.3.2 Simulation-Based Learning

It has been reported that simulated case-based scenarios can stimulate user's cognitive activity and emotional engagement because they involve learners in the same types of cognitive challenges as are present in the work environment (Savery & Duffy, 1996). Technology-rich learning environments like simulations might be important tools in various educational areas. This is especially true when practice in real world is hindered due to ethical, economical, social and cultural reasons. Examples of this can be found in a variety of settings like medicine, archeology, geology, aviation and engineering.

The learner can be trained in lifelike situations without any risk and also do this repeatedly. A well-known application is the use in the training of pilots - in their initial training as well as in a continuing training of different types of airplanes. This is an example of training of concrete skills, patterns and maneuvers. There are other examples of when simulations are used in training and understanding of more abstract skills like in management and economy. However, the use of simulations in areas like the improvement of professionalism, interpersonal communication skills including increase of empathy are more scarce (e.g. Bearman et al., 2001).

2.3.3 Authenticity and Recall

Constructivists hold that learning should occur in a realistic setting reflecting real world situations. Some argue that emphasis should be placed on engaging students in cognitive processes that reflect the real-world counterpart. In fact authenticity of the learning environment is a way to strengthen situated learning (Woolley & Jarvis, 2007).

In a study about student's perceptions of a virtual PBL experience, Kamin et al. (2002) observed that students reported that the authenticity of the case was a critical feature and that, "seeing (videos) made learning more memorable." An examination of the literature advocating the use of authentic activities suggests that cases may be useful in helping learners develop an understanding of the complexities of real-life situations (Gulikers et al. 2004). This is the case for intrinsic motivation, in particular the valence (i.e. the value placed on the activity), which can be affected by the authenticity of the task to be performed and is therefore one determining factor for effective learning (Martens, 2004).

The degree of realism and authenticity is also reflected in the level of student involvement. Authentic triggers are capable of immersing students in the problem. VR (Virtual Reality), for instance, allows medical students to be immersed in life-like situations. This is the reason why effective medical simulation must be grounded in an authentic and realistic clinical context.

The constant strive for today’s videogames to provide better and faster realistic environments has definitively influenced the way new learning experiences are designed and supported. We have even seen the very last years new kinds of online courses emerging in the academic curricula. These courses are based on virtual worlds (like for instance Second Life or MySpace) and can provide authentic experiences with high immersion impact on learners.
2.3.4 (Tele)-Presence

Presence, the sense of “being there” is a complex experience. It has been identified as one of the key factors for emotional mediated experiences. Good movies are compelling. The experience of watching them can reasonably be described as big, special, dramatic, involving, engaging, powerful, intense, even overwhelming. As the line between real and mediated gets harder to see, presence increases.

Presence is characterized by high levels of arousal and intensive affect. Presence theory and research tell us that presence has the potential to affect many related concepts and phenomena like emotions, immersion, involvement, flow, empathy, consciousness, judgment, learning, task performance, and so forth, of those who experience it (Reeves Timmins & Lombard, 2005; Lombard & Ditton, 1997).

Chris Dede (2002) argues that through situated learning, mediated and psychological immersion affects concentration, attention and understanding. In other words, it seems to shape the participants’ learning style. Virtual presence helps also to raise the sustainable remembrance effect. This has been reported in the VR simulation literature claiming that human performance related issues like the subjective sense of presence or self-consciousness do elicit different stress levels during a VR session and, as a result, might affect performance and memory retention (Nash et al., 2000).

It has been found that complex patient modeling, as well as more natural visual interaction, enhance the sense of presence. As expected, it has been showed that as the type of interaction becomes more natural, and the patient behavior modeling becomes more complex, the achieved sense of presence will be greater (Viciana et al, 2004).

2.4 COMPUTER SIMULATIONS OF THE VIRTUAL ENCOUNTER

Computer-based simulations of the clinical encounter can create a mind set that allows students to approach the problem as if it were a real life clinical situation. This kind of simulation recreates artificially a clinician-patient scenario in order to allow learning and practice of skills, safely. One of the obvious benefits of this specific area of medical simulation is that rare clinical situations can be staged, repeated and mastered. Future incidence of patient harm in real life can thus be as limited as possible.

2.4.1 Virtual Patients (VPs)

In an educational context, a Virtual Patient (VP) is a virtual representation of a patient encounter for learning or assessment, often capable of interactive and user governed illness history interview, and physical examination as well as ordering and analysis of laboratory and imaging tests (Ellaway, 2004; Bergin & Fors, 2003; Zary & al, 2006; Huang & al, 2007).
As a complement to clinical training, VPs give students the opportunity to experience clinical decision-making and problem solving in the classroom, with the added advantage of being able to discuss the patient’s situation with their teacher and peers.

Computer-based virtual patients (VPs) are an emerging medium for medical education and are still in a relatively nascent stage of development. Virtual patient encounters presented to students on-line (embodied entities) are an alternative type of patient encounter that are able to be enriched through the use of various media, including high quality graphics, video, VR and avatars. Most VP systems offer advanced interactivity consisting of a number of attributes (but not necessarily all) including immediacy of response, non-sequential access of information, adaptability, feedback, options, two-way communication and the ability for the user to interrupt the ongoing process.

VPs also enable software developers and Web authors to incorporate a new form of user interaction, known as conversational interfaces, that leverages natural aspects of human social communication. Nevertheless, the fictive encounter being a critical component in engaging VP-based learning environments (Roberts et al., 1995; Hubal et al., 2000), it is consequently important to use technology in a meaningful way so as to facilitate exploration and collaboration.

The standardized patient has been described as the most engaging simulation next to the actual patient, because it is so close to reality. However, few studies have reported on affective aspects with a virtual patient encounter.

2.4.2 Virtual Conversations with Fictive Encounters

A few VP systems (mostly avatar-based) have emerged the recent years offering a natural language interface that allows students to interact with the patient through typed or verbal questions.

A virtual dialogue method to introduce second-year medical students to patient interviewing and clinical problem solving was already used by Harless for the TIME project (Interactive Patient Simulations: Experiential Learning in the Medical School Classroom). Harless (1992) already presented findings demonstrating that students became intellectually and emotionally involved in the learning experience, they perceived the patients to be real people, and they enjoyed this method of learning.

The credibility and educational effectiveness of virtual dialogue experiences has been reported in other field tests (Moreno et al. 2001; Johnson et al., 2000).

Barrows (2000) argues that: “the computer has great potential if a natural language interface is used and the patient is presented with audiovisual representation possibly a virtual patient.” Unless a virtual dialogue system actively supports the users’ suspension of disbelief—to enable them to feel as though they’re having a direct conversation with the virtual character—the experience is less effective. To support this, the interface must be non-technical, aesthetic, intuitive, and driven by natural spoken language.
Furthermore, the system’s ability to recognize the words and phrases spoken by users must be virtually flawless (more than 95 percent accurate); should the system misrecognize an utterance, its recovery must be seamless so as not to disrupt the user’s involvement and the conversation’s flow. Finally, the questions asked to the VP must be interesting and not odd or uncomfortable for a user to say. The virtual patient’s response must be relevant and provocative and must cause the user to want to ask more questions.

2.5 THE INTERACTIVE SIMULATION OF PATIENTS (ISP) PROJECT

2.5.1 Background and Context

As mentioned earlier in the Introduction section, medical students probably learn best when exposed to patients early and often. Because of changes in health care today, students have less time to spend with patients in clinical settings. Medical schools have devised other ways of providing clinical experiences for students. In the early 70’s, McMaster University in Canada began using actors trained to accurately portray the role of a patient with a specific medical condition. Dr. William Harless created computer based patient simulations during the same time period at Ohio State University. A decade later he created a more elaborate version at the National Library of Medicine. The experience with computer based patient simulations at the Karolinska Institute (KI) emanates from these early experiments in cooperation with Dr. Harless.

Around the mid 90’s a new development with multimedia technology in computer based patient simulations started at KI. The project was entitled Interactive Simulations of Patients (ISP). There were several intentions with this project. One of them was to offer students in medicine vivid patient descriptions with interactive possibilities. Several such computer-based patients have been created and tested in courses since then.

Long-term aims were to try to improve education and training in patient management with improved talents in the students and maybe a more cost-effective education.

2.5.2 Pedagogical Aims

The ISP project has as goals i.a. to furnish the students - and the teachers – with typical clinical problems and to present a more vivid example of patient-based problem than the presently available paper-based simulations. One of the pedagogical aims of this contextualized learning environment is to offer medical students the possibility to increase their confidence in solving clinical problems as well as to deeply engage them and foster shared understanding between peers.

The medical history framework of ISP also aims therefore to enrich students’ interactions with an affective dimension towards the VP.

Thus, the pedagogical modalities of ISP lead to an explorative approach articulated around problem-based learning.
Hence, ISP is a virtual patient simulation technology that builds on the engagement-education synergy, and leads to the convergence of information processing (clinical data), interpersonal communication and media technologies (Bergin & Fors, 2003).

### 2.5.3 Design of the Simulation

The simulations consist of five main parts:

- **Medical history**, where the students can interact with a (video-filmed) simulated patient on the screen with an interface supporting NLP.
- **Physical examination**, where the students interact with a 2-D doll and with photographs, where they can perform common examinations like inspection, auscultation, percussion and so forth.
- **Laboratory examinations**, where the students can order different laboratory investigations, from the physiological department, from the X-ray department etc.
- **Diagnosis and justification**, and finally,
- **Feedback module**, where the students are told how they performed in solving the clinical problem - what medical history concepts they used and what they missed, what examinations they did and what they missed and what examinations that were harmful, expensive and/or unnecessary.

In order to activate and emotionally attach students, ISP has been designed to simulate realistic patient encounters presented in a natural (life-like) interface. Students have at their disposal an interactive free-text driven patient-history function in natural language (supporting both Swedish and English), with all patient responses available in the form of pre-recorded video clips of actors simulating different patient cases. The medical history interface is designed not only to react to asked questions, but also to trigger affective reactions such as irritation, anger, fear, etc. with the VP depending on how questions are phrased, and whether they are repeated or inappropriate.

It is important to stress that before the students enter the feedback module, no corrections, hints or other pinpoints are used – the students are fully confined to their own activity and thinking.

The collaborative workspace of the system also facilitates interaction among peers, as well as between students and teachers/facilitators (Bergin et al., 2003).
Fig. 2.5.3.a. Screen shot of the medical history-taking interface

Fig. 2.5.3.b. Screen shot of the physical examination interface
As described above, ISP enables simulation technology to support affective interactions between students and VP’s.

2.6 RATIONALE FOR THE THESIS

Few studies in PBL research have been focused on the psychological effects of the emotional engagement during a PBL session and even less with a CMC (Computer-Mediated Communication). Even fewer studies have been reported concerning the possible affective learning value of Virtual Patients (Bearman & Cesnik, 2001).

Such heuristics thus seem to have been neglected, and most of the focus has been on usability and assessment issues instead. As mentioned before, the emotional involvement is an important factor for learning outcome and memory retention, it is essential to elucidate the influence of different educational and technical settings on the emotional involvement of the students.

Therefore, there is a need to study under which conditions emotions, as well as other affective phenomena, might contribute to increased engagement in the learning experience with a virtual patient. Such information would be important when trying to develop more believable and authentic interactions between students and VPs. This might also provide more insight on the dynamics of interpersonal behaviors during a virtual patient encounter.

Based of these reflections, and aware of the intrinsic characteristics needed for the choice of an eligible VP environment, we felt that ISP, being an experiential learning method, would be a suitable VP candidate for conducting all of the thesis’ four studies.
3 AIMS OF THE STUDY

3.1 GENERAL AIM

The overall aim of the thesis was to examine the issues surrounding affective learning, perceived effectiveness, student motivation and engagement in computer simulations of patient encounter (virtual patient systems, VP).

The primary aim was thus to investigate if the specific VP system “Interactive Simulation of Patients” (ISP) might be perceived as an effective, trustworthy, activating, motivating and engaging learning environment by medical students.

3.2 SPECIFIC AIMS

• To study whether this kind of virtual patient encounter is likely to evoke emotional involvement and induce satisfactory levels of immersion, flow and presence among medical students.
• To investigate if ISP-like systems do support student-to-student communication and collaborative learning.
• To explore the learning benefits of blended case simulation methods (for instance surgical simulators combined with computer-based simulated cases) on engagement, motivation, flow and skill acquisition.
• To evaluate the potential of ISP as a possible tool for assessment of clinical reasoning and problem solving ability among medical students.

3.3 SUBSIDIARY AIMS

• To investigate if any gender-related differences could be observed, with respect to the affective interaction with the VP.
• To observe how the screen size of the virtual patient might have an impact on the student-VP social interaction.

3.4 EXPECTED OUTCOMES

• Achieve a more complete understanding of presence and emotional reactions to computer-mediated experiences for creating more effective learning experiences.
• Gain more insight on the potential benefits of advanced virtual patient simulations on affective learning outcomes.
4 MATERIALS AND METHODS

4.1 EVALUATION METHODOLOGY

Studying students’ perceptions, attitudes and affective outcomes during a virtual patient encounter borrows methods from reception studies in communication science and HCI (Human Computer Interaction) research methods. Both fields require a combination of quantitative and qualitative methods. Rather than being considered incompatible, quantitative and qualitative strategies should be seen as complementary (Mays & Pope, 2002). The qualitative approach to scientific inquiry holds considerable promise as a means of identifying and exploring non-cognitive variables such as self-efficacy, emotion and motivation (Picard, 2000). By combining qualitative and quantitative approaches the shortcomings of both strategies can be offset (Malterud, 2001).

Hence, we thought that the use of triangulation of qualitative and quantitative methods would be beneficial to the present study by providing completeness, abductive inspiration and confirmation (cross-checking of findings). Therefore, and in order to fulfill the various aims of the thesis, the four studies conducted have been based on ethnographic research methods articulated around heterogeneous data collection methods like activity log, psychometrics, questionnaires, interviews and video-observations.

The design characteristics of the studies performed are presented in Table 4.1 below. As can be seen, complementary methods were triangulated in studies I, II and IV.
Table 4.1 Design characteristics of the four studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>Clinical Context</th>
<th>Participation</th>
<th>Patient Case</th>
<th>No of Participants (a)</th>
<th>Location (b)</th>
<th>Activity Log</th>
<th>Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Exploratory Study</td>
<td>Clinical Medicine Course Global Trials</td>
<td>Voluntary &amp; Collaborative Online shared case (3 students)</td>
<td>Pneumococcal Pneumonia</td>
<td>2 Global Trials: 6 (2*3) students SU: 2 females, UU: 1 male, 1 female KI: 1 male, 1 females</td>
<td>SU, UU, KI (simultaneously)</td>
<td>Yes</td>
<td>Exit Questionnaire Yes (Individual)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clinical Medicine Course Local Trials</td>
<td>Voluntary &amp; Collaborative (pairs of students)</td>
<td>Pneumococcal Pneumonia &amp; Malaria</td>
<td>3 Local Trials: 52 students SU: 11 males, 7 females UU: 3 males, 3 females KI: 11 males, 17 females</td>
<td>SU, UU, KI</td>
<td>Yes</td>
<td>Exit Questionnaire Yes (Focus Group)</td>
</tr>
<tr>
<td>II</td>
<td>Exploratory Study</td>
<td>Summative Assessment (OSCE)</td>
<td>Compulsory &amp; Individual</td>
<td>Rectal Cancer</td>
<td>110 students 8th term DS, HS, KS, SÖS</td>
<td>Yes</td>
<td>Exit Questionnaire No</td>
<td>No</td>
</tr>
<tr>
<td>III</td>
<td>Self-Controlled Experimental Study</td>
<td>Surgery Course</td>
<td>Compulsory &amp; Individual</td>
<td>Colon Cancer</td>
<td>37 students 8th term HS</td>
<td>Yes</td>
<td>Psychometrics &amp; Exit Questionnaire No</td>
<td>No</td>
</tr>
<tr>
<td>IV</td>
<td>Exploratory Study</td>
<td>Clinical Rotation (Pilot study)</td>
<td>Voluntary &amp; Individual</td>
<td>Hyperthyroid</td>
<td>14 students 5th term KS</td>
<td>Yes</td>
<td>Exit Questionnaire No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Clinical Rotation</td>
<td>Voluntary &amp; Collaborative (Pairs of students)</td>
<td>Tuberculosis</td>
<td>30 students 6th term DS, KI</td>
<td>Yes</td>
<td>Psychometrics &amp; Exit Questionnaire Yes (Pairs of Students)</td>
<td>Systematic</td>
<td></td>
</tr>
</tbody>
</table>

(a) All participants were medical students
(b) Location: DS: Danderyd University Hospital, HS: Huddinge University Hospital, KI: Karolinska Institutet, KS: Karolinska University Hospital, SU: Stanford University, SÖS: South University Hospital, UU: Uppsala University
(c) Note: 16 students used a 19" screen and 14 students used a 50" screen.
4.1.1 Interaction logging

Log files from the VP system ISP were automatically generated during all the VP sessions in study I-IV. They collected quantitative data about the user activity with automatic recording of the complete and detailed history of the computer interaction including completion time, medical history questions and answers, performed physical exams, ordered lab and imaging tests, suggested preliminary diagnosis, confidence level (VAS scale) and diagnosis justification.

The log files were subsequently analyzed with regard to order of the activities, completion time, number and type of history questions (i.e. medical and psychosocial), the kind of the performed physical examination as well as the relevance of laboratory tests and physical exams ordered and the level of confidence for diagnosis-making.

4.1.2 Interviews

Interview is a well-established technique in social science research, in particular human-computer interaction. It is for instance a very convenient method to gain first impressions about how participants react to a new learning tool. By structuring the script of questions adequately, one can investigate user satisfaction and attitude in a standardized way.

Interviews were conducted in both study I and study IV. Individual and focus-group discussions were performed in study I to gain more understanding about students’ attitudes and acceptance of the VP.

Semi-structured interviews with pairs of students were performed in Study IV to gain more in-depth information about students’ perceptions and affective learning experiences with the VP. The interview guide was first pilot tested with 4 students and then refined.

The interviews were either audio taped (study I) or video taped (Study IV), transcribed verbatim and analyzed. The summary reports were later on approved by the students. Qualitative analysis was used in both cases. The interview guides for study I and IV are available in the appendix section (See Chap. 12).

4.1.3 Video-observation

Video-observation is a valuable method for providing insights into users’ contextual interaction (including task analysis and peer collaboration) as well as users’ affective reactions. The affective emotional state of a student can be assessed with reasonable reliability by observing facial expressions, gross body language, and the content and tone of speech.

Participants from the global trials in study I were directly observed by the researchers (live video transmission). In studies II and IV, indirect video-observations were conducted to track participants’ activities and social interaction. Behavioral variables like facial expressions, body posture and gesture were also investigated.
In observational research the researchers identify themselves as researchers and explain the purpose of their observations. The problem with this approach is that subjects tend to modify their behavior when they know they are being watched. They have a tendency to portray their “ideal self” rather than their true self. However, according to interviews or analyses of the video files, the video camera (which was a small DV camera in study I and a small web cam in study IV) was not felt as being intrusive. Further observation of students engaged in the diverse tasks demonstrated how little students scrutinized the camera during the very first seconds of their respective sessions.

It can also be mentioned that no single student was left alone under video observation. Either a facilitator (Paper I), an assistant (Paper II), a teacher (Paper III) or another peer (Paper IV) was physically present.

The coding details for student interactions differed across the studies that used video-observation. A special and comprehensive coding scheme was developed for Paper IV and assessed for inter-rater validity (by computing the internal consistency based on 3 independent observers). The observation matrix is provided in the Appendix section in Paper IV.

### 4.1.4 Questionnaires

The exit questionnaires (i.e. VP-based surveys) contained several specific questions, with either free text answers or associated Likert-type scales, designed to measure, among other things, each participant’s acceptance of the VP. The questionnaires also included demographic baseline demographics regarding age, gender, IT proficiency including video-gaming experience about the participants. They differed a bit in the range of questions based on the focus of the specific study. Elements of believability, authenticity, enjoyment, interest in the topic, and rapport with the virtual character were among the measurements obtained. Free text answers were analyzed by means of thematic categories and then ranked by frequency of most cited factors.

Study III used psychometric tests for measuring self-efficacy (3 items, 7 point-Likert scale) as well as Flow experience, challenge and skills (14 items, VAS scales). Participants also filled in a Flow related questionnaire after each task (simulator and VP).

In study IV, we measured subjective reported levels of presence and immersion during ordinary Web surfing usage by using a presence questionnaire. We then correlated these affective variables with student’s apparent sense of patient presence measured by independent raters.

Open questions at the end collected qualitative data regarding suggestions, problems and perceived benefits of the application.
4.1.5 Psychometrics

As reported earlier in the thesis, affective learning outcomes (among others intrinsic motivation and self-efficacy) play a critical role in simulation-based learning. Self-reported Flow experience was therefore suggested as being an appropriate method to assess if the psychological milieu emanating from the VP was favorable for triggering intrinsic motivation.

The Flow related instrument used VAS scales and included items like experienced challenge & expressed feelings, Flow experience and applied skills. Flow experience was computed as a mean score of 8 well-defined components (Concentration, Self-consciousness, Time distortion, and Telepresence). These latter have been used extensively by other leading researchers within the field (e.g. Jackson et al., 1997; Ghani & Deshpande, 1994; Novak, Hoffman & Yung, 2000).

Self-efficacy is a motivational belief that refers to the degree to which an individual is confident that he/she can perform a specific task. Self-efficacy was assessed to control for potential bias in student performance. This test consisted of 3 items from Pintrich and collaborators’ questionnaire (Pintrich et al., 1993): “I’m certain I can understand the most difficult parts occurring during this simulation exercise.” ; “I’m confident that I can understand the basic concepts and facts that will be presented.” ; “I expect to do very well.”

Psychometric scales were systematically used in Study III (Flow & Self-efficacy) and partly in study IV (Flow).

4.1.6 Technical design considerations

In order to foster active learning and underpin student engagement in the interactive dialog, access to predefined history checklists was prohibited. Since all participants were studying at the clinical level in all the four studies, we purposely disabled the history help menu of ISP. This help menu is a prompting system with a dynamic scroll of relevant questions ensuring that the student will never be at a loss for words.

4.2 CONTEXT OF THE STUDIES

The basic pedagogical idea was to put the students “in charge” of defining and finding adequate knowledge by means of a VP environment. Hence, the underlying pedagogical philosophy was to underpin student engagement in virtual classrooms in a problem based learning context. This contextual inquiry was explored in different settings, including collaborating learning (either online or local), individual training and summative assessment. There was furthermore an ambition to get participants emotionally involved and to study under which conditions their affective engagement was the most beneficial.
4.2.1 Study I: Collaborative e-learning with ISP

Context
This project aimed to build a virtual learning and meeting space for global collaboration in solving problems and developing knowledge in the field of clinical medicine, using real-time simulated patients. This exploratory study examined clinical problem solving with a VP-based learning environment in both on-line versions (global trials with 3 remote sites) and local versions (local trials with students working either in pairs or individually).

Objectives
The main research question for study I was to study in what ways do using real-time simulated patient environments enhance student learning and support collaborative learning (a-across cultures, and b-with students working in pairs)? Additionally, this study also targeted the possible emotional engagement of the users of such an interactive tool as ISP.

Method
Altogether, the ISP system was evaluated during 5 local sessions (students working in pairs) and in 2 global sessions using videoconferencing between individual students at Karolinska Institutet and Uppsala University in Sweden and at Stanford University in the USA.

4.2.1.1 Local trials
The local trials involved 18 students at Stanford University, 28 students at Karolinska Institutet and 6 students at Uppsala University. These trials were included in traditional courses and the participants were asked to compare the ISP way of presenting cases against the traditional paper-based case presentations they were used to. Students filled in a 23-item questionnaire and then participated in a 20-minute focus group discussion at the end of the session. See Fig 4.2.1.1.

4.2.1.2 Global trials
Three remote sites were involved (Stanford University Medical School, Uppsala University Medical School and Karolinska Institutet) contributing each with one student, one facilitator, acting as a local teacher, and one evaluator, acting as an observer during the sessions (captured on videotape). The goal of this experiment was to assess the viability of synchronously shared VP cases and evaluate the socio-cultural differences that might arise when solving a common case. The evaluator at each site gave their student an exit questionnaire (similar to the one of the local trial but with additional questions) and then conducted a 15-minute individual interview. See Fig 4.2.1.2.

Study I has a qualitative design with subsequent review of the results. The findings were therefore correlated to possible learning outcomes as well as to attitudes towards collaborative learning in general. We looked more specifically at the interpersonal communication across asynchronous learning as well as on emotional aspects on the encounter with the VP.
Fig 4.2.1.1 Local session at KI with pairs of participants.

Fig 4.2.1.2 Global session: 3 remote participants working on a shared VP case
4.2.2 Study II: Can a Virtual Patient be used as an assessment tool?

Context
This study focuses on a skills test based clinical assessment where 118 fourth-year medical students at the four teaching hospitals of Karolinska Institutet participated in the same 12-module OSCE. The goal of one of the twelve examination modules was to assess the students’ skills and ability to solve a virtual patient (VP) case (the ISP system), which included medical history taking, lab tests, physical examinations and suggestion of a preliminary diagnosis.

Objectives
The primary aim of this study was to evaluate the potential of ISP as a possible tool for assessment of clinical reasoning and problem solving ability among medical students. The feeling of realism of ISP and its possible affective impact on the student’s confidence were also investigated.

Method
The virtual patient case used was a Rectal cancer. Eight VP-based stations were part of a summative examination (OSCE) that took place simultaneously at all four University hospitals in Stockholm (See Fig. 4.2.2). We observed and analysed students’ reactions, engagement and performance (activity log files) during their interactive sessions with the simulation. An individual human assistant was provided along with the computer simulation and the videotaped interaction student/assistant was then analysed in detail and related to the students’ outcomes.

Fig. 4.2.2 Set-up of the OSCE stations
4.2.3 Study III: Blended Simulation (Mixed Virtual Reality Simulation).

Context
Empirical studies have shown that simulation technology and virtual patients support more individualized, situated and contextualized learning paradigms. However little attention has been focused on exploring the potential benefits of delivering combined simulation methods during surgical training sessions.

Objectives
The main objective of this study was to assess medical students’ appraisals of a “mixed” virtual reality simulation for endoscopic surgery by exploring the potential benefits of this contextualized learning experience (like engagement, motivation, flow levels, skills acquisition, etc). A secondary aim was to assess the impact of this simulation set-up on students’ performance.

Method
37 fourth-year medical students (8th semester) taking the surgery course at the Huddinge University Hospital participated in a self-controlled study design with two combined simulation sessions (Virtual Patient (VP) case and Virtual Colonoscopy simulator). Participants filled in an exit questionnaire about their appraisals (perception, motivation and attitudes) of the mixed virtual reality simulations. IT proficiency and videogame experience was also reported. The impact of the sequence order of the combined simulations was also assessed. Affective learning outcomes, like flow, learning experience and expressed feelings, were investigated with psychometric scales immediately after each simulation session.

Self-efficacy was also investigated -before the simulation session- in order to control for possible bias in student performance.

See the flowchart of the study design in Figure 4.3.1 below.
4.2.4 Study IV: Perceptions, Behaviors and Attitudes towards a VP driven Computer-Mediated Learning Experience

Context
Emotional mediated experiences have been reported as having a positive impact on cognitive learning outcomes. Surprisingly, few studies have focused on the affective responses evoked by a Virtual Patient (VP) learning experience.

Objectives
The primary aim of study IV was to investigate if a highly interactive and realistic VP case could be perceived as an effective, instructive and emotionally engaging learning environment by medical students. We also focused on presence and arousal during the virtual patient encounter.

Method
A pilot study with 14 students was first performed in order to test and refine the questionnaire and interview formats.
Thirty 3rd year medical students participated then voluntarily in an explorative observational study with a highly interactive VP case (Tuberculosis) based on a realistic virtual patient encounter with a natural (life-like) interface. Students worked collaboratively in pairs. They were videotaped for further behavioral analysis including proficiency in conducting the virtual patient visit. Participants self-reported (in both a survey and an interview) their personal opinions, perceptions and attitudes about the VP case encounter.

An “emotionally loaded” scenario was specially written to investigate the affective impact of the interactive video sequences and look at possible gender differences during the learning experience. This study also examined the effects of the authenticity and perception on learner's motivation and achievement. See Figure 4.2.4.1

Figure 4.2.4.1 Screenshot from video observation. Medical history with Picture-In-Picture of 2 participants
4.3 STATISTICAL ANALYSES

Study I: Only descriptive statistics were used in this study.

Study II: Descriptive statistics were used. Logistic regression (Odds ratios) was computed for assessing dependant factors related to history questions asked and laboratory tests ordered.

Study III: Psychometric properties in study III were analyzed by a Mann Whitney U non-parametric test for independent samples. Self-Efficacy was assessed by a Kruskal-Wallis test. In addition, analyses of variance were computed to assess the impact of covariates on student surgical performance.

Study IV: Descriptive statistics were used. The relationships between the IT orientations and observed behaviors during the VP session were then calculated by correlation coefficients. T-test measured the difference in affective outcomes with screen size. SPSS 15 and 16 for Windows was used to compute all analyses.

For the aforementioned analyses, the statistical package for social science SPSS (version 15) was used. P-values <0.05 were set as a basic criteria for statistical significance in all of the four studies.

4.4 ETHICAL CONSIDERATIONS

The studies included in this thesis were approved by the Research Ethics Committee at Karolinska Institutet. Permission Number: 04-817/5,

For all the studies, and in order to comply with general ethical considerations, a consent form was handed beforehand to every participant informing him/her about the specific aspects of the VP study concerned. This included possible video observation (study I and II) or systematic video observation (IV), as well as audio-taped interview (study I) or video-taped (study IV) interview.

In the case of study II, and due to assessment related issues, an additional ethical permission was given. Besides, a specific protocol informed examinees that the ISP station could not influence their grading in a negative way.

Participants in all four studies were also informed that it was allowed to quit their attendance without having to provide any explanation. Only one of all participants involved in any of the four studies was found to quit before completion of the whole VP session. This concerned study IV and the student declined to be interviewed (but completed the case and filled in the paper-based survey).

Confidentiality of all collected data was assured by de-identification of participants’ personal information.
5 RESULTS

5.1 COMMON FINDINGS

5.1.1 Participants’ general attitudes to IT-based Learning and Virtual Patients

The underlying “IT profile” for the participants in the four studies, as well as their opinions regarding ISP as a relevant tool for applying medical knowledge, is presented in Table 5.1.1. Not surprisingly, participants valued computer simulations as important for promoting learning, and they also estimated their IT literacy as proficient. The students were also well inclined towards computer-supported collaborative work (somewhat more so for males). The students generally expressed that ISP indeed was designed for demonstrating their medical knowledge (all medians above 4 on a 5 point Likert-type scale).

Table 5.1.1 Student responses to IT-related surveys

<table>
<thead>
<tr>
<th>Question</th>
<th>Study</th>
<th>Scale * Min-Max</th>
<th>Median</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are computer simulations important for promoting learning?</td>
<td>I</td>
<td>1-5</td>
<td>4.1</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>3.9</td>
<td>3.7</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>4</td>
<td>3.5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Do you master IT-based learning tools?</td>
<td>I</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>3.5</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>4</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>4.3</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I use IT-support for learning I prefer to collaborate with others.</td>
<td>I</td>
<td>4.3</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Was the VP program designed for applying your knowledge?</td>
<td>I</td>
<td>4.4</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>4</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>4.5</td>
<td>4.1</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>4.5</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*(Likert-type scale ranging from “Strongly disagree” to “Strongly agree”)*

5.1.2 Summary of Participants’ Appraisals about the VP Encounters

Participants’ appraisals about the VP encounters from all the four studies are summarized in Table 5.1.2. Overall, and as expected with any new multi-media teaching tool, a vast majority of students reported that they enjoyed the learning experience with the virtual patient. They also felt a high degree of engagement with the patient case. Most students reported that they found the application to be realistic and
rather few reported it to be unrealistic. A vast majority among them favored ISP-like systems to paper-cases. The video-mediated patient interaction with a human actor was highly appraised.

Table 5.1.2 Summary of participants’ general appraisals about the VP sessions.

<table>
<thead>
<tr>
<th>Question *</th>
<th>Study</th>
<th>Response</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning Experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How did you experience this way of solving clinical problems?</td>
<td>I</td>
<td>Positively Neutral Negatively</td>
<td>46 (88%) 6 (12%) 0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>N/a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Positively Neutral Negatively</td>
<td>36 (97%) 1 (3%) 0</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Positively Neutral Negatively</td>
<td>28 (93%) 2 (7%) 0</td>
</tr>
<tr>
<td><strong>User Engagement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was the case engaging?</td>
<td>I</td>
<td>N/a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Yes. No n/a</td>
<td>43 (80%) 11 (20%) 14</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Yes No</td>
<td>35 (95%) 2 (5%)</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Yes No</td>
<td>29 (97%) 1 (3%)</td>
</tr>
<tr>
<td><strong>Realism of the Representation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you perceive any sense of realism in the ISP case?</td>
<td>I</td>
<td>Yes Not really Neutral</td>
<td>45 (88%) 6 (12%) 6 (12%)</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Yes Not really Neutral</td>
<td>53 (78%) 9 (13%) 6 (9%)</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Yes Not really Neutral</td>
<td>34 (92%) 2 (5%) 1 (3%)</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Yes Not really Neutral</td>
<td>29 (97%) 0 (0%) 1 (3%)</td>
</tr>
<tr>
<td><strong>VP vs. Paper-Case Pros and Cons</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How do you judge ISP-like systems compared with paper-cases?</td>
<td>I</td>
<td>Good way to learn clinical problem solving: VP: 88% Paper-case: 67% Increased confidence to solve clinical cases: VP: 67% Paper-case: 45%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>N/a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Better Equal Worse</td>
<td>30 (81%) 7% 0 (0%)</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Better Equal Worse Don't know</td>
<td>25 (84%) 3 (10%) 1 (3%) 1 (3%)</td>
</tr>
<tr>
<td><strong>Impact of Video-Mediated Patient Answers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the value of motion picture with voice of the patient?</td>
<td>I</td>
<td>Important Not important No value</td>
<td>45 (92%) 4 (8%) 0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>N/a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Important Not important No value</td>
<td>32 (86%) 4 (11%) 1 (3%)</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Important Not important No value</td>
<td>28 (93%) 2 (7%) 0</td>
</tr>
</tbody>
</table>
5.2 STUDY I - COLLABORATION, LEARNING, ENGAGEMENT & REALISM

In study I, we could successfully, via the videoconference set-up, establish a functioning virtual transatlantic learning environment. This enabled us to evaluate cross cultural collaborative learning issues as well as students self confidence in clinical problem solving.

The results were based on a collection of quantitative data (exit questionnaires) and qualitative data (individual and focus group interviews with students, individual interviews with the instructors/facilitators) and observations (videotapes of student interaction) and are summarized below in Table 5.2.

Table 5.2
Students’ responses to some of the questionnaire items

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>The opportunity to work collaboratively with a partner/peer was useful.</td>
<td>0</td>
<td>0</td>
<td>4 (8%)</td>
<td>25 (51%)</td>
<td>20 (41%)</td>
<td>3</td>
</tr>
<tr>
<td>Working on ‘computer based-cases’ is a good way to learn clinical problem-solving.</td>
<td>0</td>
<td>0</td>
<td>6 (12%)</td>
<td>33 (63%)</td>
<td>13 (25%)</td>
<td>-</td>
</tr>
<tr>
<td>Working on ‘paper-based cases’ is a good way to learn clinical problem-solving.</td>
<td>0</td>
<td>1 (2%)</td>
<td>16 (31%)</td>
<td>30 (59%)</td>
<td>4 (8%)</td>
<td>1</td>
</tr>
<tr>
<td>Working on ISP cases increased my confidence in my ability to solve clinical problems.</td>
<td>0</td>
<td>1 (2%)</td>
<td>16 (31%)</td>
<td>28 (54%)</td>
<td>7 (13%)</td>
<td>-</td>
</tr>
<tr>
<td>Working on paper-based cases increased my confidence in my ability to solve clinical problems.</td>
<td>2 (5%)</td>
<td>5 (13%)</td>
<td>14 (37%)</td>
<td>15 (40%)</td>
<td>2 (5%)</td>
<td>14*</td>
</tr>
<tr>
<td>I felt these were realistic patient cases.</td>
<td>0</td>
<td>0</td>
<td>6 (12%)</td>
<td>28 (55%)</td>
<td>17 (33%)</td>
<td>1</td>
</tr>
<tr>
<td>Have you previously used any type of computer-based clinical cases for learning clinical problem-solving?</td>
<td>No: 37 (71%)</td>
<td></td>
<td></td>
<td>Yes: 15 (29%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Only 17 students at Stanford, 21 students at Karolinska and none in Uppsala worked on paper-based cases.

5.2.1 Collaboration

During the interviews, students indicated that they liked to work collaboratively. They cited three reasons for preferring collaboration:

- They learn from one another, especially when discussing which questions to ask the patient;
- The problem can be approached in many different ways;
- It was valuable to learn how other students think.
5.2.1.1 Local trials

When reviewing the video filmed sessions it was obvious that students were talking a lot to each other, laughing, interacting while working through the ISP cases. The level of laughter and interaction seemed higher at the computer-based cases than when working with paper-based cases. A very large majority (92%) of the responding students in the local trials preferred collaborating in pairs when working with both paper-based and computer-based cases (Table 5.2).

Students also mentioned that an advantage of working in pairs was that they get more actively involved than as a member of a PBL-type group consisting of seven to eight students. These positive outcomes might easily be lost if ISP is only used as a “stand alone” application — when students interact with the computer simulation on their own.

5.2.1.2 Global trials

In the global trials the results were also promising, even though the collaboration between 3 remote sites was less dynamic and vivid. This might be explained by the technical set-up as well as cultural differences. All six students in the global trials agreed that the collaboration between themselves and the students at the other two sites was useful.

Excerpts from student’s comments:

**Strengths of the collaborative experience:**

**Global Trials:**
- The collaboration with the other students was a great experience.
- I was truly surprised that the collaboration with the other students went so smoothly. Somehow we managed to establish a ‘human’ relationship while working with the case together. This in spite of the fact that we couldn’t make eye contact.
- It was good to have an easy case to help focus on the collaboration and build confidence.

**Local Trials:**
- Intellectually stimulating
- Easier to remember details.
- You don’t feel as insecure – you can support each other.
- As a doctor you often work in teams – collaboration is important.
- Good to be able to discuss and confront different ideas.

5.2.2 The learning experience

5.2.2.1 VPs vs. Paper-Cases

The questionnaire data indicated that a large majority of the students (88%) agreed that computer-based cases are a good way to learn clinical problem solving, as opposed to only 67% feeling that paper-based cases are (Table 5.2). The same result was expressed in the interviews, where students did seem to think that the ISP cases provided a good learning opportunity and even felt that computer-based cases increased the quality of the follow-up case discussion.
A majority of students (67%) also found that working on the ISP cases increased their confidence in their ability to solve clinical problems. Far fewer (45%) agreed to this about paper-cases.

Excerpts from student’s comments:

Strengths of ISP-like systems compared with paper-cases:
- The computer based cases provided a more realistic way of working compared to the paper cases where you couldn’t choose which examinations you wanted to do.
- It is always good to learn in different ways. The computer-based cases were best.
- It’s useful to decide what tests and examinations to do; it’s not a good idea (paper ex) that others decide this!
- Computers are better than papers, however not as good as in real life.

When asked to comment on their learning experience a number of positive remarks were made. Most of all, students thought it was fun! Reasons for this was that “it was possible to see the patient, which is better than with paper-based cases”, “you get less stressed because the patients aren’t real and then trial and error is allowed”. Students also thought that it “felt more free” because you could interact and choose what to do. Someone commented that this made it more realistic, which is good “because you learn to think more like a physician when it is realistic”.

The feedback part of the ISP cases was mentioned as especially important and very useful for learning. Students suggested that ISP should be used early on in medical education, because it gives an understanding and ‘feeling’ for what it is like to be a physician by “playing physician.” However, it was mentioned several times that ISP should not intrude on the use of real patients in clinical teaching.

Some students mentioned how the price labels of the lab tests made them more aware of time and money and encouraged them to think more about what they were doing and why, than they would have done otherwise. Someone thought that it prevented from trying out too many things, but was not sure whether this was good or bad.

Questionnaires showed that a third of the students were neutral or agreed that they would have liked more help learning to use the computer software. Note of these students had previously used computer-based clinical cases for learning clinical problem-solving. This result could be interpreted as a sign of the importance of students’ earlier experience of using similar computer software.

Excerpts from student’s comments:

Strengths of the learning experience:

Global Trials:
- I thought it was pretty straightforward. Not too easy, not too hard.
- I really appreciated working with the other students. Sound and picture corresponded amazingly well during the entire session, which was essential for the outcome. It was a surprise to me that the three of us reasoned so alike.
- To me this was a new and interesting way to learn.
- I liked having to find facts and information on my own. This forces you to think and reason.
• Nice to be able to see chest x-ray and hear the auscultation. I haven’t had that much extensive experience on the physical examination part, so this was good practice for me.

**Local Trials:**

• The computer model helps with the physical exam. While doing the exam you learn what pathologic heart/lung sounds sound like. I believe this tremendously helps with learning.

• The computer is fun and is a good way to practice sequencing your exam and evaluation.

• The problem-based design of the program and the freedom to interact in your own way with the patient. I thought working through them was helpful and useful as far as analysing clinical cases.

• Having so many options for history, physical exam and labs is very realistic and provides a unique opportunity to prepare for effective and efficient clinical practice.

• Good scenario to think about what questions to ask and what parts of the physical exam to include.

• The feedback was great because usually in an actual situation you just get feedback like “good” and that’s not very specific.

**Limitations of the learning experience:**

**Global Trials:**

• It was frustrating that we got stuck. The collaboration was difficult because we couldn’t see what the others were writing.

• It was hard to find the questions you wanted to ask. With a real patient it is more spontaneous.

• It was rather complicated to communicate with the patient and you had to ask questions in a very unnatural way. I would never have asked this way with a real patient. The psychological dimension is completely lost in a virtual case like this one.

**Local Trials:**

• It’s clearly limited by its artificiality – that is, part of the challenge in itself is figuring out how to manipulate the program, which is not a particularly applicable clinical reasoning skill.

• Limitations in physical exam (e.g. egophony, abdomen palpation).

• That development arrives when I have almost finished my education... That people’s computer skills and money will be more important.

### 5.2.3 Engagement

The discussions were more active and engaging and had a longer duration when using ISP cases than when using the paper-based cases. This finding was reported by all three evaluators at all three sites and was also supported by findings in interviews and questionnaires. The ISP format seems to create a more dynamic, vivid and enthusiastic learning climate than the paper-based alternative. As one student mentioned “the computer-based case gives a much stronger impression, you remember him as a person”. The students also showed a higher degree of curiosity. Videotaped segments demonstrated the degree of interaction between the pairs of students in front of the computers.

A small number of students complained that it was too much like a computer game, putting them into ‘game mode’ where they were trying to get to the diagnosis as quickly as possible instead of working through the case thoroughly and actually learn
something. However, most students liked the competitive atmosphere and thought it made them more engaged in the process.

However, limitations in the interactive dialog of the patient history contributed to some sense of frustration, in particular among certain Swedish students who were not as proficient in English as their American peers. There was a common wish for a more flexible dialog interface. As one student said, “More freedom formulating questions would have made the program easier to work with and saved time for more relevant things.”

Excerpts from students’ comments:

**Strengths of the case affecting student engagement:**

**Global Trials:**
- Wow, That’s a really cool program!
- It was a lot of fun. The computer program is really great. It’s a good tool for pathology and for now—in PCM.
- Allows exploration, learning via mistakes.
- Nice to be able to go on the wrong track; you don’t get corrected; good for learning.
- It was good to have no feedback till the end.

**Local Trials:**
- The computer program was great! It let you see the patient and get answers to relevant questions in real time. It also let you do a PE and order relevant labs.
- Overall this did make us think about the questions to be asked and learn more than if the information was given to us.
- Can work anytime, can’t cheat.
- The program emphasised the importance of putting the right questions to the patient.
- The feedback was good. That is something I miss in the traditional cases. It is also a good way to learn the examination procedure.
- It made me feel happy! You got a case from start to end, which seldom happens in real life.

**Limitations of the case affecting student engagement:**

**Global Trials:**
- The program should be able overlook minor misspellings. As long as it doesn’t the dialogue with the patient gets more annoying than it has to be.
- If he gets impatient (Tom, that is) it erases your answer (!) because he gets impatient.
  (Note: This was due to a glitch. She was a fast typist; and it erased what she wrote)

**Local Trials:**
- It’s frustrating to not be able to ask certain questions.
- Computer program has its limits, especially in the interview.
- Had to ask accurate questions.

**5.2.4 Realism**

A vast majority of the students (88%) agreed that the patient cases were perceived as realistic and useful educational exercises. However, the interviews revealed different interpretations of the term “realistic”. Some meant the realism, and even authenticity,
of the actual clinical case, whereas other meant the actor’s performance of playing the
simulated patient.

There was also a common agreement that being able to listen to pathological heart and
lung sounds) or to be able to see chest x-rays etc, made the case more realistic. Thus,
the fact that ISP offered many options for history, physical exam and labs was also
experienced as a valuable contribution to the realism of the case and provided a
“unique opportunity to prepare for effective and efficient clinical practice”.

When comparing paper-cases and ISP most students found ISP more fun and more
realistic. Some students argued that even though both are good for learning, paper-cases
promote a different way of learning, and different skills and thus the two are
incomparable. A few students thought the paper-case were better because “we had really good
discussions and I felt so creative. We came up with a lot of differential diagnoses, and
then we looked at the rest of the information, we had to re-think and exclude
those it couldn’t be”. These students had however, mainly used the help-function for
questions in the patient history part of ISP. A lot of students found it frustrating to be
given the information they hadn’t asked for in the paper-cases and not the answers to
the question they wanted to ask. The computer-case was experienced as much more
flexible and positive in that way.

Excerpts from students’ comments:

**Strengths of the realism in the ISP case:**
- It is much more real than to read books and you get an chance to try as much as
  you want without thinking about the patient, money, care.
- Very good that you have to ask for the relevant data yourself. Makes the case more
  realistic and you learn more.
- I felt the patient to be very much alive and realistic.
- It was almost like sitting there with a third person (the patient).

**Limitations of the realism in the ISP case:**
- Limited in the amount of realism possible to attain. Can never replace real-life
  auscultation.

5.2.4.1 Impact of Video-Mediated Patient Answers

Excerpts from students’ comments:

**Strengths of the value of motion picture with voice of the patient:**
- These patients were very realistic and the fact that they weren’t “real” made me
  less stressed.
- Visualizing patient was a big plus.
- The speaking computer patients are very realistic and useful.

**Limitations of the value of motion picture with voice of the patient:**
- Needs to work on the language though (quite often he doesn’t understand the
  doctor’s questions).
- A few glitches – person didn’t answer.
5.3 STUDY II - ASSESSMENT, ENGAGEMENT & REALISM

5.3.1 Assessment

The results of study II indicate possible advantages of using ISP-like systems for assessment. The VP system was for instance able to reliably differentiate between students’ performances (Table 5.3.1). We observed that female students had generally higher means of required history questions asked (69% compared to 57% for males, \( p=0.006 \)) and lab–tests ordered. Their overall performance was also slightly better as compared to male students.

As observed in the table, the inter-hospital differences (like the variability of important medical history questions asked, of required labs ordered as well as of correct diagnoses) were higher than anticipated. Students’ intrinsic characteristics like individual behaviour, ability to formulate adequate history questions, flexibility in reformulating initial diagnostic strategies, indicate, as hypothesised, that there was a rather large variability among the students’ ability to solve the case. This finding suggests that ISP-like systems might be used as one part of an ‘assessment toolkit’ for assessing students abilities to solve clinical cases.

At the following question “Should stations of ISP type be used in the practical assessment test (OSCE)?”, 35% of the examinees answered positively, 31% negatively and 34% were not sure.

But some weaknesses were also identified, like a confounding influence on students’ outcomes due to substantial effects from the human assistants. As can be seen in Table 5.3.2, significant differences on the outcome results were found between the students in their degree of affective response towards the system as well as the perceived usefulness of assistance.
Table 5.3.1  Average session durations, number of correct diagnoses and the average of students' own estimation of their confidence in suggesting a correct diagnosis for the ISP-OSCE pilot

<table>
<thead>
<tr>
<th>Hos.</th>
<th>Hospital Group</th>
<th>No. of Examinees</th>
<th>Mean Session Time</th>
<th>Mean No. of Correct Diagnoses</th>
<th>Mean No. of Submitted Diagnoses</th>
<th>Mean No. of History Questions Asked</th>
<th>Mean % of History Questions Required</th>
<th>Mean No. of Lab Tests Ordered</th>
<th>Mean % of Lab Tests Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1</td>
<td>H1</td>
<td>17</td>
<td>6 min 36 sec</td>
<td>94% 76%</td>
<td>82% 15% 76%</td>
<td>6.9 78%</td>
<td>1.6 3.2 46%</td>
<td>73%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2</td>
<td>7 min 36 sec</td>
<td>100%</td>
<td>50% 50% 75%</td>
<td>8.4 63%</td>
<td>3.5 55%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>15</td>
<td>6 min 39 sec</td>
<td>93% 96% 87% 13% 90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td>12</td>
<td>7 min 06 sec</td>
<td>100% 100%</td>
<td>100% 0% 95%</td>
<td>7.8 77%</td>
<td>3.4 5.8 56%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>4</td>
<td>7 min 05 sec</td>
<td>100% 100%</td>
<td>100% 0% 93%</td>
<td>7.2 72%</td>
<td>3.4 5.8 56%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>8</td>
<td>7 min 03 sec</td>
<td>100% 100%</td>
<td>100% 0% 96%</td>
<td>7.2 72%</td>
<td>3.4 5.8 56%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>H2</td>
<td>11</td>
<td>8 min 36 sec</td>
<td>91% 54% 64% 30% n/a</td>
<td></td>
<td>10.2 61%</td>
<td>4.6 5.4 48%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>6</td>
<td>9 min 31 sec</td>
<td>83% 50% 66% 34% n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>5</td>
<td>8 min 04 sec</td>
<td>100% 60% 60% 40% n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
<td>15</td>
<td>8 min 22 sec</td>
<td>87% 67% 80% 20% 93%</td>
<td></td>
<td>9.1 62%</td>
<td>2.8 6.9 44%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>H3</td>
<td>15</td>
<td>8 min 12 sec</td>
<td>40% 40% 100% 0% 76%</td>
<td></td>
<td>10 60%</td>
<td>4.7 6.7 53%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>3</td>
<td>8 min 09 sec</td>
<td>33% 33% 100% 0% 85%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>12</td>
<td>8 min 13 sec</td>
<td>42% 42% 100% 0% 73%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td></td>
<td>12</td>
<td>7 min 43 sec</td>
<td>42% 42% 100% 0% 90%</td>
<td></td>
<td>9.9 56%</td>
<td>3.8 5.9 32%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>7</td>
<td>7 min 41 sec</td>
<td>43% 43% 100% 0% 93%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>5</td>
<td>7 min 39 sec</td>
<td>40% 40% 100% 0% 86%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>H4</td>
<td>12</td>
<td>7 min 21 sec</td>
<td>75% 67% 92% 8% 90%</td>
<td></td>
<td>7.7 50%</td>
<td>3.6 5.9 38%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>8</td>
<td>7 min 06 sec</td>
<td>75% 75% 100% 0% 87%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>4</td>
<td>7 min 49 sec</td>
<td>75% 50% 75% 25% 96%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td></td>
<td>16</td>
<td>7 min 47 sec</td>
<td>75% 56% 81% 19% 85%</td>
<td></td>
<td>8.7 62%</td>
<td>3.5 5.1 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>6</td>
<td>7 min 44 sec</td>
<td>83% 83% 100% 0% n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>10</td>
<td>7 min 40 sec</td>
<td>70% 40% 70% 30% 85%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals/averages</td>
<td></td>
<td>110</td>
<td>7 min 45 sec</td>
<td>74% 63% 87% 13% 88%</td>
<td>8.4 63%</td>
<td>3.5 5.6 51%</td>
<td>46% 51%</td>
<td>51%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>72% 62% 88% 12% 86%</td>
<td>8.5 57%</td>
<td>3.7 58% 46%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>76% 60% 84% 16% 84%</td>
<td>8.5 68%</td>
<td>3.3 5.1 55%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 5.3.2
Video-observational variables interaction on the outcome results (% and odds ratio (OR))

<table>
<thead>
<tr>
<th>Observational variable</th>
<th>n</th>
<th>Comparison between baseline groups (n, %)</th>
<th>OR</th>
<th>Lower</th>
<th>Upper</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction</td>
<td></td>
<td>Intensive (24, 83%) vs. Weak (5, 20%)</td>
<td>17.21</td>
<td>1.30</td>
<td>&gt;500</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intensive (24, 83%) vs. Medium (18, 67%)</td>
<td>2.44</td>
<td>0.47</td>
<td>14.38</td>
<td>0.374</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium (18, 67%) vs. Weak (5, 20%)</td>
<td>7.27</td>
<td>0.56</td>
<td>426</td>
<td>0.177</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 (29, 97%) vs. 1 (55, 61%)</td>
<td>17.37</td>
<td>2.48</td>
<td>763</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Assistant/Student</td>
<td>47</td>
<td>3 (29, 97%) vs. 2 (27, 81%)</td>
<td>6.18</td>
<td>0.63</td>
<td>311</td>
<td>0.162</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 (27, 81%) vs. 1 (55, 61%)</td>
<td>2.77</td>
<td>0.84</td>
<td>10.82</td>
<td>0.105</td>
</tr>
<tr>
<td>Flow with ISP</td>
<td>47</td>
<td>Playful (6, 100%) vs. Frustrating (7, 29%)</td>
<td>12.19</td>
<td>1.21</td>
<td>&gt;500</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Playful (6, 100%) vs. Normal (34, 74%)</td>
<td>6.57</td>
<td>0.89</td>
<td>80.65</td>
<td>0.070</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal (34, 74%) vs. Frustrating (7, 29%)</td>
<td>2.72</td>
<td>0.34</td>
<td>&gt;500</td>
<td>0.034</td>
</tr>
<tr>
<td>Expression of Uncertainty</td>
<td>47</td>
<td>Certain (22, 86%) vs. Doubtful (7, 14%)</td>
<td>30.98</td>
<td>2.60</td>
<td>1834</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certain (22, 86%) vs. Neutral (18, 72%)</td>
<td>13.74</td>
<td>1.22</td>
<td>771</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neutral (18, 72%) vs. Doubtful (7, 14%)</td>
<td>2.38</td>
<td>0.055</td>
<td>2.6</td>
<td>0.474</td>
</tr>
<tr>
<td>External Signs of Stress</td>
<td>47</td>
<td>High/Medium (23, 65%) vs. Low (24, 75%)</td>
<td>1.58</td>
<td>0.38</td>
<td>6.93</td>
<td>0.679</td>
</tr>
<tr>
<td>Mouse Handling</td>
<td>48</td>
<td>Assistant (7, 86%) vs. Student (41, 68%)</td>
<td>2.74</td>
<td>0.28</td>
<td>138</td>
<td>0.658</td>
</tr>
<tr>
<td>Keyboard Handling</td>
<td>48</td>
<td>Assistant (12, 83%) vs. Student (36, 67%)</td>
<td>2.46</td>
<td>0.42</td>
<td>27.6</td>
<td>0.470</td>
</tr>
</tbody>
</table>

*a (n, %): No. of observed students, percentage with correct diagnosis.

The interaction assistant/student had also a noticeable impact on the student confidence (measured by the external expression signs of uncertainty) to solve the case (Table 5.3.3).

### Table 5.3.3
Distribution of “interaction assistant/student” by “expression of uncertainty”

<table>
<thead>
<tr>
<th>Expression of uncertainty</th>
<th>Interaction assistant/student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weak</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Intensive</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Doubtful</td>
<td>3 (43%)</td>
</tr>
<tr>
<td>Neutral</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Certain</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>All groups</td>
<td>5 (%)</td>
</tr>
</tbody>
</table>

### 5.3.2 Engagement & Realism

#### 5.3.2.1 Learning Experience

The response rate to the questionnaire was 62% (68 responses out of 110 examinees, 45 females, 21 males (2 students did not report gender)).

Strengths and limitations of the learning experience are summarised below:
Strengths of the learning experience (52 responses):
Ranking of the most frequently cited factors (no. of respondents, (%)):
1. Realism/authenticity/trustworthiness of the case: 10 (19%)
2. Fun/enjoyable/engaging: 9 (17%)
3. Easy access to lab tests and physical exam: 8 (15%)
4. New learning model/instructive/educational: 7 (13%)

Limitations of the learning experience (64 responses):
Ranking of the most frequently cited factors (no. of respondents, (%)):
1. Limitation of interactive dialogue with patient: 38 (59%)
2. Lack of time: 14 (22%)
3. Doesn’t feel authentic: 10 (16%)
4. Not familiar with the system / this way of solving problem: 5 (8%)

5.3.2.2 Engagement

A large majority of the students (80%) perceived the VP case as engaging.

Excerpts from students’ comments:
Strengths:
• Good to see the patient and hear her voice.
• To be able to think and reason with the help of the computer. Good complement to other teaching.
• The many possibilities to examine a patient. Great variation. Interesting to be able to try many tools as in real life and see what they would give you.
• The feeling of getting it right – the detective work – and having access to all options in an immediate way.
• To be able to have examination done immediately & also to get results right away!
• Exciting, fun to get results from lab directly, good exercise. That the patient was able to answer my questions.
• To be able to freely choose examinations/tests.
• That the patient describes her symptoms in her own way – not just in textbook fashion.

Limitations
• I became mostly irritated on the case.
• Nice picture, and the way examinations were done, but I don’t think it was efficient. Good pictures and examinations though.
• It was fun to try to reach the right diagnosis until I realized that she never would answer fundamental, important questions and that she began saying stuff that I already had asked without properly answering the question. That only made me irritated and I went on to do a physical examination instead.

5.3.2.3 Realism

Most of the students (85%) perceived the ISP case as realistic.

Excerpts from students’ comments:
Strengths of the realism in the ISP case:
• The voice and the pictures.
• The ‘living’ patient.
• It felt interactive, it affected the outcome.
• Real patient on the screen, with a voice. The variation of diagnostic possibilities.
• That the patient talked and moved. Not just replied with text.

Limitations of the realism in the ISP case:
• A real person speaking, unfortunately she always said the same things.
• The difficult history taking.
In summary, study II gave us the opportunity to re-define guidelines and pre-requisites for the validation of simulation-based examination. This is summarized as follows:

- Virtual Patient cases with automated scoring might be used as a complementary method for summative assessment.
- Students need to be trained in mastering the assessment system prior to exams.
- Scoring rubrics should be developed and validated before implementing computer-based assessment.
- Human assistance should be limited because of possible confounding influence on students’ outcomes.
- Most students appraised the ISP session as a positive, engaging and realistic learning experience.

5.4 STUDY III – USER APPRAISALS, SIMULATOR PERFORMANCE AND FLOW

5.4.1 Student’s appraisals

The vast majority of the participants from both groups had a very clear and positive opinion about the pedagogical value of the combination of the two simulation systems into a “mixed reality” learning environment (Table 1 in Paper III).

5.4.1.1 Learning experience

All students but one (97%) had a positive opinion about the teaching method and 95% felt it engaging. To a very large extent, the mixed reality simulation was perceived as an enriched, contextualized and beneficial learning experience.

Excerpts from students’ comments about the learning experience:

Strengths of the learning experience:

- Good complement to regular study methods. Should use more of that...
- I think it will be common practice to train like that.
- Enjoyable as a change.
- Relevant, authentic and enjoyable.
- Good to test different learning methods.
- A lot of learning in a short time, knowledge confirmation.
- Fun, but is this available to all?
- Rewarding. Good to try getting clinical skills assessed.
- Can to some extent contribute to better learning.
- Good way to learn. Time effective.
- Would be appreciated to do it more often.
- Absolutely necessary!
- Great. Especially because there is no predetermined sequence order, that one can go back and forth between lab and history. Very engaging learning.
Limitations of the learning experience:

- Fun, but a bit limited technology and ugly layout.
- Not a good as a real patient contact.
- I stopped formulating question in a personal manner quite soon and tried instead to trigger different keywords.

5.4.1.2 Realism

Most students (78%) experienced the VP case as realistic.

Excerpts from students’ comments:

Strengths of the realism in the ISP case:

- Yes, because I could ask my own questions in my way, and not choose from a list.
- Correct “age group”, the symptoms (not too obvious) etc.
- They videofilmed patient history contributed to that.
- First of all, it is a real person that we see.
- She (the patient) talked swedish finnish, is like my family.
- The patient answers didn’t flow over me. I had to investigate.
- The talking and “living” patient. All relevant questions could be asked.
- It was a realistic medical case!
- She had many answers and replied well.
- Images on the patient and her voice help to make it realistic. Stomach pain is common.
- The case was relevant and the symptoms were realistic.
- I felt the clinical data corresponded well with a real case.
- Because it is a matter of typical case example.

Limitations of the realism in the ISP case:

- The patient didn’t always understand the question.
- The system didn’t provide feedback about the order of performed examinations.

5.4.1.3 Impact of Video-Mediated Patient Answers

A majority of the students (86%) reported positive benefits in interacting with a virtual patient embodied by a video filmed actor. They strengthened that the case became more live, realistic and trustworthy; in other words closer to human conversation. Some suggested that seeing the patient’s body language and hear the voice intonation made the patient (character) more believable. It was mentioned that this increased interest. Other thought that it could even trigger emphatic feelings.

Excerpts from students’ comments:

Strengths of the value of motion picture with voice of the patient:

- It’s a fun stuff, but educationnaly it works equally with paper cases. The interest is probably maintained under a longer time with motion picture.
- Big value, the patient points out and shows where the pain hurts.
- Memorize the case better.
- Big value, it becomes much more alive then just with text.
- Big value, one sees how the mind of the patient is
- It is good to see the patient’s body language.
- It has a value to see the patient move and gesticulate, to hear voice intonation.
- Higher immersion
- It facilitates so it feels trustwortnier.
- It makes the exercise more stimulating. Another sense that becomes engaged.
• Very big value as one get more immersed (i.e. in the patient’s story).
• I believe that one gets increased empathy.

Limitations of the value of motion picture with voice of the patient:
• Maybe not that important in that case

5.4.1.4 Comparison of VPs with Paper-Cases
Most of the students (81%) favored ISP like systems compared with paper cases, provided that the VP session would be followed by a group discussion with a tutor/facilitator as for paper-cases. No one reported ISP as being worse than paper-cases. However, it was mentioned that both methods are useful and have different goals.

Excerpts from students’ comments:

Strengths of ISP-like systems compared with paper-cases:
• Good complement, although time demanding.
• More fun. One can recall the case better, more realistic.
• A mix might be the best, but rather a favor for ISP.
• More feedback and possibilities to choose different examinations.
• Positive and would hopefully replace many paper cases in the future.
• More stimulating and educational.
• It is better to go on at one’s own pace. One can choose the tests he/she wants to.
• Better, more fun, more authentic.
• A better complete picture.
• Really good if discussion with tutor follows up afterwards.
• Better and quicker answers.

Limitations of ISP-like systems compared with paper-cases:
• Good complement, but paper cases are better for discussion with other peers.

5.4.1.5 Synergy between the virtual patient and the endoscopic simulator
Students’ opinion about the synergy between the virtual patient and the endoscopic simulator are summarized in Table 5.4 below. Overall, the synergy was perceived as effective for the experimental group and a strong wish for the control group.

Table 5.4. Synergy between the VP and the Virtual Colonoscopy

<table>
<thead>
<tr>
<th>Synergy between VP and VC</th>
<th>Mean Values All</th>
<th>Mean Values Males</th>
<th>Mean Values Females</th>
<th>SD</th>
<th>Scale Min-Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Experimental Group only: How did the synergy work between the virtual patient and the endoscopy simulator?</td>
<td>3.8</td>
<td>4.2</td>
<td>3.6</td>
<td>1.2</td>
<td>1-5 from &quot;not at all&quot; to &quot;very well&quot;</td>
</tr>
<tr>
<td>b) Control Group only: Had you preferred having some kind of synergy between the endoscopy simulator and the virtual patient?</td>
<td>3.7</td>
<td>3.8</td>
<td>3.5</td>
<td>1.1</td>
<td>1-5 from &quot;not at all&quot; to &quot;yes, very well&quot;</td>
</tr>
</tbody>
</table>
Hence, the overall opinion about the added pedagogical value and the experienced usefulness of the mixed simulation set-up was overwhelmingly positive.

### 5.4.2 Simulation performance

We took into account the effect of age and gender in the 2 anova analyses concerned when computing the between-subject effects for completion time and MSE.

The experimental group seemed to perform the endoscopic procedure faster than the control group; however this difference did not reach statistical significance. We observed a general trend for shorter completion time for male students compared to female students. Intriguingly, both male and female students over 30 years performed faster than younger students (see figure 5.4.2.1). Otherwise, we did not observe any indication of differences within other prognostic variables like video game playing, IT experience or self-efficacy.

![Completion Time vs. Age and Gender](image)

**Fig. 5.4.2.1** Completion time vs. age and gender on the simulator
No significant reduction of the amount of mucosal examined could be established. (Although age was found to have a significant impact). See Fig. 5.4.2.2.

![Boxplot Median and IQR](image)

**Fig. 5.4.2.2** Comparison of mean scores for the percentage of Mucosal Surface Examined (MSE)

**5.4.3 Flow experienced on the simulator**

Even if we overall observed increased levels of Total Flow, experienced challenge and skills for the experimental group, a systematic difference between the groups could not be statistically demonstrated (see Table 5.4.2).

 Nonetheless, four components indicated significant differences between the groups:

- **Fun (p=.047)** & **Active (p=.006)**: positive outcomes for engagement,
- **Clear Objectives (p=.043)**: the VP-trained group performed more goal oriented,
- **Physically Demanding Task (p=0.03)**: higher levels of Fusion of Action & Awareness (p=0.06) might have contributed to experience the task to be performed as less physically demanding.
Table 5.4.2
Experienced challenge, flow experience and skills between the groups on the endoscopy simulator (Mann-Whitney Test)

<table>
<thead>
<tr>
<th>Grouping Variable: Control (0) vs. Experimental (1)</th>
<th>N</th>
<th>Mean Rank</th>
<th>Mann-Whitney U</th>
<th>Exact Sig. 2*(1-tailed Sig.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fun</td>
<td>0</td>
<td>14.50</td>
<td>85.500</td>
<td>.047(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>21.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exciting</td>
<td>0</td>
<td>15.58</td>
<td>106.000</td>
<td>.215(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasurable</td>
<td>0</td>
<td>15.42</td>
<td>103.000</td>
<td>.179(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>20.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>0</td>
<td>13.45</td>
<td>65.500</td>
<td>.006(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>22.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sociable</td>
<td>0</td>
<td>15.55</td>
<td>105.500</td>
<td>.202(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relax</td>
<td>0</td>
<td>17.32</td>
<td>139.000</td>
<td>.918(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>17.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotionally Demanding Task</td>
<td>0</td>
<td>17.50</td>
<td>142.500</td>
<td>1.000(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>17.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mentally Demanding Task</td>
<td>0</td>
<td>16.05</td>
<td>115.000</td>
<td>.354(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physically Demanding Task</td>
<td>0</td>
<td>14.21</td>
<td>80.000</td>
<td>.030(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>21.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Possibilities (and Frustration)</td>
<td>0</td>
<td>18.42</td>
<td>125.000</td>
<td>.560(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>16.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusion of Action &amp; Awareness</td>
<td>0</td>
<td>14.63</td>
<td>88.000</td>
<td>.060(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>21.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear Objectives</td>
<td>0</td>
<td>14.42</td>
<td>84.000</td>
<td>.043(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>21.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td>0</td>
<td>15.45</td>
<td>103.500</td>
<td>.179(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>20.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Confidence</td>
<td>0</td>
<td>15.71</td>
<td>108.500</td>
<td>.242(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense Of Presence</td>
<td>0</td>
<td>16.71</td>
<td>127.500</td>
<td>.607(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>18.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time distortion</td>
<td>0</td>
<td>16.21</td>
<td>118.000</td>
<td>.410(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Experience</td>
<td>0</td>
<td>15.58</td>
<td>106.000</td>
<td>.215(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skills</td>
<td>0</td>
<td>16.11</td>
<td>116.000</td>
<td>.372(a)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>19.27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Not corrected for ties

(Until now unpublished data)

The originality of the experiment enabled also self-reports of flow with the Virtual Patient. (See the design of the study III on Fig 4.3.1). As can be seen on the table below, a satisfactory level of flow experience as well as rather high levels of experienced feelings were self reported by the participants indicating an overall positive affective response towards the Virtual Patient.
Other Flow related findings showed that a VP session immediately followed by a VC session led to increased flow experiences for females (p=0.008), with potential positive learning effect as a result. Inversely, the reversed session order led to a slightly decrease of flow (for females from the control group).

5.4.4 Self-efficacy

The Kruskal-Wallis test performed for analyzing inter-group homogeneity did not demonstrate any significant difference in self-efficacy.

5.5 STUDY IV – EMOTIONAL ENGAGEMENT AND ATTITUDES

The computer-mediated communication was assessed in details by means of a triangulation approach. Table 5.5.1 shows the distribution of completion time with regard to gender-related group distribution. Intriguingly, it was found that the percentage of psychosocial questions was higher for male students as compared with female students. A Generalized Linear Model analysis confirmed that, regardless of the session length and group distribution, males asked significantly more psychosocial questions then females.

Fifteen semi-structured interviews investigated feelings, opinions and attitudes about the VP session (see the interview guide in the appendix section). Overall the VP environment was experienced as motivating, engaging and activating.
The case was overwhelmingly described as trustworthy with a consistent story and a believable virtual patient (felt as a real patient). Most of the students emphasized the pedagogical importance of the interactive dialogue of ISP during medical history taking. They valued it as an effective way to activate and engage in the learning activity, as opposed to a passive interaction with a “drop-down menu listing (and thereby revealing) all available questions.” It was reported that they believed they would also “recall better” when interacting with a virtual dialog interface supporting natural language, such the one of ISP.

A VP survey (summarized in Table 5.5.2) collected students’ written responses regarding perceptions, attitudes and learning preferences with the VP. We can observe that the majority of the participants were very positive concerning this kind of learning aid. The ranking showed that the VP was experienced as realistic (30%), enjoyable (25%), and instructive (25%). The perceived realism was mainly accounted to the video filmed patient (60%) as well as the trustworthiness of the case (45%). The overall ratings compare favorably with those from study II. Concerning screen size, the groups who were allocated a large 50” screen expressed a positive appreciation and showed a higher emotional involvement.

Table 5.5.2 Students’ spontaneous responses to the VP survey questions

<table>
<thead>
<tr>
<th>Question (with Free Text Response) *</th>
<th>Thematic Categories</th>
<th>Ranked Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are your first reactions about ISP?</td>
<td>Enjoyable</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Educational</td>
<td>35</td>
</tr>
<tr>
<td>2. What is your opinion about training with this learning method?</td>
<td>Complement to other learning aids</td>
<td>30</td>
</tr>
<tr>
<td>3. How did you experience this way of solving a clinical problem?</td>
<td>Realistic</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Fun and enjoyable</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Instructive; rewarding</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Stimulating; challenging</td>
<td>15</td>
</tr>
<tr>
<td>4. What contributed to the realism of the VP case?</td>
<td>Patient speaking; images and video sequences of the VP</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Trustworthy case; real patient/person</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Physical Examination and laboratory tests</td>
<td>25</td>
</tr>
<tr>
<td>5. What is the value of motion picture with the voice of the patient?</td>
<td>High value</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Increased patient’s presence, life like, realistic</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Trustworthy, believable</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Engaging, stimulating, inspiring, better focus</td>
<td>15</td>
</tr>
<tr>
<td>6. The direct feedback is important.</td>
<td>Agree</td>
<td>95</td>
</tr>
<tr>
<td>7. Do you have a previous experience with simulated or fictive communication?</td>
<td>Previous experience</td>
<td>25</td>
</tr>
<tr>
<td>8. How do you rate the ISP compared to paper-based cases?</td>
<td>More enjoyable / more fun</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>At least as good as, or better</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Increased awareness/concentration</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>More realistic</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>More engaging / stimulating</td>
<td>20</td>
</tr>
</tbody>
</table>

* Representative statements/questions from a large survey.

For triangulation purposes the survey outcomes were then related to the interview outcomes. Overall, appraisals from the respondents conformed well to their written opinions and no student was found to present contradictory reports.

The observed behaviors were assessed by a video observation. The data collection was
performed by means of a comprehensive coding scheme and 3 independent raters. The inter-rater reliability was computed and yielded a high intra-class correlation coefficient (0.84). As can be seen in Table 5.5.3, many observational variables were coded above the average, indicating positive affective learning outcomes in general. Observed variables such as Overall Interaction Flow, Immersion Level, Consensus between Students, Interest/Attentiveness, and Responsiveness/Engagement showed rather high values, which indicates that the Virtual Patient encounter appears to have engaged the students affectively, with resulting increased motivation.

Some students mentioned in the interview that it was easier to distinguish small details on the patient, such as subtle facial expressions, with a large screen compared to a regular screen with lower resolution. When analyzing the video recording it was revealed that they also perceived a heightened degree of mediated presence in the patient, and a slightly increased degree of empathic feeling.

It is therefore important to note that video sequences of the VP (Table 5.5.2), as well as their size on the screen (Table 5.5.3), seemed to have played a key role for student’s involvement.

**Table 5.5.3** Median values from observed affective and behavioral variables (*)

<table>
<thead>
<tr>
<th>Global Observational Variable</th>
<th>Scale **</th>
<th>Median All</th>
<th>Normal Screen</th>
<th>Large Screen</th>
<th>Median Males</th>
<th>Median Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Emotional Atmosphere</td>
<td>1-3</td>
<td>1.6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Overall Interaction Flow</td>
<td>1-3</td>
<td>2.2</td>
<td>2.0</td>
<td>3.0 (+)</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Immersion Level</td>
<td>1-4</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0 (+)</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Student Mood State</td>
<td>1-3</td>
<td>2.6</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Interpersonal Communication of Emotional States</td>
<td>1-3</td>
<td>2.3</td>
<td>2.0</td>
<td>3.0 (+)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Consensus Between Students</td>
<td>1-4</td>
<td>3.3</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Self-Confidence Level</td>
<td>1-3</td>
<td>2.4</td>
<td>2.0</td>
<td>3.0 (+)</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Communication Skills</td>
<td>1-3</td>
<td>2.2</td>
<td>2.0</td>
<td>3.0 (+)</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Attitude Towards Patient</td>
<td>1-3</td>
<td>2.0</td>
<td>2.0 (-)</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Patient’s Presence</td>
<td>1-3</td>
<td>1.6</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Students Speak During Patient Answer</td>
<td>1-4</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Interruption of Patient Answer</td>
<td>1-4</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Anger/Irritation</td>
<td>1-6</td>
<td>1.8</td>
<td>2.0 (+)</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Anxiety/Nervousness</td>
<td>1-6</td>
<td>1.6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Dominance/Assertiveness</td>
<td>1-6</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Interest/Attentiveness</td>
<td>1-6</td>
<td>4.3</td>
<td>4.0</td>
<td>5.0 (+)</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Friendliness/Warmth</td>
<td>1-6</td>
<td>3.4</td>
<td>3.0</td>
<td>4.0 (+)</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Responsiveness/Engagement</td>
<td>1-6</td>
<td>4.1</td>
<td>4.0</td>
<td>4.5 (+)</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Sympathetic/Empathetic</td>
<td>1-6</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0 (+)</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Respectfulness</td>
<td>1-6</td>
<td>3.5</td>
<td>4.0</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Hurried/Rushed</td>
<td>1-6</td>
<td>1.6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Body Lean</td>
<td>1-4</td>
<td>2.5</td>
<td>3.0 (*)</td>
<td>2.0</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Head Nod</td>
<td>1-4</td>
<td>1.3</td>
<td>1.0</td>
<td>1.5 (*)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Hand Gesture</td>
<td>1-4</td>
<td>1.7</td>
<td>2.0 (*)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Eye Contact/Eye Gaze</td>
<td>1-4</td>
<td>3.2</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Awareness/Sensitivity to Camera Presence</td>
<td>1-4</td>
<td>1.3</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* All median values are based on 14 students observed each by 3 independent raters.

** Scales are ranging from negative to positive

(+*) indicates a positive effect of larger positive

(-) indicates a negative effect of larger
6 DISCUSSION

6.1 STUDY I

The evaluation data clearly show that ISP is a powerful tool to support students’ active involvement in collaborative, clinical problem solving. The extensive interaction between the pairs of students in front of the computers was well demonstrated in the media clips.

Students commented specifically on the high degree of realism of the ISP system, and as examples of this mentioned the patient actor as the primary reason for the feeling of realism (and engagement), but also the realism of the physical signs and symptoms, and the inclusion of the actual costs of laboratory investigations were mentioned as positive.

However, during the interviews it was discovered that there was a difference between what students meant by ‘realistic’. Some referred to the actor’s ability to play the role, and others meant the actual medical case. They thought it was fun and that realistic cases made the situation more authentic, which is easier to remember.

They also noted the extensive interactivity in the computer simulation, and seemed to appreciate the way it afforded them the opportunity to make their own choices in working up the patient case.

Students think that ISP would be helpful as early as possible during the medical curriculum because it gives the opportunity to:

- See what it is like to be a physician,
- Think like a physician.

Students reported that this collaborative situation encouraged critical thinking and enhanced learning when solving the cases, because they could learn from each other. These aspects are easily lost if ISP is only used as a ‘stand alone’ application.

Somewhat more students reported greater confidence in their clinical problem solving ability after using ISP than after using paper-cases. Reasons for this are possibly the higher level of realism with the ISP cases.

An issue that was raised by the qualitative data was the engagement of students in the sessions. The evaluators’ observations during the sessions, together with analyses of the videotaped sessions, clearly showed that the students were interacting a lot in both situations. However, it was obvious that the level of interaction, discussion, engagement, and laughter (the fun factor) was much higher when the students were working with the ISP cases than when working with the paper-based cases.

Students’ prior experience with similar computer software seems to have some influence on how easy students find the software. It is however, not possible at this
stage to evaluate how beneficial it is for their learning although it is likely that difficulty with software interferes somewhat with their learning.

A significant limitation was the inability to use the ISP system in a networked mode over the Internet, which could have resulted in one shared application for all three students to interact with. However, these trials demonstrated that students’ enthusiasm for solving ISP patient cases supported their ability to collaborate with each other, despite differences in their level of training, in their native language, and in some of the medical terms and procedures in the two countries.

6.1.1 Summary

The results of the evaluation showed that:

- The added educational value reported by the students had to do with enjoyment, realism and awareness.
- Students enjoyed collaborating in pairs and thought it added a lot of value to the learning experience.
- Students found all the cases realistic, but the ISP cases were reported as being a bit more realistic than paper-cases.
- ISP provided a feeling of freedom to choose and get answers to one’s questions, which is more similar to the real doctor-patient situation.
- The feedback part of the computer-cases was reported as important for learning.
- The price labels encouraged more awareness of what students were doing.
- A majority of students expressed an increased confidence to solve clinical problems and felt somewhat more clinically prepared.

6.2 STUDY II

6.2.1 The case used and the assessment results

Time constraints and lack of prior ISP experience prohibited the examinees to solve the case without any external help. Nonetheless, the presence and guidance of an assistant fostered (unconsciously) the thinking aloud process on the examinee’s part.

Consequently, it allowed the assistant to cope with the student’s ongoing clinical reasoning process and thereby to canalize his/her preliminary thoughts in case he/she was deviating from the main track. However, the quality of the interaction and the degree of engagement from the assistant appeared to affect the overall performance.
6.2.2 Variation in assistant behavior and intervention

During the examination, assistants acted as both instructors and raters. However, due to the fact that the assistants/examiners’ level of help was not standardized, problems emerged with the scoring validity, compromising thus the objectivity of assistant intervention and the accuracy and fairness of the rating system. This is something that should be addressed if assistants are available in real exams.

6.2.3 Validity and usability in exams

One issue was raised about the face validity of standardized patients whose performance might be affected by human factors. In contrast, VPs guarantee the regularity and reproducibility of patient behaviour as well as the judgement of the student’s interaction.

It was therefore suggested that students should be judged on the basis of predefined scoring rubrics with well-defined cut-off points, for ease of administration and grading.

Although all examinees volunteered to use ISP and completed the whole session, findings from the statistical analysis showed that significant differences existed among the students in the perceived usefulness of the human assistance, and also their degree of affective response towards the ISP system. This might be due to human factors and the negative effects of relative high levels of stress caused by the assessment procedure.

Study II indicates that computer-based simulations like ISP are able to present and simulate realistic patient encounters to an acceptable level of complexity and allow differentiation of one student’s performance from another, including gender-related differences. ISP-like simulations can be programmed to score automatically and immediately present results of the examination thus saving expensive labour and facility resources.

In summary, it can be concluded that Virtual Patient cases might be used as a complementary method for summative assessment. However:

• Students need to be trained in mastering the assessment tool prior to exams.
• Rating compliance needs to be targeted before VP-based systems like ISP can be used in exams and if such systems would be used in high-stake exams.
• The use of human assistants should be limited because of possible confounding influence on students’ outcomes.
• Scoring rubrics should be developed and validated before implementing computer-based assessment (and preferably automated).

6.3 STUDY III

The essence of the work in study III was an assessment of the effect of linking a virtual patient history taking exercise (ISP) to a virtual colonoscopy simulator (VCS). The experimental intervention was to vary the order of ISP and VCS. This study attempted
to measure multiple factors associated with simulation-based training of a medical procedure. It was hypothesized that these factors and their sequencing may impact the way the material is learned, and consequently applied in the clinical environment.

Participants’ perception and satisfaction of the learning environment were reported as the main finding.

6.3.1 Students’ Appraisals

Students’ appraisals (i.e. qualitative data regarding affective response of participants collected in the questionnaire) about the educational values of the combined simulations (Mixed Reality) were overwhelmingly positive. Appraisals from the experimental group indicated that students experienced the simulated clinical scenario as an authentic, innovative and effective blended learning experience with a taste of augmented reality. As mentioned in the first chapter, these appraisals have positive implications for better integration of knowledge acquired during the simulation exercises. Furthermore, expert feedback was perceived as a key component for this experiential kind of learning.

Students showed a preference for the 'natural' sequence of the mixed-method instruction, i.e. taking the history before performing an intrusive colonoscopic examination. They felt it would be unnatural and probably unethical to reverse the sequence in clinical practice.

6.3.2 Performance/surgical skill acquisition

The results regarding surgical performance improvement are suggestive but inconclusive (not statistically significant). Kneebone et al (2004) reported that the first repetition is not a sufficient marker of comprehensive clinical performance on a simulator. This might explain the difficulty to measure performance improvement with only one single training episode.

Knowing that, apart from immediate task sequence, there are other important determinants of performance we looked for predictive variables. Gender and age were found to be those that had the most significant impact on performance with the simulator. These variables were consequently used as covariates when computing the between-subject effects for completion time and amount of mucosal surface examined.

The fact that we did not observe significant performance differences between the groups might be due to the fact that the experiment group included more females than males, and that most females were found to be less experienced with video games than males.

6.3.3 Flow Experience

The fact that females scored higher on Flow than male students can be partially related to their less extensive level of video-gaming experience (as opposed to men who usually are more demanding for advanced VR interfaces). The significant increase of flow experience for female students (and the opposite results with a reversed sequence
order) emphasizes the need to perform combined virtual sessions in a structured and individualized pedagogical format.

6.3.4 Summary

Participants reported the mixed virtual reality simulation as a positive learning experience. Expert feedback was perceived as a key component for this experiential kind of learning. Overall, students also expressed a wish for an increased use of similar individualized and contextualized learning environments. Our findings show that a mixed virtual reality simulation may contribute to an augmented reality experience among surgical novices.

This study addresses for the first time a systematic assessment of mixed reality simulation with virtual patients and simulated endoscopy. This new learning method was therefore presented for a redesigned curriculum for endoscopy training to ensure that simulator-based technical skills training and assessment take place within an authentic context.

In conclusion, this study indicates that VPs might enhance contextualization of simulated endoscopy and presumably will facilitate an authentic learning environment, which is important in order to increase motivation.

6.4 STUDY IV

Study IV was conducted to gauge the impact of VP features presented in the previous studies like presence, social interaction, emotional engagement, and screen size.

As reported earlier, the aim of this study was to achieve an understanding of students’ feeling of patient “presence” and reactions to a Virtual Patient encounter.

A vast majority of the participants expressed a positive consensus concerning the educational value of the VP interaction. This is in concordance with earlier results.

It was determined that the trustworthiness and the realism of this to some degree life-like situation, as well as the believability of the story, and the performance of the actor (perceived by many participants as a real patient) played a key role in students’ appraisals.

It was also found that mixed-gender groups might have lead to a better synergy during the VP learning experience. Awareness and concentration were found to be slightly superior, which can be partly explained by the advantageous combination of genders (like reducing too strong competition or game-oriented behaviors among male students).

Substantial differences were found in the students’ rapport with the VP and the flow of conversation. The variety of these observed behaviors and attitudes is comparable to the complexity of human communication in real life.
We observed slightly increased levels of patient presence as opposed to the subjective self-reported levels of presence in the cyber world. Males’ rates were also higher than females’.

The social activity between student pairs and the life-like VP appeared to be engaging and immersive with satisfactory overall flow levels. These positive appraisals can be accounted to the participants’ rich IT experience, as suggested by Liaw (2007).

Video-observation screening indicated that males seemed to be more attentive and more responsive listeners than females. This can be corroborated with the higher number of psychosocial questions they asked. Consequently, this favors valuable effects on communication skills for males.

The large screen (i.e. displaying a larger patient face) appeared to have positive effects on subjects affecting in particular the immersion level, the emotional engagement, the completion time, and leading to reduced anxiety or nervousness. This finding is in agreement with other studies (Reeves & Nass, 1996).

The collaborative workspace seems to play its role – presenting rather low levels of anxiety – leading to dynamic and engaged discussions with shared understanding.

In summary, the VP environment studied has the potential to promote affective interaction in conjunction with presence of the virtual patient, and to stimulate emotional involvement as well as favoring motivation in a meaningful contextualized learning environment.

The findings are congruent with other studies indicating that VP-based virtual scenarios can emotionally attach, stimulate and motivate users (Deladisma et al., 2007; Stevens et al., 2006).

### 6.5 GENERAL DISCUSSION

A vivid learning environment is one that appeals to multiple senses. It is this sensorially rich mediated environment that is believed to capture the learner’s attention, thus leading to increases in learning, interest, and satisfaction (Syed, 2001; Webster & Hackley, 1997). The different contexts of usage of ISP that have been demonstrated in the four studies point to two direct benefits of the ISP type of simulated learning environments: the first in enabling students to take an active role in their learning; the second is that ISP also seems to allow a reflective role. In the educational literature, both these roles are pointed out as important for learning.

Overall, students from all studies have provided valuable insights and further knowledge about the core variables and affective dimensions contributing to activate, motivate, engage and affect students in a virtual patient encounter.
Along the four studies, questionnaires and interviews were tailored to reveal relevant aspects of student appraisals towards ISP. Students’ evaluation reports demonstrated high expectations of the VPE, intolerance of technical glitches, but a positive overall response to the system.

The major findings are summarized below.

6.5.1 Student attitudes towards e-learning and ISP

According to Guru & Nah (2001), environments that are conducive to flow will yield positive attitudes and outcomes for users, and have broad implications for learning. Besides the general idea of improving learning, we think that there are two other motives behind much of the use of IT in teaching and learning: a fascination with the technology and the desire to make the whole business more personally interesting. At least in the 80’s, the fascination about personal computers as such, strengthened by the huge marketing from computer companies, probably was the main reason for the large increase of IT-based learning at that time.

In the four studies performed, there was overall a positive attitude towards e-learning and no computer-hostile attitudes were observed among the participants. This can be related to the overall positive flow observed in the studies and is consistent with the findings from Skadberg & Kimmel (2003) where they empirically evaluated visitors’ experience while browsing a Web site. Their findings suggested that when people are in a state of flow they tend to learn more about the content presented in the Web site and that the increased learning leads to changes of attitude and behavior, including taking positive actions.

The ISP system was not primarily perceived as an information source but rather as a way to elicit knowledge and problem-solving skills. This is also in concordance with the primary aims of the system as such – to present clinical cases as problems to solve and not present the cases as a textbook with facts. This is an important concept underpinning the contextual or learner-integrated approach of the learning tool, and it also points out a very important fact: VP systems do not teach – they stimulates learning.

The evaluation reports demonstrated high expectations on the VPE, (restrained) intolerance of technical glitches, but a positive overall response to the VP system favoring its acceptance and efficacy.

6.5.2 Perceived benefits

The assessments were aimed at evaluating the usefulness of the application as a tool to supplement students’ clinical education and enhance their clinical skills.

It is important to note that ISP was generally perceived as the next best option after real life experiences for increasing confidence and improving ability to solve clinical problems. As argued by Taras (2001), constructive tutor feedback, together with direct
feedback, were perceived as a crucial and effective factor to consolidate the learning process, and apply it later on in a real life setting.

Common values expressed by the students included the following:

• Good opportunity to collaborate with their peers and to develop critical thinking.
• Students believed the cases were valuable in structuring their knowledge and conceptualize how to handle unusual clinical situation.
• ISP was seen as improving clinical skills (like being able to distinguish abnormal from normal physical examination findings).
• The ISP was perceived as a supportive learning environment contributing to a favorable emotional climate that (is known to) underpins positively motivation (which in its turn has positive effects on the learning curve).
• ISP was experienced as a motivating interactive learning environment.
• Most students perceived an improvement in their understanding and confidence in their clinical skills as a result of using the ISP system.
• The general perception is that VPs are more than an add-on to the curriculum and should be part of the core.

6.5.3 Human factors and preferences

As for student attitudes toward e-learning, we found that age, gender, computer proficiency, video-gaming experience had some significant impact on performance and usage. Users’ personal and motivational characteristics, as well as socio-demographic variables, affect engagement modes and flow experience (Sharafi, 2004). The “affective signatures” depend both on the individual (his temperament, individual history, current physiological state and psychological context) and on the situational context (e.g. situations differ in the degree to which they promote or inhibit the expression of particular emotions). It is therefore important to take into account the characteristics of users’ emotional, motivational, cognitive abilities, goal oriented behaviors, and learning styles when designing medical simulation tools.

6.5.4 Increased Confidence for Problem Solving

It is a well-known fact that many medical students – often in spite of sufficient knowledge and skills – suffer from low confidence regarding their own clinical problem solving ability (Sandberg et al., 2007). This occurs even in the end of the undergraduate medical program and is due to several factors of which insufficient training is one. ISP provides an opportunity to practice and “experiment” on virtual patients in a way that of course would not be possible with real patients. Overall, the findings suggest that the ISP design helped students to counteract their feelings of lack of confidence in particular in the early part of medical school.

6.5.5 Student engagement

Students reported that they liked this (new) method of learning. ISP proved to be experienced as educational - and exciting, playful, and enjoyable. Most students liked
the competitive atmosphere and thought it made them more engaged in the process. ISP also stimulates curiosity that is so important in the coming clinical collaboration and clinical work.

We hypothesized that active involvement in the virtual patient interview would give the student the distinct feeling that he or she has actually met the patient.

Sallnäs (2005) performed different experiments to investigate how communication mode (video, audio, text-chat) affects people’s experience of social presence and interaction in a collaborative virtual environment. She found that the perceived social presence and interaction were higher with video media than with the audio media. Text-based communication was rated lowest.

Koschmann et al., (1994) and Grabinger et al., (1997) argue that student activities that are motivated by the student's desire to solve problems define a learner-centered approach to teaching. The induced situational awareness combined with the freedom to experiment (albeit within the contextual confines of the program), enabled the ISP environment to foster the development of active knowledge.

Another important advantage is the user-friendly and intuitive interface of ISP. It makes it possible for the student to navigate back and forth between history taking, physical exam and lab tests allowing trial and errors on hypothesis in an unstressful manner and without irritating, or even jeopardizing the patient. This is very seldom the case during the undergraduate medical program.

Based on data from the interviews, the students appeared to feel that the experience of conversing with a VP was a challenge. Desirable and positive emotions as enthusiasm, delight and amazement were observed or self-reported in the studies. These positive emotions trigger many benefits: they facilitate coping with stress. They are essential to people's curiosity and ability to learn. As mentioned earlier when the process of learning was working well, students expressed curiosity, enjoyment, fascination, etc. And when the learning experience became (luckily temporary) negative students experienced confusion or frustration.

Student learning appeared though to be successful and was often marked by “Aha!” moments, sometimes jointly celebrated with “high fives.”

### 6.5.6 Perceived Realism

Bridge et al. (2007) performed a correlation analysis of factors affecting performance in an immersive visualization environment and found that the level of perceived realism was correlated with both student performance and enjoyment, although the link between enjoyment and performance was weaker than expected.

Studies performed on ISP indicate that the high level of realism and interactivity - in particular features like the interactive dialog and the video-filmed actor- account significantly to the perceived authenticity of the clinical context.
Kamin et al. (2002) investigated student’s perceptions of a virtual PBL experience with digital video cases during a pediatric clinical experience. Students reported authenticity as a critical feature. It was said that “seeing (videos) made learning more memorable”.

Answer feedback, as well as motion from the virtual patient, were reported to increase the sense of presence and contributed to the perceived increased realism. Additionally, video observations revealed the mediating influence of the human actor on students’ arousal and attentional processes. Those findings are congruent with a study performed by Bearman (2003).

The findings indicate that ISP is a learning environment with a high degree of realism and interactivity that is advantageous to use in clinical and/or preclinical learning situations.

The authentic and realistic cases with embodied virtual patients were found to be compelling and may provide coherence and support better understanding of the situated experience.

6.5.7 The natural conversational interface

According to our findings, the degree of simulation realism can be significantly enhanced when advanced interactive video-based communication is used during the virtual patient encounter. Although the subjects had ample opportunity to misuse ISP, in particular the medical history, they did so rarely (for example by trying to ask inappropriate questions, like profanity, using filthy language, etc.). As a matter of fact, ISP can to some extent actually facilitate to conduct more “difficult” health-promotion conversation (e.g., sexual behavior, alcohol use). Even though the conversational interface might have felt contrived and artificial, many students exhibited great interest in patient interviewing. The free text patient interview with video responses was the primary feature students pointed out as increasing the realism and engagement of ISP. The interactive story with a patient actor became the driving force of the encounter.

The video-based virtual patient were depicted as believable and even, according to some students, looked like a real patient. Thus, provided the interactive dialog works smoothly, a talking patient has been identified as a driving force for an effective and engaging virtual encounter.

According to the students, the video-mediated communication of the ISP cases enabled them to create realistic mental pictures of patient cases, provided integrated pictures of patients as people, which challenged them to elaborate the cases seriously and were more memorable than text-based cases. High quality video of patient responses portrayed by an actor offer cues that focus student’s attention on essential issues (i.e. the patient’s concerns) and can even (emphatically) move students.

Research has reported that static menus in medical history can be a potential factor of deflecting attention from the critical thinking needed in diagnosis inquiry (Schittek, 2005). This was not the case of the ISP system powered by a NLP supported conversational interface. Some students reported that they felt like they had talked to a
real person. This is the single most important characteristic that distinguishes a virtual
dialog from other more passive media approaches to learning.
Another benefit with a NLP interface is that students can control the virtual dialogue’s
pace while posing questions to the patient.

To overcome dialog barriers, time consuming efforts were necessary to fine-tune the
semantic interpreter of the medical history and resulted in a very comprehensive
database. However large clusters of this latter can be reused as a template for wording
in new patient cases.

Interviews revealed that students favored the virtual patient's utterances represented by
the playback of high quality video and felt it allows them to perceive the rich nonverbal
aspects of the patient's message. They were uncertain of the possible effectiveness and
authenticity of avatars vs. videotaped actors. This is worthy of future studies.

6.5.8 Collaborative learning

Students believed the VP cases were valuable in collaborating with their peers and their
mentor/facilitator to develop critical thinking. This is consistent with a study by
Newman et al. (1997) confirming that face-to-face interactions provided improved
learning compared to computer interactions alone when in a problem-solving
environment.

Through collaborative learning, the social interaction benefited from the triad
interaction (i.e. two students interacting with a virtual patient) and fostered a positive
emotional atmosphere.

Much fewer students got stuck, because of issues like e.g. unanswered questions from
the patient or difficulties to find relevant lab tests or wrong phrasing of diagnosis. Most
students favored this learning strategy, and overall more positive reactions about the
ISP were observed.

6.5.9 Virtual patients as assessment tools

According to our findings, computer based systems like ISP seem to be able to present
and simulate real patient encounters to an acceptable degree, and this could be used for
assessment of for example clinical reasoning. However, in order to avoid introducing
bias in performance assessment with human raters, ISP-like systems should be
programmed to automatically score student’s performance. They could immediately
present results of the examination and they might also be able to save expensive labour
and facility resources.

6.5.10 Shortcomings/limitations with ISP

ISP can be sometimes be perceived as contrived, because of the artificial nature of
practice simulation. Areas of weakness identified were the virtual patient’ ability to
“understand” some of the history questions asked.
Much of the enjoyment factor might be attributed to the novelty of the technology. However, most students exhibited good computer proficiency and some even with extensive computer games experience, so we do not think that this is a major problem in our studies.

In contrary, it seems that students’ strong engagement observed along the four studies, and the high levels of perceived realism actually might have counteracted the technical glitches that could otherwise have had a negative impact (like user frustration) on learning experience.

This is particularly the case, for study II, performed during an assessment, where the stress resulting from the assessment procedure might have caused less positive student appraisals (summarized in Table 5.1.2).

6.5.11 Methodological considerations

Sample size Limitations
Randomized controlled studies will be necessary to determine how much of the perceived improvement/increased confidence of solving clinical problem is solely due to the VP and, crucially, how well this student confidence transfers to the clinical environment.

Case consistency (content & structure)
In general, the ISP cases were perceived as tailored to the students’ prior knowledge and structured with sufficient clinical content with a purposeful aim. The content validity of ISP, regardless of the case and the study, was overall perceived as high.

Relevance of methods
The interviews with students in study I and IV gave the opportunity to go deeper into the reasons for the opinions expressed in the respective questionnaires. Even though some authors debate the use of for example Flow in Educational research, the psychometrics used in study III (self-efficacy & Flow) were found to be valid and useful instruments. The high degrees of self-efficacy observed in study III provided a good measure of motivation and challenge.

Comparable findings were obtained along the studies regardless of sample size. Reliable assessment typically requires the concurrent use of multiple methods. Triangulation was therefore chosen to increase reliability by examining evaluation data from the alternative methods presented in the study, reducing thus systematic method error. The internal consistency of video observation, conducted in study IV, was sufficient to validate and confirm the relevance of this method.

6.5.12 Suggestions for improvements

Voice recognition:
Most of the participants expressed a clear wish for voice recognition capability integrated into the VP system, allowing the simulated patient to respond to natural, spoken English or Swedish.
**Congruent feedback:**
Group debriefing with evaluator/facilitator should entail videotaped student sessions to trigger reflection among peers and enhance discussion for better knowledge consolidation.

Medical students suggested preferences for the following possible improvements:

<table>
<thead>
<tr>
<th>Suggestions</th>
<th>Potential perceived benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice activated dialog</td>
<td>Enhanced authenticity, believability and immersion.</td>
</tr>
<tr>
<td>Possibility to ask more odd or uncomfortable questions</td>
<td>Training opportunity without human psychological barriers. Increased self-confidence.</td>
</tr>
<tr>
<td>Modify patient's mood</td>
<td>Challenge ones’ ability to deal with and react to different emotional contexts.</td>
</tr>
<tr>
<td>Script coherence and dynamic branching</td>
<td>To ensure that any patient utterance and any student question makes coherent sense regardless of the interaction path leading up to that utterance.</td>
</tr>
<tr>
<td>Possibility to include empathetic statements</td>
<td>Users would like to be able to formulate empathic responses reflecting the patient's emotional state and the heart of the issue. This could be, for instance, partly achieved by means of emoticons embedded in the interactive dialog box.</td>
</tr>
</tbody>
</table>

### 6.5.13 Educational VALUE OF ISP

Almost without exception, when medical students are intellectually involved in a learning situation, they will master the material and understand what they have learned. If they are also emotionally involved in the situation, they will also be able to internalize the experience, remember what they have learned, and be inclined to apply it to similar real-life situations. If students are both intellectually and emotionally involved in a learning situation and, in addition, they have the opportunity to influence that situation, they will feel responsible for the decisions made during the session. This ultimate sense of responsibility is what creates an "active learning format" and is the basis for the powerful educational method known as "experiential learning" – that is, learning through the participation in, and observation and analysis of, an evolving situation.

Based on, and in accordance with, these considerations, the ISP simulation model has proven to be an interactive, contextual format where active, experiential learning can occur. An environment of ISP type can stimulate learning and comprehension, because it provides a tight coupling between symbolic and experiential information. ISP was thus found to be appealing and a viable option for fostering problem resolution skills.

Furthermore, realistic virtual environments like ISP do allow students to make (and learn from) errors that would not be tolerated in the real world where patient safety and care of costly equipment are paramount considerations.
ISP has been mainly reported as a tool to supplement students’ clinical education and enhance their clinical skills. Students appraised positively the potential of ISP to scaffold learning in a positive manner.

Features of the VP learning environment do not act in isolation; other factors such as the concepts or skills to be learned, individual characteristics, the learning experience, and the interaction experience all play a role in shaping the learning process and its outcomes. In doing so, we are beginning to understand the interplay between virtual patients’ features and other important factors in shaping the learning process and learning outcomes for this type of material.
7 SUMMARY AND CONCLUSIONS

The medical curriculum is changing; student-centered learning is increasingly used in medical schools. We are facing a new paradigm where medical education offers opportunities for students to practice in safe and responsive environments. Innovative educational simulations that aim to immerse medical students in problem based learning or other student activating activities around virtual patient cases might contribute substantially to the student-centered learning approach. Although not as challenging as Human actors (SPs) for developing skills in patient communication or interpersonal doctor-patient relationship, ISP-like VP systems do present a valuable, standardized and cost-effective alternative. Besides they promote an emotional dimension that brings a human touch to the patient simulation. This, in turn, enhances the user’s perceived level of satisfaction.

As discussed earlier, the importance of affective learning outcomes justifies the emphasis placed on design. Poorly designed systems can cause major frustration. The development of computer simulations of patient encounters should thus include more humanistic issues and take into account both cognitive and affective aspects of learning styles. The exclusion of these factors is one reason for the annoying and lack of user engagement (Vermunt, 1996). As it is the case for other virtual learning environments, VP system development can suffer from rationality and logic that, too often, constitute the norm. Greater attention and awareness of the contextual issues should therefore be paid by educationalists and faculty to identify possible student emotional responses as part of initial tutor training and continuous staff development.

As mentioned in Aims of the Study (Chapter 3), the primary aim was to investigate if ISP might be perceived as an effective, trustworthy, activating, motivating and engaging learning environment by medical students. All these aforementioned core issues were investigated and more light could be shed on the expected outcomes. To summarize, the results of the four studies presented in the thesis support the following conclusions:

**Effective learning environment**

The ISP was perceived as an innovative and content rich educational simulation. The simulated patient encounter was experienced as a good way to foster critical thinking about the patient-doctor relationship. Students were challenged to deal with clinical problems in a contextualized environment. The studies performed around ISP also revealed that the students were receptive to the use of the VP in learning how to increase their confidence to solve clinical problems. They reported the VP provided them ad hoc clinical data to successfully investigate patient cases in a hypothetical-deductive approach. The ISP system was found to provide safe and valuable experiential learning bridging humanistic and scientific aspects of typical clinical scenarios.
Authentic learning environment

Trustworthy situations, authentic environments and realistic scenarios have been previously described as key components for effective and enriched learning experience with VPEs. The ISP system was reported to fulfill these criteria and to offer interesting, meaningful and credible virtual dialogues. Technical glitches did not significantly affect students’ appraisals. In fact, most of the students exhibited great interest in patient interviewing, mostly accounted by the free-text driven interactive dialog and the perception of patients as being real persons.

Active learning environment

The PBL oriented design of ISP enabled students to acquire and apply content knowledge and to learn and practice individual and/or group communication skills, which are critical to learning. Students' readiness to engage in the social interaction was enhanced with active and vivid discussions when working collaboratively, promoting thus an active learning format. Students emphasized the educational value of the constructive debriefing sessions that took place after VP training. Indeed motivational discussion with ad-hoc feedback plays a crucial role for consolidating the learning process and enhancing participants’ long-term memory retention.

Engaging learning environment

Video observations and interviews revealed that the contextual format of ISP, in particular the natural conversational interface, had a positive impact on students’ engagement in the learning activity. This kind of virtual patient encounter modality was found to evoke satisfactory levels of presence and emotional involvement, and contributed to enhance students’ flow experience. It was also observed that the degree of immersion and presence upon students could be strengthened with a larger screen. These are beneficial characteristics for personalizing the experience, remember what has been learned, and be inclined to apply it to similar real-life situations.

Through the studies presented in this thesis we have gained further knowledge about student’s engagement modes with virtual patients. Distributed collaboration around structured and facilitator driven VP cases has also proven being effective, dynamic, challenging, and cross-cultural learning experiences for medical students.

It can therefore be concluded that high-fidelity computer simulations of the clinical encounter, powered by a natural language conversational interface, are good technological mediators to activate, motivate and engage students, resulting in possibilities of effective knowledge building, increased confidence in clinical problem solving and enhanced memory retention.
8 FUTURE PERSPECTIVES

8.1 FUTURE DIRECTIONS

Due to the complex nature of doctor-patient interaction, we need to direct our efforts towards thoroughly designed embodied Interactions for enhanced VP environments. Future studies should focus on the roles of the various factors that affect learning through the process of interaction. Ongoing attempts to enrich the Virtual Patient Encounter format should therefore be encouraged. In order to maximize the potential of adaptive interfaces for providing authentic patient cases, computer enhancement of simulations should better track and record individual and group thinking and reactions.

Further research is needed to gather empirical evidence that advanced and enriched VP systems can afford real learning with long-lasting effects on recall. Experimental studies could focus on the following issues:

- Investigate users’ retention of knowledge gained through virtual dialogue methodology (in particular the modality effect).
- Future work is needed that focuses on follow-up observations of cohorts of students to verify longitudinally the recall effect of VP exposure on learning.
- Look a difference on learner's motivation and achievement between high and low perception level of authenticity (text-based dialog versus interaction via intelligent agent).
- Investigate the effects of different technical designs (like text or video-based answers, different cinematographic techniques, possibly real actors compared to avatars, etc) on the emotional involvement during the virtual patient encounter.

8.2 FUTURE SCENARIOS

Video games and virtual reality are becoming increasingly realistic. There is a definite move towards more frequent and more compelling mediated experiences. The line between virtual (i.e., mediated by technology) and real (i.e., non mediated) will be more and more blurred (e.g. Kim, 2006). As a result, and as already mentioned in chapter 2.3 about Computer Simulations in Education, presence experiences will increase in number and intensity.

Medical simulation does not escape to that trend and augmented reality technology is already on its way to many simulation-based training centers. Moreover, new virtual worlds like Second Life have recently emerged where avatars of users from around the world can interact via the Internet in a great diversity of virtual communities like distance learning forums. Medical simulations also began to appear in Second Life in 2007 in the community known as Ann Myers Medical Center (Mesko, 2007).

There is a need to integrate human perspectives into the functional paradigm of VP development. Individual utterances require a considerable adjustment of vocabulary, grammar, emotional tone, and rhetorical strategy that overcome traditional VP techniques. Subsequently, technical issues raised along the studies entail harnessing
sensing technology and affective computing in patient simulation for more believable and persuasive computer-mediated communication interfaces. It has been suggested to look at adaptive interfaces with advanced branching capabilities, where dynamic scripts, based on student’s actual activity and affective states, could easily scaffold a complex variety of paths through the virtual patient session. Hence, the seamless integration of human-like avatars, data probes, biofeedback with sensors, and advanced communication technologies in educational scenarios would allow more targeted and compelling virtual patient experiences with heightened presence and optimized flow. Developing hybrid models of simulation methods, as suggested in Study III, could be an additional option.

Embedding cutting edge features of augmented reality into patient simulation would thus be a powerful way to enhance learning content and promote deeper engagement. This could also significantly contribute to the development of innovative medical simulation curricula.

However, sharing sense data, like physiological states, will raise ethical concerns that the medical simulation community will need to deal with.
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Olivier Courteille
10 REFERENCES


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11 SUMMARY IN SWEDISH

Syftet med denna doktorsavhandling var att undersöka frågeställningar kring emotionell inlärning, upplevd effektivitet och studenters motivation och engagemang vid datorsimuleringar av patientmöten. Eftersom det interaktiva patientsimuleringssystemet, Interactive Simulation of Patients (ISP), som är en virtuell lärandemiljö, uppvisar en hög grad av realism, autenticitet och interaktivitet, ansåg vi det vara ett lämpligt tekniskt hjälpmedel för utförandet av denna forskning.

Fyra studier genomfördes inom ramen för denna doktorsavhandling: Studie 1 undersökte om delade virtuella patientmiljöer kunde främja studenternas inlärning och stöda den gemensamma inlärningen. Studie 2 utvärderade ISP-liknande systems potential som möjliga verktyg till examination av läkarstudenters kliniska resonemang och problemlösningsförmåga. Studie 3 undersökte hur läkarstudenter upplevde en integrerad virtuell simulering av en endoskopisk operation genom att undersöka de potentiella fördelarna med denna typ av kontextualiserad upplevelsebaserad inlärning. Studie 4 syftade till att utvidga de vetenskapliga forskningsresultaten från de föregående studierna samt att uppnå en bättre förståelse för studenters känslor av ”patientnärvaro” och deras reaktioner inför ett video- och patientmöte.

Resultaten gav underlag för ett antal slutsatser om ISP-liknande lärandemiljöer:
• De uppfattas som övertygande, innovativa, realistiska och effektiva lärandeverktyg.
• De stöder studenters aktiva engagemang för klinisk problemlösning.
• De verkar motivera studenterna pga. att lärmiljön är meningsfull, autentisk och kontextualiserad.
• De stimulerar studenters engagemang för läraområden och har potentialen att främja social interaktion.
• De uppmuntrar till kritiskt tänkande och förbättrar inlärningen när de virtuella patientfallen löses i en kollaborativ lärandemiljö.
• Avancerad interaktivitet, naturlig konversation, gränssnitt och den videofilmade patienten (skådespelaren) är nyckelfaktorer för närvarokänslan och det emotionella engagemanget.
• Denna typ av system har förmågan att uppriva och simulera realistiska patientmöten med en acceptabel komplexitetsgrad samt tillätta en differentiering av studenters prestationer för examinationsändamål.
• Denna typ av system skulle kunna förbättra kontextualiseringen och höja autenticiten i integrerade verklighetssimuleringar

De fyra studierna visade att verklighetstrogena datorbaserade patientsimuleringar av det kliniska mötet är lämpliga tekniska medel för att aktivera, motivera och engagera studenter och resulterar i möjligheter till effektiv kunskapsbyggnad, bättre förståelse för situerade upplevelser, ökad tilltro till klinisk problemlösning samt förbättrad minnesretention.

Nyckelord: Virtuella patienter; medicinsk simulering; emotionell inlärning; datorbaserad kommunikation; upplevelsebaserad lärande.
12 APPENDIX

12.1 STUDY I

12.1.1 Interview Guide Global Trials

ISP-VL GLOBAL SESSION
(Karolinska Institutet, Uppsala and Stanford Participants)

1. What did you like most about this learning experience?
2. What did you like least about this learning experience?
3. How would you change the case and/or session to make it better?
4. How did you feel about collaborating with the students at the other sites (Probe: did it help you learn?)
5. How helpful was the facilitator? (Probe: at your site? At the remote site?)
6. What changes would you recommend to make the computer cases better?
7. Do you have any other comments about this case or this collaborative learning experience?

12.1.2 Interview Guide Local Trials

ISP-VL LOCAL SESSION

1. What did you like most about this learning experience?
2. What did you like least about this learning experience?
3. What did you think of the computer-based clinical cases?
4. What did you think of the ‘paper-based’ clinical cases?
5. How would you change the cases and/or session to make them better?
6. How did you feel about collaborating with your learning partner/peer? (probe: did it help you learn?)
7. How helpful was the facilitator led case discussion? (probe: did it help you learn?)
8. What changes would you recommend to make the computer cases better?
9. Do you have any other comments about the computer-based cases or this learning experience?
12.1.3 Interview Guide

Legend:
RQ: Research Question
FQ: Follow-up Question

• You just run and tested a new educational model (learning aid?) called ISP. What are your first reactions and comments?
  Alt. Question: What were your expectations before trying ISP?
  \( \text{(RQ: look for positive and negative attitude; the goal was to awake spontaneous descriptions from the interviewees.)} \)

STRUCTURE AND DESIGN
• What is your opinion about ISP as a learning modality/tool?
  \( \text{ \( \text{RQ: Best/worst} \) } \)
• Do you think ISP program was constructed in a such a way that you had the possibility to apply your knowledge?
  \( \text{FQ: (if yes) Can you give concrete examples?} \)
  \( \text{(if no) Why? What did you miss in the simulation? How should it be designed?} \)
• What is your opinion about the medical history-taking section? How did it work for you?
  \( \text{Possible FQ: Can you tell me more?} \)
• You just used ISP program together with a classmate. How was it to work in pairs (together with someone else)?
  \( \text{ \( \text{RQ: more engaging in collaborative mode?} \) } \)
• There are propositions to use ISP-like programs for assessment – What do you think about that?
  \( \text{(If yes) - for which level in the curriculum?} \)
• Can you give examples of knowledge and skills that you judge as appropriate respective inappropriate to be assessed by means of ISP-like programs?

FEELINGS/LEARNING EXPERIENCE
• Was ISP stimulating or fun to use?
• Have you used similar teaching aids in another context, like games or similar systems/programs that enable communication with a simulated person?
• How do you perceive ISP compared to paper cases?
  (RQ: Is ISP more motivating and/or engaging than paper cases?)
• How did you experience this way of solving clinical problems?
  (RQ: Did your engagement arouse when you used the ISP case?)
• How did you experience the meeting with the virtual patient (authentic? realistic?)
  (if realistic) What contributed to perceive it as realistic?
• What did you think of the possibility of free communication in the history taking for you?
• Did the communication between you and the virtual patient arouse (awake?) any kind of feelings?
  How did the Elisabeth’s (i.e. patient name) story affect you?
• How trustworthy did you feel the simulated patient’s performance/behaviour?
  In which way?
• What is the value of motion picture (i.e. video clips) with voice of the patient?
• Do you believe that the size of video image had any significance, if yes what then?
  FQ: Are you moved when you see the patient from a close distance / In close-up?
• What does the direct feedback mean to you?

COMPARISON BETWEEN SP (STANDARDISED PATIENTS) AND ISP
• What are the advantages of standardized patient (SP)?
• What are the advantages of ISP?
  (RQ: best/most appropriate in which context/setting?)
• How would you describe ISP to a student who never tried it?

CONCLUDING
• Do you want to add anything?
• Is there anything I should have asked?

The interview person is then acknowledged for the participation