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AVATAR
–
SAVING LIVES IN
VIRTUAL WORLDS

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我听见 我忘记; 我看见 我记住; 我做 我了解

I hear and I forget; I see and I remember; I do and I understand

Confucius

To my beloved ones –
Renée, Edvin, Simon and Adam

ABSTRACT

In medicine, education and recurrent training is fundamental for efficient and safe care. In emergency situations one has to rely on robust protocols that reduce the risk for errors. However, today there is plenty of evidence that the professional level of knowledge, manual, cognitive and teamwork skills as well as suitable attitudes needs to be raised. By using new and promising educational technology it has been proposed that one can address several problems in today's education and training. So far, in medicine there haven't been many results on whether gaming technology supports learning although findings from several authors are encouraging. One area of particular interest is that of cardiopulmonary resuscitation (CPR), since all health care professionals are assumed to possess competence in this field. To disseminate the knowledge and skills, with the goal of reaching better outcome after out-of-hospital sudden cardiac arrests, CPR is also trained at schools.

With the rapid development in information and communications technology (ICT) and the increase in computer access and skills in a digital native generation, the stage is set for "serious games". By using cardiopulmonary resuscitation as a model, **the aim** of this thesis project has been to understand if a virtual world is suitable for training medical and high school students to assist in emergency medical situations.

A virtual world with capabilities to train teamwork CPR was developed. Short scenario based training sessions using a virtual school environment was carried out in teams. In **study I and II** user experiences and reactions were assessed from a social cognitive and games research perspective. The findings in terms of strengthened self-efficacy beliefs and positive ratings on dimensions of "flow" experience indicated that this tool could engage the subjects and carried properties important for learning and execution. Results from Swedish and US high schools were comparable. **Study III** was a transfer study in which virtual world pre-trained groups were assessed and compared to control subjects in a full-scale high fidelity patient simulator, 6 and 18 months after virtual world CPR team training. Main findings in this study indicated that subjects trained 6 months before simulator assessment delivered higher quality CPR in terms of chest compressions, and followed the CPR protocol better than the other groups. In **study IV** the aim was to get a more complete picture of how the virtual world CPR team training was perceived by the participants and compare the findings with theories on learning and serious games. Using a qualitative approach, four categories evolved as end result. The findings support many of the proposed benefits of serious games, such as high levels of enjoyment and engagement. Further, learning in teams is beneficial for several reasons. However, there are areas that call for some caution. It can be questioned if a sense of mastery created in a virtual world easily transfers to the real world. Also, not all students are enchanted by computers and computer games – when establishing training in virtual worlds one has to consider the level of computer interest among the users. To evoke the proposed positive effects of virtual world training, one has to meet the demands this game derived method poses in terms of high levels of challenge, proximal goal-setting, affective involvement and rich feed-back.

Although being exploratory to its nature, the results from this project demonstrate possibilities within virtual worlds for training in teams. Being accessible, relatively inexpensive to run and rich in variations, virtual worlds based training can be motivated in a variety of settings within medicine.

LIST OF PUBLICATIONS

I.   Creutzfeldt J, Hedman L, Medin C, Heinrichs WL, Felländer-Tsai L. *Exploring virtual worlds for scenario-based repeated team training of cardiopulmonary resuscitation in medical students*. J Med Internet Res, 2010, vol.12, e38.

II. Creutzfeldt J, Hedman L, Youngblood P, Heinrichs WL, Felländer-Tsai L. *Cardiopulmonary resuscitation training in high school using avatars in virtual worlds: An international feasibility study*. J Med Internet Res, 2013, vol.15, e9.

III. Creutzfeldt J, Hedman L, Felländer-Tsai L. *Effects of pre-training using serious game technology on CPR performance – an exploratory quasi-experimental transfer study.* Scand J Trauma Resusc Emerg Med, 2012, vol.20, 79.

IV. Creutzfeldt J, Hedman L, Felländer-Tsai L. *Training CPR by avatars: A qualitative study of medical students' experiences of a multiplayer virtual world*. Manuscript.

CONTENTS

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
BLS	Basic life support
CPR	Cardiopulmonary resuscitation
CRM	Crew resource management
ICT	Information and communications technology
IQR	Interquartile range
MMO	Massively multiplayer online game
MMORPG	Massively multiplayer online role-playing game
MMVW	Massively multiplayer virtual world
MUVE	Multi-user virtual environment
MVW	Mulitplayer virtual world
OLIVE	On-line interactive virtual environment
SCA	Sudden cardiac arrest
SUMMIT	Stanford University Medical Media and Information Technology

1 INTRODUCTION

1.1 LEARNING AND TRAINING

1.1.1 Acquiring competence

With the aim of investigating whether team training in virtual worlds has potential to be used in medical education, let us first turn to a general discussion on the concept of competence, a common goal for education and training. Competence, in the form of knowledge, skills and attitudes, is necessary for perceiving, analyzing and understanding our outer and inner world, for communication and creation, but also for general self-regulative activities such as attentiveness, endurance and self-assessment [1].

Competence is also a prerequisite for performance, but how well we perform in various situations, for example in medicine, is also influenced by many other factors - internal and external [2]. With reference to Nadler's definition, training can be regarded as a continuation of learning, with a specific goal of on-job performance [3][1].

1.1.2 What signifies efficient education?

The characteristics of good teaching have changed during history. For long times focus has been on the teacher – a person that educates. However, in the 20th century the role of the teacher changed. Instead the student as a learner has (again) come more into focus.

1.1.2.1 Pre-understanding and knowledge creation

The dominating constructivist learning theories, essentially based on a relativist paradigm, rest on the assumption that there is no absolute, objective knowledge. Rather the learner has to create his or her own knowledge and understanding [4]. Contemporary approaches, taking stance in the developmental theories conceived by Piaget and Vygotsky's social constructivist theory, highlight important aspects of learning such as the learner's pre-existing knowledge, skills and beliefs [5, 6]. For example, assumptions, conceptual misunderstandings and erroneous interpretations may not be detected in ordinary theoretical assessments, but may later pose major challenges to learning and expanded understanding [7, 8]. Rodgers, in his works on academic learning, emphasizes some consequences this has in respect to the educator and the learning environment. It can be hard to adopt new knowledge, in particular if this challenges important aspects of the identity of the learner [9]. This may require much support, respect and humbleness from the instructor's side. On the other hand, if this succeeds, the learner can acquire new knowledge, expand his or her competence

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[1] In the literature the definitions of learning and training, and their delimitations, are often vague and changing depending on source. Involving several disciplines with different guiding grand theories this is perhaps not surprising. In skills training, often constructivist theories are combined with or replaced by learning theories heavily rooted in behavioural theories. In this thesis these words are used to describe a continuous process, irrespective of theoretic standpoint.

and strengthen the self-beliefs.

The importance of the guiding expert to support new learning is emphasized by many theories. Efficient learning and training on the learner's side involves several internal and external factors, some of which can be modified (such as motivation and self-regulation) and others which cannot (or at least to a much smaller degree - ability). Modifiable individual factors seem to be of major importance to achieve good learning outcomes. Much attention has been directed towards external assistance of learning [10, 11]. This includes guiding, mentoring, providing feedback, facilitating and supporting self-regulated learning. Hence, focus on the educator has changed from that of a subject matter expert that transmits knowledge to a more supportive role. As the learner's self-regulation grows, the teacher's function changes from external guidance to shared guidance [12].

Knowles have described the features of *andragogy* [4]. He claims the importance of increased self-direction among adult learners as well as their greater experience not only increases the amount of pre-existing knowledge, but also moves the motives for learning from the future to problems and interests in present time. Also Kolb acknowledges the concept of pre-understanding in his *experiential learning theory* [13]. Kolb suggests that we learn by using different learning strategies, and that different individuals may have different preferences [14, 15]. However, as Biggs and others propose from a more behavioristic standpoint, various modes of delivery will also be differently suitable to attain the learning goal, depending not only on individual characteristics, but also the nature of the content [16, 17].

1.1.2.2 Self-regulation

"Active learning", stressed in current educational principles, includes helping the learner in using *metacognitive strategies* [4, 18, 19]. These span over different areas that influence how learning is tailored by the individual to his or her needs. Part of *self-regulated learning strategies*, these include goal setting, special task strategies, imagery, self-instruction, time-management, self-monitoring, self-evaluation, environmental structuring, help seeking and several others. Common to training, as well as learning, is that such self-regulating learning competencies are important to learn and cultivate if one sets out to reach high goals [20]. Today there is neurophysiological support for the use of active learning methods in terms of neuronal activation and theories on memory imprinting [21]. As a rule, new knowledge should be approached in a systematic manner; first giving the learner a general idea, thereafter confronting his or her pre-understanding with the new knowledge and then applying the knowledge to finally incorporate it [5]. Although *overlearning* is acknowledged to be effective on retention, in particular for cognitive skills [22], long-term effects are disputable [23].

1.1.2.3 Empirical evidence on efficient training

It is reasonable to believe that knowledge on how training should be performed has existed for as long as people have been trained. More recently in empirical studies on experts, partly based on a model developed by Dreyfus and Dreyfus [24], Ericsson has characterized what signifies successful experts and how training of complex skills can

be structured in order to reach mastery [25]. Describing so called *deliberate practise,* Ericsson points out that experts "deliberately construct and seek out training situations to attain desired goals that exceed their current level of reliable performance" (p.991). Attainment of continuous development is done by seeking a task with a well-defined goal and ample opportunities for repetition and refinement based on immediate feedback. Further, time for problem-solving and evaluation, and a strong motivation to improve is essential [25]. Zimmerman and Kitsantas argue that "attainment of peak level of academic and athletic competence requires more than basic talent and high quality instructions – it also involves self-belief, diligence and self-discipline" [20] (p.509).

Salas and Cannon-Bowers, and Ford argue that good results of training are depending on many factors, from needs-analysis to focusing on individual factors of the trainee [26, 27]. When creating training programs, good results can only be expected when this is taken into consideration.

1.1.2.4 Medical education mostly focuses on knowledge and manual skills

Medical education has by tradition mostly been preoccupied with theoretical knowledge and manual skills. Clearly, it is not enough for medical education to focus on declarative knowledge and repetitive actions. Moving from encountering to applying and performing new knowledge and skills, training is crucial in medicine. Further, capacities relying on more cognitive effort – higher level skills – such as reasoning, problem solving and synthesizing, are of great importance for efficient processes and good outcome in medicine [28]. For training skills – manual, social and cognitive – medical education is still to a large degree an apprenticeship situation. To some part, skills are instructed and trained at skills-laboratories, in practical workshops and through simulations. The advantages of using these methods are several; in clinical practice training opportunities are becoming fewer as today's patients are unwilling to being practiced at. By using out-of-clinic practice sessions the tutors may tailor the training in terms of suitable elements and learning situations that are learner-centered [29].

1.1.3 Theories on self-beliefs and motivation

Theories in cognitive and motivational psychology acknowledge the existence of psychological inner drives that explain certain human actions as being necessary for wellbeing (as opposed to the ideas of human drives only being physiological needs). According to White and several followers, one of these needs is that of competence. This drive is the foundation of what has been named *intrinsic motivation* [1]. Intrinsic motivation, although having its roots in a universal drive, is amenable to influence from the environment [30]. The level of aspiration is affected by social comparison, and has clear relations to goal-setting [31]. Hence, and in accordance to theories of Wheeler and Elliot, motivation is amenable to social and contextual influences [32]. In this context, there seem to be a natural tendency for so called *upward comparison,* which describes the tendency for individuals to compare themselves with peers that are slightly higher achieving. This has been found to be beneficial for the individual, resulting in better achievements when upward comparison is being employed [32].

The drive for competence is also the cornerstone of Bandura's *social cognitive theory* of human functioning [33]. Also according to this, this drive is strongest in the fields that at the time are regarded most essential to the individual. How people interpret the results of their behaviour informs and alters their environments and the personal factors which, in turn, inform and alter subsequent behaviour (*reciprocal determinism*). Humans are engaged in their own development. Bandura recognizes the core features of human agency to be comprised of intentionality, forethought, self-reactiveness and self-reflectiveness [34]. From an individuals' subjective standpoint the level of competence is mirrored by his or her self-beliefs. "Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" [33](p.3). These beliefs have central roles guiding human behaviour.

An individual's self-efficacy beliefs are thought to be formed by external and to some degree internal factors. These experiences and observations are cognitively and affectively processed and remembered by the individual, and help shape social behaviors and cognitive processes [35].

Despite having the same measured level of knowledge and skills, peoples' self-beliefs concerning their competence, may vary widely. People with a high level of self-efficacy are generally of the opinion that they are in control of their own lives and are shown to be encouraged by obstacles to make a greater effort. On the other hand, people with low self-efficacy may see their lives as somewhat out of their hands and are unlikely to grow and expand their skills.

Efficacy beliefs affect thought processes that may enhance or undermine performance. A high level of perceived self-efficacy not only guides action, but also increases engagement and effort as well as perseverance in the face of adversities. Further, perceived self-efficacy influences thought patterns and emotional reactions (e.g. promoting serenity when approaching difficult tasks as opposed to anxiety, stress and depression that might be the case when having a low level of self-efficacy). Much evidence exists in various fields, such as health, sports, business and interpersonal relations, that self-efficacy beliefs heavily influences the persons' attitudes on goal-setting and persistence as well as their achievements [2, 33]. In the area of education, positive effects on academic outcome and self-regulated learning have been demonstrated by Zimmerman [36]. By assessing the individuals' self-efficacy beliefs we can find a correlate for future performance, and by considering the input and cognitive processing of self-efficacy related information, we can understand and intervene at the subjective basis for a person's achievements.

Since social cognitive theory postulates how we are involved in acquiring competence, it is commonly used to understand the learner and the learning situation. Four observational learning processes are identified: The process of *attention* deals with extracting useful information. *Retention* involves transformation and creating a memory trace (which can be strengthened by cognitive rehearsal). *Production* is the performance of the observed behavior and *motivation* is defined as the intensity, valence and persistence of learning-directed behavior [21]. Aiming for positive training

effects, all these aspects should to be considered.

A theory close to the social cognitive is the *expectancy-value theory* developed by Eccles and colleagues [37]. This also stresses that achievement choices are impacted both by expectancies for success (depending on self-efficacy beliefs), but it also acknowledges the impact of the so called task values, which are in turn dependent on the short- and long-term goals of the individual [5, 38]. These goals are operationalized through personal interests and feelings of self-determination.

Bandura and Eccles have directed interest towards gender differences in self-beliefs. Today there is some evidence of higher self-efficacy among males in certain domains and contexts [33, 39]. However, there seem to be a great deal of variation and – as predicted by Bandura's theory – self-efficacy can be modified by many factors.

According to Deci and Ryan's *self-determination theory*, in order to fully understand motivation one has to take three basic human needs into consideration – the needs for autonomy, competence and relatedness [5, 30, 40]. In social cognitive theory the human desire for autonomy is regarded more implicitly and not recognized as a specific need [41].

Influencing motivation and engagement is of major importance for education and training. Given the human drive of exploration and search for competence in the above mentioned theories, many ways to affect this have been suggested.

1.2   SIMULATIONS AND PATIENT SAFETY

1.2.1 Simulations and visualizations for surgical and diagnostic proficiency

In line with trends and changes in society overall, as new generations of teachers and students enter medical school, they are used to, and to some degree even expecting, new methods of teaching and training. Demonstrations, visualizations and simulations have to some part moved from the real world to the virtual realm. Hence videos on the internet, anatomical and physiological simulations and patient cases are commonly moved to the virtual arena of computers. Advantages of this may include accessibility, individualization in terms of level of difficulty, cost and less need for professional educational support. Visualizations and simulations may facilitate learning by augmenting, simplifying or varying the tasks and the feedback [42]. Simulating a patient case by using so called Virtual Patients is a feasible and effective way of individually learning in areas such as diagnostic skills and clinical reasoning in medical school [43, 44].

Using virtual image-guided skills training in different types of endoscopic and image-guided surgery or intervention is an evidence-based way for improving skills of physicians and students [45]. Training in surgical simulators increases quality and reduces time when evaluated in real-life surgery [46-48]. This has been shown in various surgical settings and currently such training is employed in many specialty training programs within medicine [49, 50]. However, Kneebone sketches skills centers

as "seductive places". In order to be effective, several conditions have to be fulfilled when using clinical simulations for learning [28]. These include the use of a deliberate practice model in a safe environment which is part of a defined curriculum, access to expert tutors at early stages, connection to real-life clinical experience, and a supportive, motivational and learner-centered milieu. "Pre-operative warm-ups" and case-specific simulator training are examples of the continuous development within the area of surgical simulation [51, 52].

1.2.2   Safety concerns and teamwork

In particular in the last two decades communication and teamwork, dealing with the multi-personal and multi-professional dimensions of care, have been recognized to substantially contribute to errors occurring in medicine [53]. Teamwork affects outcome [54]. In various areas inefficient teamwork, poor communication, and cultural issues have been recognized to be major contributors to medical harm [55-60]. By tradition physicians and nurses are trained separately, with much emphasis on professional knowledge and skills [61]. Currently, being recognized as a high-risk organization, more attention has been directed towards multi-professional team-training and routines for safe communications and hand-overs in healthcare.

There are many different stressors in the medical work environment [62]. Inexperience to deal with these requires systematic training in both simulated and operational settings. From applied research fields outside of medicine – work psychology and human factors – much general knowledge has been adopted to medicine regarding the requirements for individuals and groups when faced with sudden high-stakes challenges [63-65].

Non-technical skills, such as effective teamwork and stress management, are recognized as non-innate skills which can and should be practiced [66-70]. This involves combining necessary skills with relevant teamwork related attitudes. In medical education teamwork related behaviors and attitudes are mainly approached by training in educational clinical environments and through multi-professional patient simulations, the latter also covering aspects of recognizing and coping with stress. Although historically questioned, accumulating evidence indicates that training efforts using full-scale simulator training for multi-professional teams can modify behaviors and reduce the incidence and consequences of medical errors, hence decreasing morbidity and mortality within health care [71-76].

1.3   LEARNING WITH DIGITAL MEDIA IN MEDICINE

1.3.1   Learning in the digital native generation

With a history dating from 1947 when media-supported instruction was found to be more effective than traditional education, "e-learning"[2] has been shown to be on the same level of effectiveness as traditional, class-room based learning [77]. The boost of

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[2] The description of e-learning varies. According to Wikipedia "e-learning refers to the use of electronic media and information and communication technologies (ICT) in education. E-learning is broadly inclusive of all forms of educational technology in learning and teaching" (Wikipedia. http://en.wikipedia.org/wiki/E-learning. Accessed on April 22, 2013).

e-learning is propelled by the developments on ICT hardware, software and increased computer skills in the population. Today almost everyone is a computer user. A generation of *digital natives* has grown up to early adulthood. According to Prensky, acknowledged as the founder of this term, this generation is defined by its familiarity with computer technology [78]. It has been suggested that the digital natives to a higher degree than previous generations involve in parallel processes and multi-tasking and expect to have immediate access to a multitude of information [79, 80]. Further, it is assumed that they prefer graphics before text and function best when networked. The higher speed of accessing and the increased availability of information might be one reason for the hypothesized thrive for instant gratification and frequent rewards in this generation. Others have questioned the existence of the "digital natives" [81, 82].

The learning premises characterizing ICT-based education and training are well suited for learned-centered education, as pointed out by O'Neill and McMahon [83]. However, after initial enthusiasm, concern around e-learning has emerged. Lack of face-time between students and teachers has been mentioned as a risk. Also, critics have warned that deep learning cannot be achieved [84]. Although e-learning has received much attention, only in recent years quality and assessment issues have gained interest [85]. In general e-learning is believed to support and develop the user's self-regulatory learning [86, 87], but how well guidance is moved from the distant teacher to the learner (as suggested by many learning theorists) is not entirely elucidated. Another issue is how well learning theories, such as experiential learning theory, is transferred from the traditional learning environment to a virtual e-learning context [88, 89]. Further, cultural differences in network-based learning systems have turned out to be large [90-95].

The *stereotype threat* represents a phenomenon coined by Steele [96]. He claims that competence is much more fragile and malleable than we tend to think. The stereotype threat moderates the achievement of individuals that are subjected to it. Statements such as "girls are less talented than boys in mathematics" might be self-fulfilling. The stereotype threat has been shown to exist in many situations, besides education and training also in computer use [97]. It has been suggested that anxiety, expectations, reduced effort or increased cognitive load may be mediators of the effect. Steele concludes that "often feeling competent matters more than becoming competent" [96](p.450).

1.3.2 Serious games and virtual worlds[3]

Experimentation, visualization, simulation and modeling have been parts of traditional education and training. With the rapid growth of electronic leisure games (i.e. computer- and video-games) these activities have moved into a new context. The appealing characteristics of computer-games have been identified as beneficial to

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[3] In the computer- and video game literature, virtual world technology is described as Massively multiplayer online games (MMO), Massively multiplayer virtual worlds (MMVW), Multiplayer virtual worlds (MVW), Massively multiplayer online role-playing games (MMORPG) and Multi-user virtual environments (MUVE). Some authors have defined established taxonomies in this field. However, currently no general praxis is established, possibly due to the rapid evolution in this area. Through this text mainly "virtual worlds" or "virtual environments" will be used.

learning and the amount of time spent in such activities has been interpreted as a sign of their potential for engagement [98].

Przybylski, Rigby and Ryan have applied Deci and Ryan's self-determination theory to explain the appeal of video games. By addressing the 3 fundamental needs associated with self-determination, video games are identified as having intrinsically motivating capacities to various degrees [99]. Klimmt and coworkers have found an association between the level of effectance and enjoyment [100].

So called *serious games* have been defined as "digital games used for purposes other than mere entertainment" [101]. Their raison d'être, according to Ratan and Ritterfeld, is their ability to facilitate deep and sustained learning and to reach wide audiences by building on the native language of the "Games generation" [102]. In serious games the advantages of e-learning are supposedly combined with those of computer- and video-games – "the most engaging intellectual pastime we have ever invented" [103, 104]. Ritterfeld expresses the promise of serious games depending on 3 factors (table 1) [105].

Table 1. The potential of serious games for learning according to Ritterfeld.

The intrinsic motivation found in game play
The responsiveness in the game environment giving rise to immediate feedback to the user
The possibility for the content to be complex enough to give rise to learning opportunities

This proposition is also supported by others [106-109]. A model for game play is presented by Garris, Ahlers and Driskell in which input factors gives rise to the "game cycle" of engaged game play [110]. The common feature in computer- and video games of long-term goals being supported by sub-goals in near time is congruent with Bandura's notion that "self-motivation is best sustained through a series of proximal subgoals that are hierarchically organized to ensure successive advances to superordinate goals" [33] (p.134). Evidence is accumulating that serious games are beneficial for learning, although there is still a lack in systematic studies and large heterogeneity among those reported [111, 112].

In a games context, virtual world environments represent a special type of visual video-game technology. They can be defined by giving the users a perception of being present in the on-screen representation of the environment, and through the use of avatars to interact in it [113]. Virtual worlds are also used for serious games. By immersion in the environment, they may be used for exploration and visualization and direct interaction with others as well as the environment in real-time [114-116]. Jarmon and coworkers suggest that virtual world learning supports an experiential learning model [117]. In the virtual environment the typically active learner changes the role of the teacher, as pointed out by de Freitas and collaborators [106].

1.3.3 Studying virtual worlds

Different aspects of virtual worlds have been studied, such as user perceptions of a particular game or game genre, characteristics of the interface and their consequences, and short- and long term effects on the user [118]. With the focus on the game, variables that commonly have been assessed are how the virtual environment is perceived in terms of immersion, presence and flow. Birkenbusch and Christ address how these constructs partly are related, and how they are operationalized in varying ways by different researchers [119]. For example, some regard immersion as a psychological state during virtual world interaction, whereas others look at this construct as an objective description of the virtual environment system and its technology. It has been found that a high degree of immersion and engagement predicts greater enjoyment and more time spent with the particular game [120].

1.3.3.1 Flow experience - concentration

A concept that may be of importance when engaging in a task is that of *flow*. Resting on ideas from beginning of the 20th century, Csikszentmihalyi developed this proximal theory of motivation. The ability to enjoy challenges and then master them is a fundamental meta-skill that is essential to individual development. Individuals fully involved in a specific activity tend to find the activity enjoyable and rewarding. The experience of flow is defined as an internal state of total focus, involvement, and absorption in an ongoing task associated with positive feelings [121]. Flow seems to work in close relationship to the intrinsic motivation in that it is the monitoring of the present compared to goals and self-beliefs, as well as the level of challenge [122, 123].

Attaining a high degree of flow implies the subject being highly engaged and motivated to continue in the activity [121, 124, 125]. Which component that accounts for the flow experience has been debated. Choi and Baek have found that representational fidelity and interactivity are factors of a virtual gaming world that mostly contributes to the flow experience [126]. Chen, in a study on internet use, used some dimensions from the flow construct to characterize the flow experience (table 2) [127].

Table 2. Main dimensions characterizing the experiential stage of flow during web use according to Chen.

Telepresence
Time distortion
Concentration
Loss of self-consciousness

This compound index, that we in turn have called *concentration*, is closely related to *focused attention* which is a skill to selectively focus on relevant information in the task(s) at hand and ignore distractors such as anxiety, mistakes, and negative thoughts [128]. It is not entirely viewed as a function of perception, but as one of several hypothesized executive functions of the human mind. As such, it is a system that controls and regulates basic cognitive processes. Styles has shown that concentration is

positively correlated with effective teaching and learning [129]. It may also be an important characteristic of computer based learning.

1.3.4 Serious games and virtual worlds in medical education

Serious games may be used to shape and improve behavior. In medicine, use of virtual worlds have been reported in a variety of settings with different target populations [130, 131]; e.g. patients for therapeutic or interventional reasons [132-139], and students and staff for learning and training [140-156] as well as assessment [157, 158]. In general, results in the area of psychotherapy are promising [135]. Also, the suggestive properties of serious games and virtual environments may have great potential within medicine [133]. Within the area of learning and training, subjects most often report appreciation and enjoyment, but there still is a definite lack of outcome based results. Positive effects were reported by Knight and coworkers after practicing major incident triage in a virtual environment [145], and Vincent and associates after mass casualty training [153]. LeFlore and colleagues reported better knowledge acquisition and application amongst nursing students who learned pediatric respiratory evaluation in a virtual environment [146]. Further, Mitchell et al found positive effects when training motivational interviewing in a virtual world [147], and Stevens and coworkers reported knowledge structure to become more expert-like after medical students trained in a virtual case displaying a head trauma [149]. However, few areas are studied, group sizes are small and results on transfer to an everyday health care setting are absent. As Kharrazi and co-workers claim, at this time it is difficult to make any comparative studies due to heterogeneity in evaluation methods, small sample sizes and short follow-up periods [159]. Akl and collaborators draw similar conclusions [160].

1.4 CARDIOPULMONARY RESUSCITATION AS A MODEL FOR PROCEDURAL TEAM INTERACTIONS

Sudden cardiac arrest (SCA) is one of the most common serious conditions in medicine. It is therefore not surprising that pathophysiology, recognition and treatment of this has been extensively studied. Due to its sudden occurrence, often without alarming prior signs, and the criticality of time, much effort has been spent on public education with the aim of starting out-of-hospital cardiopulmonary resuscitation (CPR) before the arrival of paramedics. For many years the main initial treatment during SCA has been chest compressions and ventilation. As soon as possible cardiac electric activity should be controlled in order to treat a "shockable" electric cardiac rhythm. Regularly international treatment recommendations are developed and revised. In the more recent revisions the notion of "the chain of survival" has been recognized and post-arrest care emphasized. The goal of these activities has been to reduce mortality and post-arrest morbidity. However, despite implementation of CPR guidelines, often the results following cardiac arrest are disappointing. An encouraging observation is that there seem to be geographical areas of excellence [161]. Without other explanations some regions in the world demonstrate results that are considerably better than average. According to the present model, better results indicate that the chain of survival begins earlier and is stronger in these areas. Besides quicker responses from the emergency medical system, a possible factor could be more active bystanders,

initiating effective CPR at an earlier point of time [162-164].

In recent treatment recommendations, known obstacles for effective CPR have been addressed [165]. How training should be carried out has been the topic of a considerable amount of research. Only covering knowledge and procedural skills in a standard class-room setting is a weakness and point of critique against previous traditional CPR-courses [166, 167]. Also, there seem to be a rather rapid decay of CPR knowledge and skills [164, 168-171]. Possibly the mode of instruction and the engagement of the trainees might contribute to this decay. In some organizations there are plans for repetitive CPR training, but often this is lacking. Often CPR-training is a onetime occurrence. Critique has also been raised against CPR training that hasn't been learner centered [172]. Several researchers have pointed out how inefficient teamwork (e.g. lack of clear role assignment, poor workload distribution, lack of situation awareness and ineffective communication) contributes to poor CPR [173-178]. Recently attempts have been made to identify specific effective teamwork behaviors in CPR [179]. Also, human factors, such as working conditions and stress, have traditionally not been included in the CPR curriculum [180]. To deal with this, efforts are now undertaken to assist performers of CPR with cognitive support [181-185]. In addition, in recent guidelines some of the above problems have been addressed [165]. Focus on scenario-based team training and effective instructional strategies are recommended.

In general, traditional CPR curriculum has been focusing on knowledge, presented either as reading assignment or as lecture, and procedural and manual skills, often demonstrated on video vignettes. Several suggestions for alternative instructional approaches have been made [186-196]. By reforming instructional design and method of delivery, the ambition has been to increase retention of relevant knowledge and skills, strengthen learner self-beliefs, decrease costs or increase accessibility of CPR-training/re-training.

2 AIMS OF THE PROJECT

The overarching aim of this project has been to increase knowledge and to investigate if virtual world team training has the potential to be used for medical emergency team training. The specific aims of the included studies were:

Paper I   In addition to finding a feasible way to carry out virtual world team CPR training, the aim was to investigate how this would influence medical students' conditions for learning, as well as assessing their subjective experiences. The hypothesis was that using a virtual environment for CPR team training would render strengthened self-efficacy beliefs.

Paper II   The aim of this study was to investigate if a virtual world would be suitable for training high school students (i.e. digital natives) to respond appropriately to a medical emergency requiring CPR teamwork by evaluating their experiences, self-efficacy beliefs and concentration during use. Hypotheses were that virtual world CPR team training would be associated with high levels of concentration and that self-efficacy beliefs would be strengthened, further that a correlation between concentration and self-efficacy would be found.

Paper III   The study aimed at following up whether medical students, previously CPR team-trained in a virtual world, had retained knowledge and skills, and if they were able to transfer their proficiency gain to a full-scale simulator environment. Further, the aim was to investigate if virtual world training would support additional learning. The hypothesis was that subjects who had received virtual world training would perform CPR more correct and efficiently than their peers.

Paper IV   Following up results from previous studies, the aim of this study was to establish better understanding of the Swedish medical students' perspective in terms of how they subjectively react to and perceive multiplayer virtual world CPR team training. By using a qualitative exploratory method, results would be rich enough to be compared to established and suggested theories and models on serious games.

3 METHODS AND MATERIAL

3.1 OVERVIEW AND EPISTEMOLOGICAL CONSIDERATIONS

3.1.1.1 *What knowledge does CPR consist of?*

What does the practice and training of CPR – and other emergency medical procedures for that matter – consist of? Depending on philosophic standpoint, the answer will vary. Aristotle explained what *episteme* consisted of and how it should be attained [197]. Then, does CPR-training consist of this, or are we searching for something apart from declarative knowledge? From an epistemological view, there certainly are parts of knowledge in CPR defined by this Aristotelian term, but also of so called *phronesis*, practical wisdom – today perhaps translated to *tacit knowledge*. However, probably the trainee in a CPR class would mainly look upon the curricula as full of what Aristotle defined as *techne*, commonly translated into craftsmanship. As implied by current deficiencies in CPR practice, these aspects might not have been considered when constructing CPR-training. Another question is which values we put into the different Aristotelian descriptions of knowledge. Today, commonly techne and phronesis are regarded as knowledge in their own rights [198].

3.1.1.2 *Current ideas of CPR – objective, effectiveness and outcome*

Traditional emergency medical education to lay persons is mainly directed towards recognizing and making the decision to follow a certain procedure. This is a way of dealing with simplicity for safety – following a scheme based on heuristics is arguably the safest way to manage sudden emergency situations. Also effectiveness issues are important in education; teaching with a minimum of effort, with the greatest impact, to as many as possible. From an ethical standpoint it can be justified that education in emergency medicine, especially amongst lay persons, should be centered much on cost-effectiveness. This in turn would enable us to help as many, as much as possible at a given cost. Hence, finding ways to implement an "effective" training seem to be of highest priority.

3.1.1.3 *Risks not to include subjectivity - implications*

Through the commonly occurring natural science spectacles, we might prefer to look at emergency medical training in a very objective way. With the aim to find an as effective form of training as possible, it is tempting to look on education and training as an instrumental process. However, as Gustavsson points out, this introduces a risk and may be counter-productive [199]. Pursuing this view can make us loose connection to deeper needs and virtues of knowledge as well as with ethical and democratic issues. Additionally, there are other, practical, considerations. When studying what works and what does not, we find that motivational determinants, attitudes and context have important bearings on the outcome of training. Forgetting the influence of society, peers, and instructors on the trainees, will prevent us to explain or fully understand the effectiveness of training. Education and training is much a matter of competence beside theoretical knowledge on the particular subject. The successful teacher uses such didactic and psychological competence in a fruitful manner. In research these are factors, hard to control for and difficult to reproduce, that might pose problems, but yet have to be accepted. This brings in subjectivity into teaching. Experimental research

commonly tries to go as far as possible to control these factors, empirical studies rather describe them. The complexity of training is commonly not focused on in the current model for CPR training. However, it implies that we in some aspects must meet the participants on a very subjective level.

3.1.1.4 Learning on learning – focus on subjects

Focusing on what happens to persons who are students or trainees is challenging, irrespective of whether we consider them as objects to be affected by the education, or subjects who interact with the trainer. Trying to understand what happens during learning – learning about learning – is a meta process, characterized by a demarked distance from the primary process. Further, studying how the training affects the subjects is to focus on their inner world – their perception, cognition and emotions. However, asking the individuals about their conceptions and reflections would actually be a study of their meta-cognition. What are we interested in? Going back to the aims of the research, it means that we have to translate and extrapolate how these processes affect the subjects as to how the training experience is incorporated and used – how attitudes changes and behaviors will become manifest in other, future situations.

3.1.1.5 Different views on education and training

Learning in virtual worlds can be looked upon in different ways. If we use a pedagogic approach we can discuss different learning models such as how to structure the training and set up the learning environment. If we use sociological approaches we may study interaction between the learner and fellow students or any other part of society. Turning to psychology and behavioural sciences, a more fine grained analysis can also be performed regarding how individuals are affected by training itself. The determinant of which paths of theories one should follow is to a large extent dependent on focus, context and aim.

3.1.1.6 Moving across paradigms

In education, when it comes to studying and understanding, one might consider using other methodologies and paradigms than the primary pedagogic effort rest on. Assumptions and theoretical shortcuts in the conceptual models used in teaching and training can justify us to refrain from staying in the same models when studying it. This argument is partly close to the bracketing problem in phenomenological theory. How far away can or should we move from what we are studying? In the extreme objectification we are so distant that we might lose understanding of what we are seeing [200]. Combining qualitative and quantitative data can be essential to get a sufficient overall picture, to understand the findings as well as measuring their impact. In the area of serious games this has already been implied by researchers. Maybe multi-methodological approaches, methodological triangulation, might be easier to establish in this developing area of scientific interest [201].

Acknowledging humans as key drivers of action – initiative, interaction, process and outcome – understanding the trainees will be of paramount importance, as well as how motivation and behavior change in response to external conditions. From a philosophical standpoint there is a bridge between paradigms in terms of dependent and

non-dependent factors although the explanations of the phenomena are the defining incommensurable barriers [202]. The paradigms and assumptions used in this project have been the following:

•An interpretive, constructivist paradigm, suggesting that there are multiple paths to knowledge and that models of relationships and connections between phenomena are established by science. This paradigm suggests that there is no "true" cause-effect model. The qualitative empirical work in Study IV and to a lesser degree Study I and II are examples of this, which by themselves may be hypothesis-generating. An advantage of this paradigm is when a new and relatively unexplored training method, such as virtual world team training, is studied. How individuals behave and relate in the virtual world as well as their attitudes are governed by prior knowledge and other individual factors, which are difficult to explain with natural science terms.

•A post-positivistic, relativistic paradigm, found in behavioral psychology, arguing that peoples' undertakings can be studied in terms of behavior. Largely behaviors, forming the basis for human interaction, can be defined and measured. The goal for training is to generate and form more suitable and effective behaviors. Positive outcome of training is achieved through practice and feedback with gradually increasing difficulty (e.g. deliberate practice). This project is exploratory and evaluative to its nature and a behavioristic paradigm is justified, empirically having a *black-box* perspective on the subjects, focusing on results and how exposure affects these. Further, the scenario-based training model of effective behaviors and structured feedback is largely rooted in this paradigm.

•A positivistic dualistic paradigm is also employed. During activities, we are in different levels of concentration. Also mental workload and stress may vary. These factors could affect our thought processes and our decision-making capability.

3.1.1.7 *Evaluating training*

Study III has partly had a different goal. Evaluation of training has been characterized by Kirkpatrick in different levels [203]. The final level of evaluation in emergency medical training may be the level of service that society receives – good care, little harm. Other outcomes may include changes in attitudes, ability to pass on knowledge and skills to others and so on. In an emergency medical situation, it would seem most appropriate to know if virtual world training made any difference for patient outcome. However, such studies are complicated, expensive and, at least due to the so far unproven usefulness of virtual world team training, may be unethical.

3.2   RESEARCH SUBJECTS AND TRAINING MODEL

3.2.1 Subjects

Table 3 summarizes the methods and material of the studies. The subjects have been male and female students. In Study I, III and IV focus has been on medical students, in Study II the study group has consisted of high school students. Subjects have been described in terms of age, sex, in some studies level of computer game literacy as well as amount of computer - and video game play.

Table 3. Characteristics of methods and material in Study I-IV. Please see text for details. VW=Virtual world. Ctrl=Control

	Study I	Study II	Study III	Study IV
Type of study	Test- retest exploratory study	Dual location test- retest exploratory study	Exploratory quasi-experimental controlled study (3 groups)	Qualitative phenomenological
Recruitment	By invitation	By invitation	Follow up (Study I) and by invitation	Follow up (Study III)
Areas of interest / assessments	Knowledge, self-efficacy, concentration, mental strain, users' perceptions	Self-efficacy, concentration, users' perceptions	Knowledge, performance: time, no-flow time, adherence to CPR guidelines, compression rate	Understanding of medical students experience of virtual world team CPR training
Data collection	Quiz, questionnaires, psychometric instruments	Questionnaires, psychometric instruments	Questionnaires and recordings	Focus discussions
Inclusion time	6 months	Sweden: 6 months US: Same day*	Same day (ctrl), 6 and 18 months (VW)	6 months
Number of subjects	12	Sweden: 12 US: 24	30	12
Females : Males	6 : 6	Sweden: 5 : 7 US: 15 : 9	14 : 16	6 : 6
Study group	Medical students (1st year)	High school (grade 10-11)	Medical students (2nd and 3rd year)	Medical students (1st year)
Age, mean (SD)	22.6 (3.5)	Sweden: 16.6 (1.2) US: 15-16 years old	VW groups: 25.5 (3.9), 22.8 (2.6). Ctrl group: 22.9 (2.0)	21.8 (2.9)

Table 3. continued.

	Study I	Study II	Study III	Study IV
Previous CPR	Within last 3 months	Within last 6 months	Within last 2 years	Within last 3 months
Level of computer- and video game play, median (range)	2 (1-5) / 6**	2 (1-5) / 5	–	2 (1-4) / 6**
Virtual world training	4 scenarios in groups of 3. Two sessions	Sweden: 4 scenarios in groups of 3. Two sessions US: 3 scenarios in groups of 3	4 scenarios in groups of 3. Two sessions	4 scenarios in groups of 3. Two sessions
Methods for analysis	Descriptive statistics. Repeated measurements analysis for time dependent data. Mann-Whitney U test and Student's *t* test for comparisons between groups. Pairwise Student's *t* test for correlated means for within group analysis. ANOVA for multiple comparisons of continuous data. Chi-square and Fisher's exact test for variables in contingency tables. Level of significance: $p < 0.05$.	Descriptive statistics. Repeated measurements analysis for time dependent data. Regression analysis for time dependent changes. Mann-Whitney U test and Student's *t* test for comparisons between groups. Spearman rank correlation for correlation between variables. Level of significance: $p < 0.05$	Friedman repeated measures analysis on ranks for time dependents non-parametric data. Wilcoxon signed rank test for comparisons before-after. ANOVA on ranks with pairwise comparisons for comparisons between groups. Chi-square test for nominal data. Level of significance: $p < 0.05$.	Semi-structured group discussion. Phenomenological data-driven approach (Malterud) using analytical reduction, distillation, aggregation and negotiation

*See study for details
**The scale was in the original paper 0-5, which here is converted to 1-6.

As the nature of the studies was experimental, all subjects were included by invitation and on a voluntary basis. Participants from high schools were invited by their teacher and medical students were recruited by open announcements on bulletin boards and by e-mails to all first semester medical students at Karolinska Institutet. The training model was developed to be suitable for 2-4 subjects as this team-size demands high participant activity during CPR. Hence we aimed at recruiting for training in groups of 3. When choosing subjects among the medical students time of contact (first volunteering were first recruited), sex and practical aspects (possibility to attend during training) were considered. A balance between female and male participants was aimed for. At time of recruitment, the studies were presented as occasions for emergency medical- or CPR training. All studies were approved by institutional review boards (Karolinska Institutet and Stanford University) and informed consent was obtained from the participants.

3.2.2 Technical platforms for the virtual world

In previous research a virtual world developed in Adobe Atmosphere® [204] was used. Simtech was developed as a joint project including Karolinska Institutet, Umeå University and SUMMIT at Stanford University [205]. However, this solution was considered to have too low fidelity and was associated with technical underperformance. Instead, OLIVE (On-Line Interactive Virtual Environment) developed by Forterra inc, San Mateo, CA was used. The relation to Forterra inc. was on a consultancy basis with full cost reimbursement for development and support. This virtual world was designed on an existing platform originally developed for leisure gaming. In the early phases of this project OLIVE was customized for CPR training incorporating necessary features in the virtual environment. Further, the virtual world was equipped with outdoor and indoor life-like environments from San Mateo and Huddinge high schools. In this customized medical version of OLIVE avatars could collapse (and regain consciousness) and basic CPR procedures could be executed by using the computer controls. Communication between subjects in this world was mainly based on voice-over-internet-protocol by the use of headsets with microphones, although a text message feature was also incorporated. Avatars were used to represent the subjects in the virtual world (fig. 1 a, b). Each trainee controlled one avatar (fig. 2). Avatars were also used as victim and paramedic who were controlled by the instructors. Multiple male and female avatars could be used and their appearances (e.g. color of skin and clothing) could be changed since evidence exists that the avatar-representation affects subjects' engagement [206-211]. In the virtual world extra objects could be added such as a telephone (to call the emergency medical dispatcher), an ambulance (for transportation of the paramedic), a gurney, furniture etc.

Figure 2. Avatars performing CPR in virtual world (OLIVE).
a) On the top screenshot a female avatar executes chest compressions in a classroom setting. The line above her head indicates that she is talking – maybe counting as she performs the compressions.
b) The lower screenshot is from the instructor's view. Rescue breaths are administered by a trainee's avatar and a paramedic, operated by the instructor, has just arrived.

Figure 3. Student using standard PC equipment and a headset to communicate with others during a CPR scenario with avatars in the virtual world.

It was assumed that the trainees had some (moderate) computer literacy, but that their experience from virtual worlds varied, including some that might have no such experience. Therefore, before the virtual world training the trainees were familiarized to the virtual environment and basic features in OLIVE. In the studies carried out in Sweden (Huddinge High School and Karolinska Institutet) this familiarization was carried out by letting the subjects experiment how to move around with the avatar, how to communicate and by an instructor-avatar led tour of the environment. The CPR capabilities were also demonstrated. Before the training started, the trainees were encouraged to address technical and practical problems through virtual world interaction. Problems were then resolved. In order to ascertain that the trainees possessed necessary knowledge, the subjects also received a 10 minute lecture covering basic life support (BLS) including the recently modified adult CPR guidelines as well as some other emergency medical protocols (such as the algorithm for foreign body obstruction). Parts of Study II were carried out in the US (Woodside High School, CA). Familiarization for these subjects included a short demonstration of how to control the avatar followed by a warm-up scenario

3.2.3 Scenarios for virtual world team based CPR training

For the training two scenarios were developed, one inside a school and one outside the school building in the parking area. The responses from the victim on the actions taken were manually controlled by the instructor as were responses from the paramedic. The same course of actions was expected; as the victim collapsed with little prior indications beside "my chest hurts", the trainees should be alerted to move to the victim, diagnose circulatory arrest, notify the group and commence chest compressions

as stated by the CPR guidelines. Further, one of the trainees was expected to notify an emergency dispatcher by a telephone call. When calling, there was an automated dispatcher voice response. The rest of the trainees were to continue CPR by administering rescue breaths and chest compression and switching positions as stated by the guidelines [212]. The scenarios continued for 4-6 minutes which was enough to ensure that all these steps were carried out. The scenario was terminated as a paramedic avatar arrived at the scene or, in a few cases, as the victim recovered and regained consciousness. After each scenario the trainees and the training instructor assembled for a short reflection on the scenario. Although the software had recording capabilities, to keep the training focused and the reflection short, the reflection was carried out as an instructor-led structured feed-back. The aim for this reflection was to acknowledge correct behaviors in the scenario and identify measures that should be corrected or modified. In a few cases technical issues were raised and clarified. Overall the real world reflection on the virtual world training lasted between 2 and 5 minutes. Directly after most scenarios, before the reflection, assessments of subjects' experiences were carried out using questionnaires (concentration and mental strain). In all, each subject practiced in 4 scenarios during the training session. Trainees' tasks in each scenario were not assigned, but had to be negotiated within the group.

In Study I and II the plans were to use a training-retraining protocol. This would enable data collection after a period of knowledge and skills decay. Based on findings in the literature and on convenience, a 6 month study period was scheduled for the training sessions [213, 214]. The second session was identical to the first with the exception that the CPR lecture was left out. The assumption was that the groups would have basically the same theoretical platform when the second session started. Although information on decay of knowledge and skills as well as changes in self-perceptions could be obtained using this method, the risk of losing subjects could create a problem. In particular when studying groups, even losing a single subject would create problems for the team in which he or she was a part. Fortunately this didn't occur in the Swedish study groups. In the US study group (Study II), on the other hand the dropout rate was so high that the re-evaluation had to be abandoned. The reason for this was that many students weren't allowed to leave classes for the second session of the study.

Study III was an add-on to previous studies. Except for the control group, the included subjects had previously been CPR trained in virtual worlds. The aim to look on how the virtual world training could be transferred to the real world was in focus for this study. Real-life evaluations of CPR skills (as well as skills covering other emergency medical procedures) are difficult. After focused training of small groups which very seldom encounter these situations and where real-world evaluations is practically impossible, another model for transfer had to be found. In order to study behaviors that would be as close to tentative real world behaviors as possible, and also in order to get as objective and rich data concerning CPR team work as possible, evaluation in a high fidelity simulation environment was chosen. Also during this evaluative training, to ensure equal theoretical knowledge, the session started with some short theoretical lectures. These covered basic life support, and, after the first base-line evaluation, a brief lecture on teamwork was given. The aims for this study were twofold – to identify if preceding virtual world training would have beneficial effects on team CPR performance during an evaluation scenario, and secondly if CPR learning would be different during further

full-scale simulator scenario-based team CPR training. Hypothetically a pre-trained group might gain more and develop quicker during continuing training.

3.2.4 Team based CPR training using a full-scale human patient simulator

The set-up for the full-scale evaluation of team CPR was based on standard high-fidelity simulator laboratory equipment. The environment was a hospital storage room and the CPR-scenarios were recorded. The recordings included audio-video recordings using dual cameras and also recordings on quality of CPR (depths of chest compressions and rate as well as quality of rescue breaths) from the simulator (Laerdal SimMan®, Laerdal Medical). Normally this simulator can display vital signs (e.g. breathing, circulation and consciousness). The first scenario started with a victim shouting for help. As the subjects reached the room they found the simulator-manikin on the floor without any signs of life. As previously instructed, the subjects were then expected to start CPR. Just like in the virtual world scenarios, the groups were expected to follow the guidelines in terms of CPR delivery and calling for help. They were relieved by the course instructor arriving on scene as a paramedic. The scenarios were terminated after 5.5 - 8 minutes, as a short report had been given and the paramedic had switched position to continue CPR. After the scenario the trainees received oral feed-back from the instructor. The following 3 training scenarios were somewhat varied – they included CPR on an unconscious victim laying on the floor (same as during first evaluation), but also CPR on a victim that had been found sitting in a chair and a case were an unconscious breathing victim had been found on the floor. For this victim CPR was not to be delivered, rather just the procedure of *checking airway-breathing-circulation-neurological deficiency and exposing the victim* was expected to be carried out, as dictated by BLS guidelines. After the training scenarios a final evaluation scenario was conducted. This was identical to the first scenario of the day.

The training session during Study III lasted somewhat longer than the virtual world training - approx. 180 minutes compared to approx. 100 minutes for the virtual world training (both including considerable time for questionnaires). Two groups were trained at a time. This gave one group the opportunity to observe their peers conducting CPR during the training scenarios. The observers then contributed during the after-action reflection. As in the virtual world training, this 5-6 minutes reflection focused on the CPR procedure, but also manual skills and teamwork was addressed. These reflections lasted 5-10 minutes. Access to the simulator was only possible during weekends and after work-hours. Due to scheduling difficulties, although 12 subjects were recruited to each of the 3 groups, there was a considerable loss of subjects.

3.3 ASSESSMENT INSTRUMENTS AND DATA COLLECTION

3.3.1 Psychometric evaluations and psychological theories

There is a strong emotional component of learning that has a heavy influence on the acquisition of knowledge and skills [215]. Kraiger and collaborators claim that summative and formative evaluations of various levels of achievement in learning and training should be model-based [216]. This caution in the literature is considered by relating the evaluation work in the studies on applicable theories and models within

social cognitive theory, flow, and human factors research.

3.3.1.1 Self-efficacy

According to Bandura's theories one's sense of self-efficacy can play a major role in how one approaches goals, tasks, and challenges. Also, self-efficacy beliefs influence performance directly and indirectly through motivation, exertion and perseverance and therefore can serve as a measure of competence. Further, they can convey important information on competence that actual performance measures misses, or as Bandura puts it: "The use of performance as the unalloyed index of actual ability should be tempered by considerable caution, however, because performance is usually confounded with interacting motivational, self-regulatory and affective nonability determinants" [33] (p.71). Zimmerman and Kitsantas argue that self-efficacy beliefs exist not only for performance, but also for learning, the latter being predictive for effective learning and consequent performance [20]. Strong self-efficacy beliefs is a necessity to effectively develop skills. Backlund and collaborators have also reported use of the self-efficacy construct as a basis for design of a virtual environment simulator [217].

In Study I and II, perceived self-efficacy, was self-assessed before and after each training session using a five item questionnaire based on a validated instrument. Each item was rated on a 7-grade Likert-type scale. The value for self-efficacy was then calculated as the mean of these items as described by Pintrich and coworkers [218].

3.3.1.2 Concentration

Characterizing the virtual world experience in terms of *concentration* indicates important aspects of focus and involvement. This construct and that of *flow* experience (although somewhat more ambiguously defined) have frequently been used to assess experiences during computer use and in virtual environments [119]. It can be hypothesized that involved participants who experience a flow of work, indicated by a flow experience, or a high level of concentration, are more likely to engage in exercise, which facilitates learning. Another hypothesis is that stronger self-efficacy beliefs, indicative of increased persistence and engagement in the activity, will correlate to deeper concentration.

From a flow-instrument constructed and validated by Chen [127], we selected the items with high consistency used for assessing aspects of concentration (focusing, time distortion, loss of self-consciousness, and telepresence). Concentration was self-assessed by the participants after each scenario on visual analogue scales from 0 to 100, and was estimated by averaging the four input variables, each of which is calculated from separate estimates of two parts.

3.3.1.3 Mental strain

Medical emergency situations, in particular cardiac arrest, are commonly characterized by a high level of stress which can inflict on effectiveness and safety through a number of mechanisms. Mental strain is a process measure of subjective cognitive load. In research, virtual worlds have been used to exert stress among users [219]. According to

Huang and coworkers there is a risk to rely on motivational aspects of the game in such a high degree that they actually may inflict on learning [220]. Such engagement could presumably be detected by high levels of strain.

Methods to assess stress and strain have been developed based on Stevens' psychophysical ratio scales which made it possible to describe stimulus-response functions mathematically [221]. Ratio scales may have better psychometric properties than VAS-scales [222]. By assuming inter-subjectivity in human perception, such as perceptive discrimination and range, and by using non-context sensitive verbal anchors to support subjective assessment, Borg developed the CR10 scale [222]. This scale has been used and validated in a variety of settings. Assessing mental strain in the virtual world is indicative of how the mental workload was perceived in the virtual world training scenarios. This was done by using the Borg CR10 instrument in which the subject was asked to rate the level of mental strain that was experienced during the exercise.

3.3.1.4 Engagement modes

Carver and Sheier claim that the engagement of an individual in a given situation is fundamental for how humans make choices to engage in activities. In their model they incorporate basic human drives and affects which are important for self-regulatory control on what actions to take and with how much engagement this is done. Resting on behavioural approach and avoidance concepts, explanations and predictions can be made on why people act the way they do. Important in the motivation literature, these concepts may have less bearing in the given training situation. However, this issue may have to be addressed when building curricula and creating training opportunities. For example, it may have tremendous effects on explaining if individuals will train and if and how they will perform in the situation they have prepared for [223].

Engagement modes have been defined as different ways of interacting with new information technologies [224] – in the present studies they are the students' different thoughts and feelings towards cardiopulmonary resuscitation training using avatars in a virtual world. Engagement mode might potentially affect the strength of relationship between self-efficacy beliefs and behavior differently in the CPR groups and therefore act as a confounder. For this reason engagement modes were assessed as a background variable in Study I and II.

The negative engagement modes were calculated (sum of scores for the frustration/anxiety and hesitation/avoidance modes), as described by Hedman and collaborators [224]. This was assessed before each session from a 15 item questionnaire using a 5 point Likert-type scale.

3.3.2 Evaluations of knowledge and skills

In Study I, II and III acquired declarative knowledge within the area of CPR and BLS was assessed by means of quizzes in which questions were answered by indicating the right alternatives. The questions were mainly focusing on actions, i.e. of the kind "when the situation is like this, what do you do?"

However, training is primarily focused on skills and behaviors. This could be studied in the virtual world by direct or recorded observation of virtual world behaviors. During Study I and II there were possibilities to do so, but technical malfunctioning as newer versions of the software replaced older ones, and storing the recordings on a central server complicated these attempts and thus were abandoned. Instead these areas were focused on during Study III in which the main goal was to look on how CPR was performed. Here assessments on performance and skills were done mainly by analyses of video recordings. By leaving out a live observer in close vicinity to the trainees, it was assumed that the trainees could feel more at ease with the situation. Also, recordings can be reviewed several times. Studying complex interactions during the brief CPR scenarios was considered more accurate by the use of recordings.

Which performance measures matter during CPR? There seem to be some hard facts – e.g. time before start of CPR as well as quality of chest compressions seems to be evidence based performance measures [225, 226]. Also, stressed by CPR guidelines, is the necessity to keep the interruptions of CPR (i.e. chest compressions) at a minimum – mirrored by the so called *no-flow time* – as well as keeping the compression rate within a narrow interval [212]. Administering chest compressions with correct positioning of hands and using the rescuers body weight to give effective CPR are of importance for safety reasons, but also to be able to continue giving efficient CPR for as long time as possible. The value of rescue breaths has been debated [227]. However, when delivered the aim is to ventilate the lungs rather than inflating the ventricle with exhaled air. All of the above aspects could be studied with the use of recordings [228]. Other non-technical behaviors, related to teamwork in the group could also have been studied, but due to lack of validated scales and trained observers this was not carried out within this study.

3.3.3 Other subjective perceptions, attitudes and feelings concerning virtual world training

Besides levels of appreciation, knowledge is scarce on how virtual world training in medical education is experienced. Therefore the opportunity was taken to gather information on how the participants perceived the virtual world and the scenarios, their immediate feelings on this type of training and how they though it had affected them. After the first two studies, with data recovered from exit questionnaires, there was still much to be clarified – to some extent more questions than answers came up. This was the motive for Study IV in which more in-depths data was gathered. To manage this, data collection in this study relied on focus discussions.

3.3.3.1 Exit questionnaires

In Study I and II exit questionnaires were used. These covered aspects of usability (easiness to use, technical difficulties), usefulness (pedagogic soundness, preparedness and in Study II change in confidence), and quality of the virtual experience (in Study I realism, in Study II immersion). The subjects' rated these aspects on 5-grade Likert type scales. Further, in the questionnaires the subjects were asked how they experienced the scenarios (strengths/weaknesses) and if they felt that they had learned anything by participating in them. These questions were asked as open ended questions

allowing the subjects to answer without limitation.

3.3.3.2   Focus discussions

In Study IV, to get a broader picture of how the subjects were affected by the virtual world training and how they experienced it, data was collected through semi-structured focus discussions. With this aim, based on answers in the exit questionnaires in Study I and II as well as with reference to serious games literature, an interview guide was developed in collaboration among authors. The development and structure of the guide was that suggested by Kvale and Wibeck [229, 230]. The main areas (themes) for investigation were: Focus during training, teamwork, computer/virtual world interface, effects on knowledge and affective engagement. Exploration of affective states among trainees was based on Tomkin's *affect theory*. According to Tomkin affect is one of the sub-systems of the human being and connects the conscious to the unconscious, thought with action and psyche to soma. In this theory there are 9 basic affects which are viewed as inborn autonomous, adaptive somatic reactions with a communicative value and which works as amplifiers [231, 232].

The focus discussions were carried out after the second session of virtual world CPR team training, interrupted only by a 5 minute intermission. Beside the 3 discussants from the training, a moderator was present. The discussions were audio recorded and there was an option for supporting notes to be taken. The lengths of the discussion were between 40 and 48 minutes.
As the study was carried out, probing for the richness of the material was done. Since there are no general rules for how large the sample of informants should be in qualitative research, it is central to assess the material for saturation. With this well-defined and narrow population and experience, saturation was judged to be reached after 12 subjects had contributed in the focus discussions.

3.4   METHODS FOR ANALYSIS

3.4.1   Quantitative methods and statistics

Data on knowledge and subjective experiences were collected by paper and pen. Subjects were encouraged to ask if they experienced any ambiguities or if the questions needed clarification in other ways. In Study I, II and III data retrieval was high, between 1-2 % of data was missing. As a general rule, subjects with single missing data were excluded from the particular analysis.

After data was acquired, the VAS scale-data was processed by measuring the position of the mark on the scale (in 100 mm). To reduce transcription error in this process and when data was inserted in computer spreadsheets, quality check-ups were made on parts of the material.

Knowledge data was on basic life support. However, only part of the content of basic life support was actively trained. Therefore, in the knowledge test (Study III) a post-hoc analysis was performed on the part of questions covering CPR.

In Study I and II the open ended questions in the exit questionnaires (strengths/weaknesses of the scenarios, notion of having learnt something) were processed. The answers were fragmentized to meaning bearing units [233] which subsequently were classified and organized. If a similar answer was given several times by a single participant, it was counted as only 1 occurrence to have it justly weighted during analysis.

In Study III audio and video recordings were analyzed by a trained, blinded final year medical student that had no other connections to this project. Quality assurance measures included re-assessment of some of the recordings by the authors. Times were noted and calculated and rates were calculated. The no-flow time was calculated as the summarized time between chest compression-cycles divided by the number of performed cycles minus 1. The effectiveness of chest compressions and ventilation were determined by analyzing video and simulator data. Chest compression skills were further assessed using a four item scale, based on CPR guideline recommendations (table 4).

Table 4. Assessments of CPR quality in Study III. Each item was evenly weighted for chest compressions and ventilations, respectively. Information from recordings and simulator was analyzed by an external assessor.

Item	Score
Chest compressions	
Correct positioning of hands	1 p
Allowing equal time for compressions and decompressions	1 p
Keeping the arms extended	1 p
Applying own body weight by leaning over victim during compression	1 p
Ventilation	
Ventilating effectively, indicated by chest rising / simulator indicating ventilation	1 p
Checking that the chest raises during ventilation	1 p

Further, it was assessed if the tasks in the CPR protocol were carried out in correct sequence (adherence to guidelines), if the group called for help and if they changed positions as stated by the guidelines. Each omitted step of the protocol (or if occurring in wrong sequence) was regarded as one error.

Descriptive statistics included means (SD) or median (range or interquartile range) depending on scale characteristics and distribution.

As a general rule, parametric analyses (Student's t-test and ANOVA) were used for statistical comparisons of data that was normal distributed, otherwise non-parametric methods were used (Mann-Whitney and ANOVA on ranks). Repeated measurements

analysis (ANOVA and ANOVA on ranks) was used to analyze time-dependent data that was measured several times during training (i.e. concentration, mental strain and CPR performance). Regression analyses were performed to evaluate dependency between some of these variables (concentration and mental strain). Spearman rank correlation (ρ) was performed for correlations (concentration and self-efficacy). For nominal data (correct chest compression frequency), Chi square test was used. Significance levels were set at $P < 0.05$. Calculations were performed by using SAS version 9.1 (SAS Institute Inc, Cary, NC, USA) and SigmaStat version 3.5 (Systat Software Inc, Point Richmond, CA, USA).

3.4.2 Qualitative methodology

Phenomenological research methodology has been pointed out in the literature as an important way to gain information in computer games research [201]. Issues on beliefs, attitudes and subjective reactions can be clarified to further curricular and software development. Also, qualitative methods can direct interest on areas to be studied by quantitative methods at later stages [234].

The researcher using phenomenological methodology uses him or herself as the main instrument for data collection. Therefore the interaction is not only means of investigation, but rather part of the reason. By using rigorous bracketing techniques and equivalents, a sense of neutralization of the researchers own influence is maintained. Phenomenology has its power in the process of understanding phenomena in groups, cultures and other social settings – to unfold the subjective meaning of phenomena to individuals. In qualitative research the concept of richness is important and may be paralleled with the strive for exactness and reproducibility in quantitative methodology.

A phenomenological approach was chosen to reach for the aim of understanding and describing, as well as having the option to compare and adopt the results. Malterud has described a method that to its nature is phenomenological in theory and structure [233]. This method includes a data-driven approach including analytical reduction, distillation and aggregation.

Verbatim transcriptions of the interviews were read back-and-forth independently by 2 researchers. Meaning bearing units were identified in the transcripts and themes characterizing the material were negotiated. A matrix was created in which the identified meaning bearing units were arranged according to theme. Further de-contextualizing, the themes were replaced by codes that were refined, split and combined as the process of connecting the analysis to the transcriptions and notes continued. The analytic process can terminate on different levels of abstraction and theorizing [235]. Themes, categories, models or theories may evolve depending on type and richness of data and ambition from researchers. In Study IV categories evolved as end products – attempts to further refine the material did not seem meaningful.

Quality measures, to increase trustworthiness of the findings, included validation by researchers independently reading the transcripts, and negotiations in the analytic process of distillation and condensation. In this process back-and-forth reading was also done in order to connect the analysis to the transcripts. The end product of analysis,

categories and descriptions were presented to informants willing to assist. Seven subjects took part in this validation.

Another form of validation to increase credibility of the results was through triangulation with results from psychometric questionnaires, primarily self-efficacy, as well as with exit questionnaire data that was collected in Studies I and II [234].

3.5   ETHICAL CONSIDERATIONS

Disseminating knowledge and skills as preparations for emergency medical encounters is certainly an ethical imperative, since this underpins the treatment outcomes in disease and injury. As pointed out, today the problem is not merely that of insufficient knowledge and skills learning, but also issues such as poor retention, low engagement in emergency medical situations, poor teamwork and difficulties in spreading knowledge and skills must be attended to. Finding solutions that can address these problems in cost-efficient ways would increase the chances to save lives.

There are ethical considerations in the use of computer games. In the last couple of decades, a common position in society has been that computer games can be harmful to young people by creating dependency problems, augmenting aggressive traits or changing attitudes and norms [236, 237]. Further, increasing time spent with computers may contribute to physical inactivity. Encouraging the use of serious games could thus be sending counterproductive signals.

Knowledge on serious games in general and virtual worlds is insufficient. Especially in quantitative research, there is a risk that so called "negative results" don't get attention through publication. This can only be influenced by trying to carry out high quality studies with elaborated protocols.

4 RESULTS

This project was in a sense a logical continuation of previous work on early virtual worlds for team interaction. As the project started, there was very little literature on the use of virtual worlds for medical education and training, hence the project was explorative to its nature and, as it progressed, new areas of interest evolved.

4.1 STUDY I

For Study I a refined virtual world with CPR training capabilities was developed and deployed. Not only was this qualitatively on an equal level to commercial leisure games, it was also developed for ordinary use; standard personal computers (PC) could be used, they were connected to a server over internet and the user controls for the avatars were common standard.

The objective in study I was to explore how virtual world emergency medical training would affect medical students.

Findings from this study supported the hypothesis that situational self-efficacy increased after virtual world team CPR training. Also, concentration was on a moderate to high level and rising during training. Mental strain was low to moderate and stable. The subjects enjoyed the training although it was by many perceived as being a bit too easy. There were also indications that differences between males and females existed in this training situation. In the training-retraining model, the results were replicated the second time. It was also noted that the initial increase in self-efficacy was attenuated 6 months after the training. The impression in this study was that the training model and software were robust and worked as intended.

4.2 STUDY II

The second study was partly a replication of the first. Widening the scope to another group of bystander trainees could make the findings more generalizable. Cardiopulmonary resuscitation is already part of the curriculum in many high schools around the world [238]. High impact in this group would be of interest to many educators and students. At the time for the study, high school students in countries with high ICT-literacy were identified as digital natives. Using the training model established in Study I and the same assessment tools would create an opportunity to investigate if our findings from in the first study would be different in these groups.

The training-retraining model that was developed for Study I had to be abandoned in the US group due to an almost 50 % drop out. Hence, some comparisons on changes in self-efficacy and concentration over time could not be made.

The results in Study II corroborated those in Study I; concentration increased as did self-efficacy as hypothesized. Figure 3 displays the findings on self-efficacy from Study 1 and Study 2 when pooled. In the Swedish group mental strain was low. Comparing the US and the Swedish groups, results were similar but concentration was superior among the US subjects. Technical problems in the Swedish group were

experienced to a somewhat higher degree than in Study I. Also, in these groups the training was enjoyed but, by many, considered too easy. The benefits of training to work in a team were mentioned to a higher degree than among the Swedish medical students in Study I. Further, a hypothesized correlation between the level of self-efficacy and concentration was found. Also, at least in the US group, the subjects felt more confident to assist in a medical emergency.

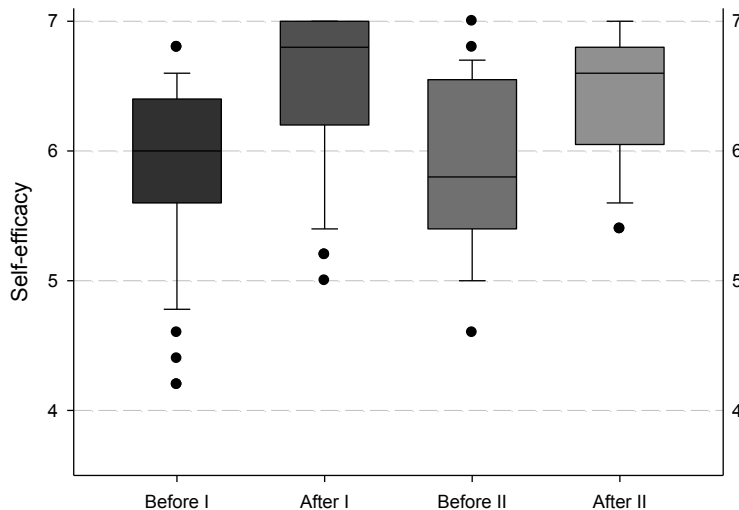Self-efficacy ratings among all subjects in Study I and II

Figure 3. Rated self-efficacy from all subjects in Study I and II. Since there were 2 sessions in the Swedish groups, but just 1 in the US group, N=48 before and after session I and N=24 before and after session II. The box-plots illustrates median and quartiles, whiskers 10th and 90th percentiles. Significant changes in self-efficacy occurred after each training.

4.3   STUDY III

The model used in Study III is a surrogate for real life outcomes. Of course it would be ideal to study CPR skills in a real-life situation, but as with many other hazardous and infrequently occurring events, another solution had to be found. This accounts for the quasi-experimental design. A benefit of using a simulator laboratory setting, on the other hand, was that data collection could be richer and more controllable. Instead of using just one assessment scenario, we wanted to address the dynamics of CPR training. Could it be that the groups would benefit from continuing CPR training in different ways? Using 2 groups that had trained at different times could inform us about decay of knowledge and skills.

As control group, peers from the same population as the 6 month-intervention group (medical school, previously CPR trained) was used. Unfortunately also this study suffered loss of subjects due to practical reasons.

Findings supported the hypothesis that using virtual world CPR team training increased CPR knowledge and skills, still detectable 6 months after such training. A large decay of knowledge and skills had occurred after 18 months. The differences during the assessment scenario were however soon abolished during continuing full scale simulator team CPR training.

4.4 STUDY IV

For the purpose of deepening knowledge about the reactions to and thoughts about virtual world training, a qualitative approach was called for. The focus of interest in this study was the life-world of the participants. Instead of exploring learning and outcomes, such concepts as motivation, immersion and activation and attitudes were looked at. New insights into applicability of concepts and theories when studying this field as well as generating new ideas and hypothesis could inform research and development within the field of virtual worlds for learning and training.

Taking stance in a constructivist paradigm, a phenomenological approach was used during analysis of the focus discussions. By careful methodological structure and execution, by triangulating results with other findings and validating the results with the informants, the goal was to reach high trustworthiness of the results.

Four categories evolved as result of the analysis. These are presented in table 4.

Table 4. After a qualitative analysis, four categories associated with virtual world based team training of CPR appeared.

Focused mental training
The interface takes away focus from training
Benefits of practicing in a group
Easy to lose focus when getting passive

5 DISCUSSION AND IMPLICATIONS

5.1.1.1 The aim – how it was approached

The aim for this exploratory project on virtual world team training in an emergency medical context has been to explore, evaluate and understand this potential training method from an educational viewpoint. The novelty of using serious games in this way has influenced the course the project has taken in several ways. First, theories and hypotheses concerning virtual world based training have been general to their nature. This is not to say that their implications are smaller, but merely that specific models for using it for medical emergency training so far are hard to find. Also, care has been taken to select theories that can be of value when studying the multiplayer virtual world for possible future development and use. Secondly, the explorative nature of the thesis project is due to the same fact. Any hypotheses have been weak and built on assumption from other contexts. Therefore instead of conventional intervention or implementation studies, utilizing broad multi-focused evaluations has been a way to approach this field. Lastly, as the project has developed and new knowledge has been created, it has evolved in directions not foreseen from the beginning. By exposing the participant to a full session of training increased the likelihood of receiving context-dependent results. On the other hand we avoided some sources of error which may occur in a laboratory setting. The aim was to control and account for as many factors as possible that may influenced the results, but at the same time creating a credible basis for the practical usefulness to them.

5.1.1.2 The crave for new technology – serious games!

Today serious games such as virtual worlds are being increasingly used for education. The drives for this are multi-fold: Students are commonly at least as digitally literate as their teacher and often have experienced an impressive amount of computer- or video game play [239]. Solutions to problems and deficiencies identified in current education, whether economic, psychological or social to their nature, are looked for. Advocates for computer- and video games, inventors and early adopters, emphasizes the potential benefits of gaming-derived technologies for education [240]. Probably never before have economic interests in new technology for education been so large. In 2010, market analysts predicted the serious game sector to have an annual growth rate of nearly 50 %. In 2015 global revenue of about 10 billion Euros was expected [241, 242]. The search for a "magic bullet" is not new. History shows us that high expectations are most often unattained. However, when it comes to serious games, the driving forces to introduce them in education are unparalleled also in terms of student demand.

The downside to this enthusiasm is that studies and shared experiences are not always waited for before introduction of serious games in education and training. This may lead to disappointments, suboptimal use of economic resources, ineffective education and other problems [243]. From this view research and evaluations on serious games development and use is imperative and timely.

5.1.1.3 CPR as model. Different goals with CPR training

The virtual world scenario based team training was based on CPR scenarios. Others have studied training for other emergency medical situations in virtual environments [143, 145, 146, 149, 152-154, 156]. In principle, a variety of procedures could be trained using virtual worlds.

The benefits of using CPR as a model are (but not exclusively) pedagogic, motivational and ethic. It is a well described routine of great importance to healthcare. When implementing the training in a new mode of delivery, there already exists much knowledge about evaluation and outcomes. Existing guidelines to some degree defines goal behaviors. Also, weaknesses in current practice have been identified. From an individual standpoint, instructors and trainees can be expected to be motivated for the training and the questions of what, when, how and why do not present as major obstacles. Finding efficient means of training lifesaving procedures to as many as possible is an overarching rationale. Further, the necessity to find methods to easily re-train subjects has been emphasized [244].

On the other hand, there are also some dilemmas with this training model. Cardiopulmonary resuscitation is an evolving procedure. Historically, changes in the protocols occur frequently. What has been evaluated in this study, guidelines emanating from 2005 are already out of date. Therefore it's important to stress that CPR training is merely a model system, i.e. a prototype. Other standardized procedures could also be trained in the future, for example following checklists [148, 245]. Further, CPR, simple as it may seem, is a complex procedure involving psychomotor skills as well as knowledge and non-technical skills [246]. The psychomotor skills (e.g. chest compressions during CPR) have by tradition been emphasized during training. Not being able to practice these aspects of CPR in the virtual world is a weakness that should be taken notice of.

Using a virtual world for learning can have different goals. In training CPR the goal can be to identify the diagnostic and procedural steps and performing them in the correct sequence as fluently as possible. This has certainly been the case in these studies. Another area of interest has been the interaction within the team. Performing CPR in a team setting means that one can depend on other members of the team for physical, cognitive and psychological support. In an inefficient team this can have opposite effects. Teamwork skills, such as role assignment, communication and coordination, are other competencies that can be explored and trained in this model. Hence, the virtual world is mainly used for training, although some degree of exploration can be involved. In other cases virtual world learning may have quite different learning goals, such as theoretical learning, exploration of concepts or social modeling to name a few.

5.1.1.4 Is this training worthwhile?

Then, should we use virtual worlds for emergency medical procedural team training? My short answer is: I believe so. However, there are some clear limitations to this. These will be addressed later. The main reasons to support this notion are:

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- The trainees learn
- The trainees change
- The trainees enjoy

Although small in size, and restricted in populations, in particular in Study III and IV it was evident that the students had gained knowledge about CPR. Also skills, performing what you know, seemed to increase, mirrored by better results among the virtual world pre-trained subjects of Study III, and by comments from the subjects in Study I and II. Of course such learning is necessary in order to argue in favor of virtual world CPR team training, in particular since we today know that repeated training is necessary in light of the skills decay that is bound to occur in an area such as CPR [247].

A large portion of the studies have been directed towards assessing psychological process measures and outcomes of training. The reasons for this have been to better understand how the trainees are affected by virtual world team CPR training. Theories and models of mediating processes are important to understand what happens during this learning. However, it is not certain that all models apply neatly. The aim of Study IV was to understand and compare the trainee's experiences to the suggested ones. Social cognitive theory on development of competence has been used to assess changes in self-beliefs. A clear strength with this concept is the convincing evidence of the fundamental role that self-efficacy beliefs play on performance and attitudes.

As already noted, there is a drive for gaming derived educational methods – at least as long as they associate to the appealing features of leisure video- and computer games [248]. Perhaps the no 1 argument for using serious games is the quality of engagement and fun that is found in the non-educational games. If this is lost in serious games, probably much of the incentive to develop and use them is also lost. Of course, it also depends on what the alternatives are. Serious games can be used to learn by demonstration and experimentation in areas where such alternatives previously weren't practically possible. When it comes to skills training, Rosser and others have shown a carry-over effect from video-gaming to surgical skills [249-252]. The engaging features of virtual worlds are already used therapeutically in various areas showing this quality in non-gaming settings [132, 134, 135]. As reported by the subjects in Studies I, II and IV, also virtual world team CPR training was considered engaging and fun.

5.1.1.5 *Concentration – immersion – flow*

According to theories of engagement, an activity such as learning can be perceived in ways that has causal influence on the level and type of engagement. In a traditional learning setting this may be noticed by the teacher. Possibly, then if needed the teacher can intervene by changing activity, degree of support or assist the student's cognitive reasoning. In serious games, in particular when used for distance education, this may not be so easy. Hence, level of engagement can be of great interest for several reasons when studying virtual world training. Also, indices of flow or concentration are common in games research. With the specific characteristics of virtual environments the degree of immersion may also have effects on engagement. It may be ideal to reach high levels of immersion and concentration since this will contribute to the concepts of intrinsic motivation and self-determination. Probably a high level of concentration has direct

effects on learning through higher levels of directed attention. Also indirect effects of the level of concentration are likely to exist. Training that doesn't possess such characteristics will depend more on external factors, and probably will be of shorter duration which may inflict on learning. It can by hypothesized that such training will have shorter retention and that the subject are less motivated to come back for retraining (or even use virtual world based learning).

The level of concentration in Studies I and II was moderate to high, and increased during training. The latter may be indicative of more interest as time passed. Another reason could be that the teams were better coordinated and performed more efficiently in areas of communication and task assignment (i.e. teamwork skills). Probably the level of concentration would be even higher if the subjects had experienced fewer technical problems. It is easy to lose interest and the sense of immersion when you suddenly have to exit the virtual world for this reason. The difference between the US group and the Swedish group in this respect is also, at least to some part, explained by differences in technical problems as well as some differences in the set-up of training. From Study IV we get more informed as to ideas about how to increase the level of concentration in the scenarios. One of the themes in Study IV was "focused mental training". If not perceived as particularly realistic affective involvement would probably be low.

Immersion was assessed in Study II. As with concentration this was in the moderate to high range. In their model, Shafer et al suggest that physical presence and immersion, are powerful predictors of enjoyment of video games. Enjoyment in turn has clear effects on motivation [120]. From a games perspective, and applying the theoretical framework around the concepts of flow, immersion and presence, having fun is not only nice – it is crucial for immersion and sustained and deepened learning [119, 253]. According to learning theories affective involvement will influence mental processing and contribute to long-term learning [254]. Being regarded as a "mental training" this can have negative implications. Gorini and coworkers in a study on medical students found that narrative and immersion had impact on the perception of presence [255]. In a model on perceived reality in video games, Popova suggested 6 dimensions contributing to this multidimensional construct [120]. Studies by Shafer, Carbonara and Popova, in particular found the dimensions of identity (an affective dimension) and utility (applicability) to influence the results on spatial presence and enjoyment [120]. These two dimensions are clearly addressed also in this project. As pointed out, there are some suggestions to make the virtual world team CPR training more realistic and involving, these include:

- Making the virtual world more like the real world both in appearance and situation
- Creating an affective link to the victim
- Introducing other components (sounds, fellow avatars, situations) with high affective value
- Increase the degree of challenge
- Focusing on easiness to operate and low tolerance for malfunction
- Introducing interfaces that allow psychomotor skills to be trained (which has also been suggested by others [120, 188, 256])

There has been some research on how the interface should look like and how much resemblance the virtual world avatars should have with the gamers, or in this case, the trainees [257]. These factors were not mentioned to any larger degree during the focus discussions, although there was a tendency, in particular among male subjects, that the experience of the virtual environment would gain from making it more attractive – better fidelity in audio-visual representation and smoother movements by the avatars could be examples of such.

5.1.1.6 Mental strain

In Studies I and II, in general perceived mental strain was low. In Study IV the experience of the virtual world training as not particularly stressful was confirmed. In part this may be a problem. The low level of mental strain may be positive from a learning point of view. Very high involvement in game features and interactions might distract focus from the actual learning by inflicting on the capacities for attention and retention, a distractive phenomenon known as "the seductive detail effect" [258-261]. If the trainees experienced high levels of mental strain in the situation, probably the gain from training would be lower. Further, high levels of strain during longer periods would not necessarily imply that the stress arose from the situation in the scenario. For instance, it could also have been provoked by technical difficulties. However, the low level of stress gives us some ideas of how the scenarios were experienced. Transfer from a classroom setting, performing CPR in the realm of a computer screen, to the disastrous event of a live cardiac arrest situation can be hampered by the vast differences in the situations [262]. The level of experienced mental strain will also affect other evaluations made on the trainees' side. For example, if stress was high, the demand for more difficult scenarios and distractors would probably not arise. This cautious us from draw conclusions from only parts of these results.

Today stress management is not sufficiently addressed in medical school curriculum – at least not in Sweden. Experiencing stressful situations, for example in a virtual setting, could serve as a input for further discussions and to some part as a platform for training how to cope with these, in emergency medicine, quite common occurrences.

5.1.1.7 Self-efficacy, competence and transfer

In virtual world-based training naturally the goal would be that of increased competence and transfer of relevant knowledge, skills and attitudes to a real world setting. As stated above, learning during the training seemed to have taken place, and there were also some evidence that competence for real-world CPR had increased. However, due to the small sizes of the samples and the fact that assessment of transfer still was under non-threatening conditions far away from the pressure of real world emergencies, the magnitude of these benefits must be interpreted with caution.

In both Study I and II there were clear increases in the perception of self-efficacy. According to Bandura's theories this has several consequences, one of them being predicted better performance, another predicting better self-regulation in learning. However, being situational to their nature, the raised beliefs would mainly be in the area of CPR in a virtual setting. Further, as Rasmussen and coworkers point out, the transfer of skills are also dependent on the real world social environment, or community of

practice, the trainee later will act in [263]. Moreover, although the construct of self-efficacy is more than just theoretical "mumbo-jumbo" (it has clear practical applicability), and the assessment of it has been validated, transferring self-efficacy beliefs acquired in a virtual environment to predicted performance in real world is challenging.

Bandura has also described the concept of self-efficacy on group level [34]. However, since teams during CPR normally are short lasting and comprised of individuals assembled in a haphazard fashion, the view on self-efficacy in these studies has been from an individual's perspective.

Indeed, the high self-efficacy beliefs demonstrated by the subjects already before training in both Study I and II are rather striking, in particular for male subjects. They previously had been trained by traditional means, but it is well known that the effects from such training commonly are attenuated within some months. Unfortunately, in the literature there is no other information on levels of self-efficacy in this context to compare our results to. According to social cognitive theory, self-efficacy is the individual's own apprehension of his or her competence in a certain field. As Bandura points out "to determine whether people harbor exaggerated appraisals of their capabilities, one must also measure what they believe the task demands to be and the accuracy of those beliefs" [33] (p.66). Possibly the perceived task demands might have been erroneous, either due to miscomprehensions from earlier traditional training or from other sources.

Self-efficacy beliefs are self-construed, meaning that they not only rely on input information from own experiences and observations. Also to a large degree they depend on conscious and unconscious processing and interpretations of this input [33, 264]. Therefore, if regarded as surprisingly high, the source of this, according to theory, could lie in one of these factors. As pointed out by Backlund and coworkers in the context of driving safety, misjudging one's own ability might make one more accident prone [217]. The decrease in self-efficacy beliefs found before the second sessions in Study I and II would probably be accounted for by a decay in knowledge and skills during this period, but still the level of self-efficacy was high.

In Study III transfer effects after virtual world training (subtracted by forgotten knowledge and skills) were studied. Although there are rather clear indices of CPR-performance, theoretically and practically connected to actual CPR outcomes, in this constructed assessment situation it turned out to be quite difficult to collect credible data. Due to influences from individuals' involvement and acting and due to inherent flaws in the processing of data some of the outcome measures were regarded as unreliable. For example, time to engagement, indicating the criticality of a quick response, was heavily influenced by how the "acting" turned out. It was quicker to just run to the victim than to start with an "oh dear, what has happened here? Hallo, do you hear me…" Also, the no-flow-time, being a valid measure from both a theoretical and clinical perspective, was reduced if the CPR-algorithm was violated (e.g. by giving just one rescue breath instead of two which was stipulated). Hence, some of the planned outcome measures could not be used. Despite these drawbacks, the findings all pointed to the benefits of virtual world pre-training: Clearly fewer mistakes were committed and the chest compressions were

more accurate in terms of rate. Previously, de Vries and collaborators have also found fewer mistakes after a computer-based CPR simulation program. However, this training was an individual internet based training [188]. As suspected, and interpreted as a sign of decay of knowledge and skills, performance among groups that were pre-trained 18 months before assessment were lower compared to the ones pre-trained 6 months before.

These results – increase in self-efficacy after training and superiority in performance in the pre-trained groups – together point to the beneficial effects of virtual world CPR team training on resuscitation competence.

Another result from Study III, was that the control group of peers, lacking virtual world pre-training, quickly approached the performance of the other groups. This is interpreted as a sign on the strengths of full-scale simulator-based training [265]. Apparently after 1 or 2 training scenarios, this group was on the same level of performance as the others. This might be mediated through increases in knowledge, individual skills, teamwork skills or self-beliefs. If the gain persisted of course we don't know.

5.1.1.8   Are current theories regarding serious games applicable?

In Study IV findings were compared to propositions of current theories on serious games. Perhaps because serious games have been developed and evaluated by innovators and early adopters, these early theories have focused on positive characteristics of this learning method. Several proposed benefits mentioned in the literature were also identified by our subjects. However, some findings need to be stressed to moderate the evangelistic support for serious games. From the discussions it was clear that engagement during virtual world activities varied. To some part this was an individual variation, but engagement also clearly varied due to which tasks the trainee was assigned. Standing-by, observing or just waiting led to loss of interest and concentration. This might of course also happen in a real-world event, but the easiness to leave the virtual world, and the opportunities for alternate forms of observational learning in the real world unmatched in the virtual environment, could probably explain this clear sign of dis-engagement that was noticed in these situations. With this in mind, it seems important to challenge the idea that serious games and virtual world learning is inherently engaging. Instead one can speculate that for virtual worlds, parts of their engaging characteristics lie in their capacity for novelty, for challenging situations and for displaying rarities that seldom happen outside your imagination.

Feedback is another proposed characteristic and strength of serious games. This important factor was used after each training scenario. However, as Bardy and coworker point out, feedback in virtual environments can be delivered in a multitude of ways, differing in content, medium for delivery and format [42]. Most of such feedback is primarily directed towards individuals and towards motor skills training. Using more rich concurrent feedback in the training could steepen the learning curve.

Another suggested benefit of virtual worlds is that they can be socially valuable to the users. Certainly in leisure games the interaction with others (people, monsters and so on) is a common key feature. In a recent thesis the very social characteristics of digital games were pointed out [266]. These characteristics are not only a hallmark of the

cultural phenomenon of gaming, but also influence society and the people populating it. The informants in Study IV also pointed to benefits of training together. Clearly, despite traditional CPR training largely being individually oriented, CPR in real life often involves several rescuers. However, also the experience that the group setting contributed to joy and commitment was noted. Although present in the pedagogic literature, in the serious games literature such findings are not prominent [267].

5.1.1.9 Group and sex differences

A reoccurring subject in education and in computer- and video game research is that of gender-, or sex differences[4]. In computer- and videogames research there is some evidence that males and females of different ages engage in different amount of gaming, that they prefer different genres and that the games have different meaning or function to them [239, 268-273]. However, some of these results have been disputed, and probably there is a high degree of sociocultural influence on these aspects [274-279]. Over time and under other cultural influence, such results might vary considerably. Reasons for differences between males and females concerning motivation and level of competences have been vividly discussed. Adhering to social cognitive and expectancy-value theories, current beliefs are that such differences due to sex therefore seem small and context specific. Basically there are clear sex and gender similarities which in turn often are affected by influence from parents, peers and society, as expressed by Hyde and Durik [39].

In order to make the study groups representative, a balance between male and female subjects was aimed at. This also allowed for sub-group analyses. Of course, due to the small sample size, the findings must be cautiously interpreted. On the other hand, some findings were of recurring nature strengthening their credibility.

Beside the differences between the US and the Swedish group in Study II, mentioned above, a difference in concentration was also detected comparing the male and female subjects in Study I. Certainly this could be accounted for by several explanations. The females could be more engaged in the scenarios (which also could explain the higher level of mental strain in this group). However, other explanations, such as males to a higher degree focusing on other things than the scenario (such as the interface or exploring the virtual world in other aspects) would also explain these findings. The difference in mental strain between male and female subjects in this study could be caused by several other factors. There was a somewhat lower level of computer game experience among female subjects which could result in increased demands on the trainee. Another explanation could be found when correlating this observation to the levels of self-efficacy, which also were different in the male and female group.

In Study I the mean score for self-efficacy before training in the female subgroup was significantly lower than that of the male subgroup. Although Bandura and others have noticed and discussed such differences in other areas, in medical education this difference has not received much attention. Is such a difference indicative of true

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[4] In gender research there is a clear distinction between sex and gender. In order not to complicate, and since there was only data on the sex of the participants (and not their gender identities or gendered roles) throughout this work the term used to distinguish male and female subjects is "sex".

difference in competence? Can we expect female medical students to perform CPR less efficiently than their male counterparts? These results again call for considerations on the sources of self-efficacy beliefs. It can be hypothesized that, due to sociocultural factors, the information that accounts for self-efficacy beliefs as well as internal processing of them can be different in these groups. In fact, Wigfield and Eccles find evidence how social mechanism such as the stereotype threat influences gendered self-efficacy beliefs [96, 280]. Further, as discussed above, in particular the males in this study may have over-inflated self-beliefs in this respect. Such phenomena have also been described by Bandura, and as such it may contribute to erroneous perceptions of one's capability. In the context of emergency medicine this could in turn have consequences on teamwork and patient outcome. However, the increase in self-efficacy occurred in both sub-groups. The reason for the difference not being significant after training could be due to the fact that the male group peaked in their perceived self-efficacy.

5.1.1.10 Implications for future virtual world use in medical education

From the results and conclusions of this project, are there any recommendations for virtual world use in future education?

First of all, it almost universally seems that serious games are appreciated by the learners. Hence, we can predict that introduction of these learning aids, at least in the near future, will be supported by the learners. If the same interest is shown also by other stakeholders, teachers, parents, authorities and society is not as obvious. For example, the debate on computer- and videogames in terms of promoting aggressive behavior, addiction and other negative behavior may also influence serious games [236, 281-284]. Although still not settled, in recent years the cause-relationship in this matter has been questioned as it has been demonstrated that postgame aggression mainly is associated with insufficient skills of mastering game controls and a lack of players' basic needs satisfaction, rather than the characteristics of the game [99].

On the positive side, the results from this project support the use of virtual worlds for training. However, in designing such training one must be aware on some pitfalls. It's important to keep in mind that uncritical use of serious games in medical education might solve some issues, but certainly create new [84]. The training should be designed in an evidence-based way [17, 285-287]. The behaviors or cognitive skills should be clearly defined and supported by the training environment. One should try to take advantage of the positive qualities associated with serious games and virtual worlds, such as formative feedback, engaging and challenging situations and possibly also learning in groups [288]. As implied by social cognitive theory, the model of flow and the deliberate practice model, the level of difficulty should be matched to the person's actual ability and increase as training continues. From a training perspective the level of challenge should be just above ones abilities [289]. However, this puts demands on clear understanding of the task by the trainees. Increasing the sense of competitiveness – competing with others or yourself – can be explored to a higher degree by more clearly creating levels of difficulties that are reached as sign of competence or by introducing more in-world feedback systems. The latter may also support accelerated learning.

The interface and the sophistication of the virtual environment should be designed according to learning objectives. Today it is easy to spend fortunes on developing sophisticated virtual worlds or using cool interfaces such as head-mounted displays and cave-technologies. Although there have been some suggestions from experienced gamers in the study groups towards making the virtual environment more appealing, in general such opinions have not been prominent. The need to consider a broader user perspective is also emphasized by the results from Kron and collaborators [248]. Conclusions from Study IV instead create a vision of a virtual world that can be interacted with in an easy and intuitive fashion. This could imply some changes in direction when using virtual worlds for training, such as the use of motion detection facilities [290], adding models for psychomotor skills training and pre-recorded sound for increased immersion. Incorporating meaningful inventions from the rapidly developing fields of computer software and devices for connecting the user to the virtual realm can give the field of serious games tremendous potential.

This project has been a contribution to serious games research in medical education. Virtual world team training is just one method to train subjects in emergency medicine. If it is to be used, it must be adapted and incorporated in a curriculum. For example, it could be used for preparations before full-scale simulation training, or for re-training not-so-new skills. One could train parts of complex procedures or basic skills after they have been demonstrated and trained on real world models. Future studies, using a virtual environment designed in accordance to above recommendations, would preferably include more studies on retention, comparative large scale studies and studies on implementation issues.

5.2   LIMITATIONS - IMPLICATIONS FOR STUDYING VIRTUAL WORLDS

As with all results from scientific explorations, there is a degree of uncertainty in the results, as well as the interpretations. This may theoretically be due to use of theories and models that don't fit, using instruments that aren't reliable or valid, or receiving erroneous data. However, it has been proposed that theoretical learning models also apply in the virtual realm [291]. Further, it may be argued that the virtual world team CPR training hasn't taken place in a game, rather a game-like environment. Hence models of serious games can only partly be applied. Also, the researcher may influence the results. Such influences may be almost impossible to rule out, and calls for studies after large-scale implementation in a curriculum. Mistakes can also be made in the processes of analysis and interpretation of data. By using recognized theories and validated instruments, and adhering to established routines in research efforts have been taken to decrease such uncertainty. Taking use of quantitative, psychometric and qualitative methods it has been possible to triangulate results in order to increase reliability.

The small sample sizes in these explorative studies preclude us from major generalizations. There may also be some skewedness in the selection of subjects. However, although there were no straight forward random samplings, the students volunteered by own choice. These could of course mean that subjects with special interest in computer games or CPR training volunteered. In Study III however, we can assume that such bias is balanced by the same confounding in the control group. It

should be pointed out that the results also are quite context dependent. Using virtual worlds in other training populations and domains may decrease the transferability of results. A factor of at least the same importance is how the virtual world is used; if the virtual world is used for other learning purposes than training skills, and using knowledge. For example, if the world is used for understanding concepts much of the results in this project must be questioned. The results from the current exploratory journey can therefore only cover some aspects of virtual world use in education.

The instruments for assessment may also be critically discussed. Knowledge can be measured in a variety of ways. A commonly used assessment tool was employed since this was not the primary aim of the research. Self-efficacy is a construct that has a high explanatory value. In spite of the issues discussed above, it appears to have an important role in research on virtual world-based training. Immersion and concentration are perceived characteristics when the individual is engaged in the virtual environment. The flow model has been somewhat confusing with some inconsistencies in the concept. Using the more narrow concept of concentration is theoretically more appealing, but not as recognized in research. Concentration affects learning as long as we focus on what is intended. Immersion is a common construct in virtual world research. However, the mechanisms how it affects learning outcomes in virtual world learning is to be further elucidated.

Using observable behavior outcomes may appear logical, in particular if you apply a behavioral paradigm in training, but also seem to have some limitations. There are at least as many sources of error when observations are introduced and, as noticed, some observational measures may be better in theory than in reality. However, in Study III some process measures of CPR were less sensitive to such flaws. Although learning could be detected and relevant measure on CPR performance were used, it is difficult to ascertain the relative importance of the factor that was assessed. Coming back to Kirkpatrick's levels of evaluation, it would have been preferable to study transfer to the real world [203]. However, this was not ethically or practically possible. Other aspects contributing to outcome after CPR are teamwork skills. Although this fact has been acknowledged in the most recent CPR guidelines [165], to date there is a need for validated scales for measuring teamwork effectiveness during CPR. In short, there do exist some performance variables that easily can be used for studying CPR, whereas others still need development.

6 GENERAL CONCLUSIONS

The focus of this thesis has been on developing and exploring team based virtual world learning and training for increased CPR competency and preparedness. From the findings, several conclusions are drawn:

- According to this multimodal assessment, the findings support the use of this novel educational method among both high school- and medical students.
- Training increased both self-efficacy beliefs and knowledge. Effects were similar in both Swedish and US high school contexts.
- Transfer effects on CPR-related performance were discovered from virtual world to assessment using a high fidelity human patient simulator.
- Theories on virtual worlds for serious gaming were partly supported whereas some proposed qualities need further exploration. Some cautions in the design of the virtual world as well as the training itself are called for.

The findings have several implications for the use of virtual world team based training in medicine. As supported by theory, motivational aspects such as immersion and indices of flow experience are relevant for predicting engagement in the activity. Clear goal-behaviors should be identified. Further, positive consequences of practicing in a team support the use of this technology. However, when designing the training, care has to be taken to integrate this in a curriculum and to make use of the potential benefits of the virtual gaming model. This includes creating opportunities for affective engagement. However, the level of sophistication of software and interface should be tailored to different user categories.

7 SUMMARY IN SWEDISH

Dataspel används idag inte bara till hobbybruk. Under senare år har s.k. "serious games" växt till en multimiljardverksamhet. Idén är att dra nytta av dataspelens benägenhet att engagera och trollbinda sina användare och under tiden lära ut, eller träna viss kompetens. På senare år har dataspel börjat användas för lärande på olika nivåer inom utbildningsväsendet. Fördelen med att använda spelbaserat lärande bland yngre individer är deras ofta självklara förhållande till och kunskaper kring datorer och datorspel. Det har antytts från flera håll att yngre personer, "dataspelsgenerationen" (på engelska "Digital natives" – de digitala infödingarna), skiljer sig från sina föregångare avseende förväntningar. Genom att använda dataspelsbaserad pedagogik finns möjligheten till självreglerat lärande bland dessa individer.

Trots att det finns en omfattande litteratur avseende dataspel, är kunskaperna om hur man bäst använder dessa för lärande och träning mer begränsade. Det existerar idag modeller och teorier som fokuserar på vissa egenskaper hos dataspelen och kopplar dem till goda effekter på lärande. Vidare anses det vara av stor betydelse hur de integreras i resten av undervisningen. Inom hälso- och sjukvården är dock kunskaperna inom området otillräckliga, inte minst när det gäller s.k. virtuella världar. Dessa är tredimensionella dataspelsmiljöer i vilka användarna kan röra sig och interagera med omgivningen eller andra personer via sina s.k. avatarer (personifierade representationer).

Genom att använda en virtuell värld för träning i hjärt-lungräddning (HLR) har en modell skapats för teamträning av några tämligen enkla men livsviktiga akutmedicinska procedurer. Idag känner man till att flera typer av problem existerar just avseende HLR-träning, vilket kan innebära att liv som kunde ha räddats går till spillo. Under avhandlingsprojektet har en virtuell värld utvecklats, anpassats och senare använts för sådan träning bland läkarstudenter och gymnasieelever. I de fyra delarbetena har olika aspekter av detta belysts:

I delarbete I och II har effekter av HLR-teamträning i en virtuell värld bland läkarstudenter i Stockholm och gymnasieelever i Huddinge och Kalifornien studerats. Forskningsmetodiken som använts har till stor del hämtats från motivationspsykologin. Deltagarnas engagemang under träningen i den virtuella miljön har studerats. Detta har gjorts genom att undersöka i vilken grad de försjunker och engagerar sig i uppgiften utifrån modellen för den s.k. *flow*-upplevelsen. Vidare har påverkan på deltagarnas självupplevda tilltro till sin egen förmåga (engelska: "*self-efficacy*") och den mentala belastningen under aktiviteten studerats hos dem. Resultaten av dessa studier visar att deltagarna har en benägenhet att finna koncentration i den virtuella träningen. Graden av självuppfattad tilltro till sin förmåga steg. Generellt sett var deltagarna positivt inställda till träningen och såg flera goda egenskaper med den, även om somliga gärna hade önskat sig mer komplicerade och utmanande träningssituationer, och önskade mindre tekniska problem.

I delarbete III studerades överföringseffekter (s.k. transfer) från tidigare träning i den virtuella världen. Eftersom det är svårt att studera sådant i den verkliga HLR-

situationen, valdes istället en s.k. kvasi-experimentell metodik; kunskaperna och färdigheterna i HLR kontrollerades i en s.k. patientsimulator – en modell av en människa med människoliknande funktioner bl.a. avseende andning, hjärtverksamhet, blodomlopp och medvetande. Studenter, som tidigare deltagit i HLR teamträning i den virtuella världen, bedömdes avseende kunskaper och färdigheter i HLR i patientsimulatorn. De jämfördes också med sina klasskamrater som bara tränats på traditionellt sett (med s.k. HLR-attrapp). Resultaten av denna studie visade att de som i tillägg hade tränat HLR genom dataspelsbaserad teamträning i virtuell miljö hade bättre resultat avseende korrekta bröstkorgskompressioner. Vidare följde de HLR-schemat bättre än de som inte tränat på detta sätt. Särskilt gällde det den grupp som hade tränat 6 månader innan försöket, medan effekterna hos gruppen som tränat 18 månader innan till stor del var utsläckta – ett känt fenomen inom traditionell HLR-träning. Det visade sig också i denna studie att de som inte erhållit den dataspelsbaserade teamträningen snabbt kom ikapp sina kamrater vid vidare träning i patientsimulatorn.

Målet för det sista delarbetet var att fördjupa kunskaperna om deltagarnas upplevelser och deras uppfattningar om HLR-träning i team i en virtuell värld. I studien fick deltagarna efter träning delta i en gruppdiskussion, en s.k. fokusdiskussion, då denna information inhämtades. Genom strukturerad analys av materialet utkristalliserades 4 kategorier som avspeglade deltagarnas erfarenheter och uppfattningar. Resultaten jämfördes med de i teorier föreslagna förhållandena vid dataspelsanvändande. Resultaten pekade till stor del i tidigare föreslagna riktningarna. Bl.a. kunde träningen upplevas som engagerande och rolig. Deltagarna tyckte den var motiverad, lärorik och lämplig för ändamålet. Känslan av att lära sig och träna tillsammans i den virtuella världen var positiv och förhöjde upplevelsen. Det uppkom emellertid också en del farhågor avseende lärande och träning i virtuella världar. Engagemanget var bara stort när man verkligen hade något att göra – om inte, var det lätt att tappa koncentrationen. Liksom i de första studierna efterfrågade deltagarna mer spännande och utmanande situationer i den virtuella världen. Detta stämmer väl med dataspelsteori – känslan av utmaning är ofta central vid dataspelsanvändning och sannolikt en viktig faktor för att uppnå djupt engagemang. Frågan uppkommer dock om lockelsen till utmanande situationer kan skapa fel attityder och självuppfattningar hos deltagarna när de senare kan komma att behöva agera vid verkliga hjärtstoppssituationer. En annan fråga är hur gränssnittet mellan användare och datorn ska vara beskaffat. Individer med dataspelserfarenhet verkade inte uppleva detta som ett problem, mer än att det inte var tillräckligt utmanande. Däremot fanns det bland studenterna även individer som inte är var så lockade av dataspel i vanliga fall. För att dessa individer också ska känna sig tilltalade av dataspelsbaserad träning kan det vara klokt att eftersträva lättanvända, intuitiva, gränssnitt.

Sammanfattningsvis har detta projekt belyst effekter av att i en dataspelsvärld i grupp träna sig i att hantera akutmedicinska tillstånd. Resultaten är generellt positiva. Ännu finns dock inte förutsättningar för att detta ska ersätta konventionell HLR-träning. Man kan däremot i framtiden tänka sig att den här sortens träning skulle kunna vara en del av den återkommande träningen. Dataspelsinspirerad träning kan också vidareutvecklas och så småningom integreras med flera moment, som t.ex. handgripliga färdigheter.

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