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Trends in E-Learning

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Trends in E-Learning

An overview of current trends, developments, and research in E-Learning

Preface

This report provides an overview of current applications and research trends in the field of e-learning. There are various technologies that can be used to support learning. They range from web-based training (WBT) to tangible e-learning, mobile learning, virtual and mixed realities, and more.

During the summer term 2008, students from the Computer Science Department at the Ludwig-Maximilians-University in Munich did research on specific topics related to e-learning and analyzed various publications. This report comprises a selection of papers that resulted from the seminar.

Each chapter presents a survey of current trends, developments, and research with regard to a specific topic. Although the students' background is computer science, their work includes interdisciplinary viewpoints such as theories, methods, and findings from educational and psychological sciences. Therefore, the report is targeted at anyone who is interested in the various facets of e-learning.

In addition to this report, there are slides from the students' talks available at http://www.medien.ifi.lmu.de/lehre/ss08/hs/ .

Munich, August 2008

The Editors

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Abstract. Tangible User Interfaces increasingly gain attention for their supportive potential in cognitive processes. More and more often the terms e-Learning and tangible interaction are been referred to in one word as Tangible e-Learning. This paper gives a general overview on the topic in reference to development history, research and effectiveness. It explains how epistemology, together with its idea that physicality enhances learning and that the cognitive process can happen in expressive or exploratory manner, motivates the emerging of TUIs and acts as a basis for the classification of Tangible e-Learning Systems. The benefits of TUIs in comparison to classical GUIs in terms of their contribution to the learning process, engagement, enjoyment and collaboration are empirically proven, although poorly. Nevertheless, it is not known whether TUIs have stronger potential than common Physical User Interfaces that are not electronically augmented. Still, TUIs that support learning have a strong potential to be integrated into real world scenarios.

1 Introduction

The modern society we live in has brought along many changes and innovations. One of them is the requirement for education not to be about teachers and teaching anymore, but rather to put the learner and his learning activity in its center. (Tavangarian et al., 2004; Williams and Goldberg, 2005) Metaphorically speaking, learning began as a live stage performance in form of classroom trainings and became comparable to modern motion pictures, as nowadays we increasingly run across concepts of e-Learning. At a first glance, e-Learning seems to be a revolution in our era, but looking back on its history and giving it a second thought, it rather concludes to have an evolutionary character. (Tavangarian et al., 2004) After online tools and software replaced educational CD-ROMs, all commonly designed to use personal computers, Graphical User Interfaces and traditional Human Computer Interaction, the evolution finally takes a new turn, exploiting the possibilities of Tangible User Interfaces in favor of education and learning. This paper aims to provide a broad coverage of the topic, starting off with defining the terms "e-Learning" and "Tangible User Interfaces" in chapter two. The subsequent chapter dives deeper into the topic of tangible e-Learning by first motivating its emergence, then offering a classification of Tangible e-Learning Systems. Furthermore the effectiveness of Tangible e-Learning Systems in comparison with classical, GUI based, learning shall be discussed. Chapter four will give examples of several Tangible e-Learning Systems, will explain how they work and apply on them the theoretical knowledge from precedent chapters. An outlook on future research and development and possible employment scenarios of Tangible e-Learning Systems in contexts drawn from life will wrap up the topic.

2 Terms and Definitions

2.1 E-Learning

Getting a clear idea of what exactly the term "e-Learning" is supposed to define is a complicated undertaking, as there are numerous different definitions available throughout literature. What is not sufficient in order to call learning as "e-Learning" is the simple use of electronic equipment, i.e. a microphone during a lecture, because a proper definition should require that the electronic media has to enhance the learning process in a way, which wouldn't be possible with other media. (Tavangarian et al., 2004) In some definitions e-Learning comprises all learning enhancing software(Baumgartner et al., 2002; Tavangarian et al., 2004), in other definitions it is a networked form of learning based on Internet technology (Rosenberg, 2002; Tavangarian et al., 2004). Still, all these definitions do not combine all aspects of e-Learning. The definition rather needs to emphasize the differences of e-Learning in comparison with traditional learning, should not resume to software or the Internet and also has to justify the benefit of the electronic media to the learning progress:

e-Learning "[is] all forms of electronic supported learning and teaching, which are procedural in character and aim to effect the construction of knowledge with reference to individual experience, practice and knowledge of the learner. Information and communication systems, whether networked or not, serve as specific media (specific in the sense elaborated previously) to implement the learning process". (Tavangarian et al., 2004)

E-Learning aims to give students a greater autonomy regarding the point in time, the content and the method by which they learn by providing on-demand-learning, that eliminates the barriers of time and distance. (Tavangarian et al., 2004) Hence, for covering today's expectations from e-Learning, a paradigm shift is needed. Contemporary technology and pedagogical skills, brought together as an effective combination, can achieve this shift of focus towards the learner.

2.2 Tangible User Interfaces and Tangible Interaction

Tangible computing can be understood as a historical evolution from Human Computer Interaction (HCI) aiming to design user interfaces that expand the abilities humans have when interacting with computers. (Dourish, 2001; Marshall et al., 2003) Early definitions of Tangible User Interfaces (TUIs) in 1997 already focused on the idea that HCI should move away from the interaction with a Graphical User Interface (GUI) on a desktop computer to interaction where the world itself becomes the interface, giving physical form to digital representations. (Ullmer and Ishii, 2000) Thus,

TUIs can be defined as everyday objects or environments that augment the physical world by being coupled to digital information. (Ishii, 1997; Ullmer and Ishii, 2000) They give humans the possibility of grasping and manipulating digital information through objects from the physical space(Ishii, 1997; Fishkin, 2004).

While GUIs draw a clear line between input devices and output devices, TUIs explore the conceptual space created by the reduction of this distinction. (Ullmer and Ishii, 2000) Since the introduction of the term TUI, conceptual frameworks that should help researchers, designers, and developers to classify them and understand the various ways in which the coupling between physical objects and digital information can be realized, continued to be proposed. (Koleva et al., 2003)

In order to understand the concept of TUIs, two defining attributes are of outstanding relevance: the degree of embodiment and the metaphor the information coupling underlies. (Fishkin, 2004) Embodiment features four degrees(Fishkin, 2004):

– *full embodiment*, where input and output device are one and the same object(Fishkin, 2004; Ullmer and Ishii, 2000),
– *nearby embodiment*, for instance a display placed in immediate proximity of the TUI, showing the effects of the tangible interaction,
– *environmental embodiment*, example given loudspeakers playing sound as a reaction to the user's input via the TUI
– *distant embodiment*, which is comparable to conventional HCI, having an output device placed more or less close to the input device(Fishkin, 2004).

The second relevant concept is the metaphor of the activity the user carries out while interacting with the TUI. The high impact of the metaphor is justified by findings of cognitive anthropologists, stating that the ability to use metaphors is what sets modern humans apart from their early ancestors. Various properties of the TUI, like size, shape, color, weight, smell, texture and temperature can be used to create such an interaction metaphor, which, in turn, can concentrate only on the tactile sensation and visual appearance of the object, but also on its movement or even use both. (Fishkin, 2004) Whether a strong metaphor, like the exact mapping of the real world, or a weak to no metaphor at all holds stronger cognitive potential is still to be discussed. Some researchers share the view that the absence of metaphors has the benefit of not constraining the user to a particular thinking scheme and thus produces the most compelling TUIs. (Fishkin, 2004) Contrarily, there are views sustaining that stronger metaphors create a higher degree of coherence, which is advantageous for successful interaction. (Koleva et al., 2003)

Measuring the performance of a TUI thus consists of analyzing the extent to which the embodiment and metaphor criteria are fulfilled, concluding that TUIs underlie a gradient principle of “tangibility”, being more or less tangible. Hence, tangibility can be considered a multi-valued attribute. Nevertheless, when it comes to understanding the importance of metaphors in Tangible Interaction, TUI research still is at its beginnings and can collect valuable knowledge from industrial design, where the high relevance of metaphors and product semiotics has shaped the research process from its very starting point. (Fishkin, 2004)

3 Tangible E-Learning

3.1 Motivation of its Emerging

E-Learning emerged from the use of Information Communications Technology (ICT) in classrooms, which gives the learner more the position of an “onlooker” than to attribute him an active role as ”participant” in the educational process. Price and Rogers concluded that introducing physicality into learning could solve this problem. (Price and Rogers, 2004) From an historical point of view, the importance of physical objects in the cognitive process has been noticed relatively recent, as until the 19th century education was conducted exclusively using lectures and recitations. (Resnick et al., 1998) Swiss educator Johann H. Pestalozzi is the one, who in 1803 set the foundation stones for learning through physical manipulation. He stated that students need to learn trough their senses and physical activity, that “things [should come] before words, concrete before abstract”. (Pestalozzi, 1803; Resnick et al., 1998) TUIs present the advantage of the ability to unify the concrete and the abstract. Consequently, they are gaining popularity as an effective approach to the design of systems suited for learning. (Marshall, 2007) In 1972, developmental theorist Jean Piaget found out that children construct their view and understanding of the world based on their interaction with the physical environment they live in (Zuckerman, 2004), a process that is encouraged by TUIs through the learning benefits of physicality(Marshall, 2007).

Through the assignment of a metaphor to each object/activity, TUIs build upon a concept that is deeply engrained in human consciousness: the concept of noun (the way an object looks) and verb (the way it can be interacted with), which reflects even in deaf-mute children. (Fishkin, 2004) Regarding this, TUIs might present higher accessibility and intuitiveness, particularly for people with handicaps, learning disabilities or young children. (Marshall, 2007) Especially when working with children, the design of TUIs that use toys children are deeply familiar with and passionate about as manipulatives, could result in serious improvement of the learning process(Resnick et al., 1998), as, according to constructivist research, people learn most effectively when involved in projects they care about(Zuckerman et al., 2005). Furthermore, familiarity is a crucial criteria for accessibility, thus accordingly designed TUIs can extend the range of concepts that children can explore trough direct manipulation, even those concepts considered too advanced for them(Resnick et al., 1998), lowering the age at which children gain access to complex knowledge.

Again, the employment of metaphors and the novelty of links, resulting from the flexible combination of manipulatives and digital representation, allows access to different information than is normally available in immediate physical environments(Resnick et al., 1998) and therefore can increase reflection in children (Marshall, 2007), in conformity with the old saying "Give a person a hammer and the world looks like a nail"(Resnick et al., 1998). The learner receives contextually relevant information based on an abstract concept, information which might not be available in a real environment, hence this information can disclose new ways of engaging with learning(Price, 2008).

TUIs are said to support increased playfulness(Marshall, 2007; Marshall et al., 2007), as physical engagement creates an involvedness that passive listening and watching does not(Price and Rogers, 2004). Involvedness partially increases the level of motivation and interest in the learning activity and it is this engagement and motivation that, in turn, can exert a positive effect on the cognitive process, in terms of attention, curiosity and reflection. (Price and Rogers, 2004) Furthermore, when observing children, one can take notice of the social and collaborative connotation of the playing activity. Collaboration, achieved by talking about the learning content and thus encouraging social interaction supports active learning. (Price and Rogers, 2004) TUIs create a shared space with increased visibility of actions, encouraging effective turn taking by offering multiple access points for multiple learners and the facility of increased awareness because of the ability of monitoring the activity of all the other participants. (Marshall et al., 2007; Marshall, 2007)

Because of the children's willingness to learn and in conformity with cognitive research, the majority of Tangible e-Learning Systems are developed to support children's education(Xie et al., 2008), which also reflects in the typical learning domains for TUIs, that follow to be discussed in chapter 3.3.

3.2 Classification of Tangible e-Learning Systems

3.2.1 Epistemological Background

Epistemology, a branch of psychology, is the science concerned with the nature and scope of knowledge. (Encyclopedia of Philosophy, 1967) In early epistemology there exist two perspectives on how children's cognition can be extended. They emerged subsequently as a result from the other.

Pestalozzi's demonstrations on concreteness preceding abstractness strongly influenced German educator Friedrich Wilhelm Froebel, founder of the world's first kindergarten in 1837, to develop special toys for children. The twenty so called "Froebel Gifts"(Zuckerman et al., 2005), consisting of balls, blocks and sticks, aimed to help children recognize and appropriately appreciate common patterns and forms existent in nature(Zuckerman, 2004) by using the gifts to create representations of these forms and patterns. Around 1912, Italian educator

Maria Montessori extended Froebel's gifts to suit the needs of older children by picking up his initial idea and developing new materials and activities for the toys. The intention was of putting the children in control of their learning activity, enabling them to learn through personal investigation and exploration, it was intended to perform an "education of the senses". (Zuckerman, 2004)

While Froebel's approach supports the concept of constructivist learning, where children get to express their personal understanding of the world, Montessori's idea consisted in building knowledge through exploration. It is these two keywords, expression and exploration, that shaped the criteria by which Tangible e-Learning Systems can be classified, as depicted in Fig. 1 under "learning activity".

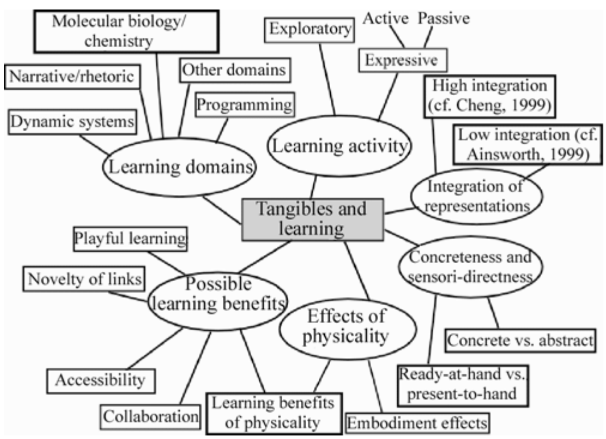


Fig. 1. Analytic Framework on Tangible e-Learning. (Marshall, 2007)

3.2.2 Expressive Learning and Froebel Inspired Manipulatives

Expressive learning implies expressive activities, where learners create an external representation of a domain accordingly to their own understanding and idea of the topic, by which they make the understanding explicit. The resulting representation serves as an object for reflection on how accurate the representation depicts reality. By this analysis, identifying inconsistencies, conflicting beliefs and incorrect assumptions is facilitated and triggers the revision, rectification and thus increase of the learner's knowledge. (Marshall et al., 2007) Tools, that are coupled to digital information and that support this type of activity are called *Expressive Tangible Systems* or *Froebel inspired Manipulatives* (FiMs). FiMs are building tools offering the possibility of designing real-world objects and physical structures(Zuckerman et al., 2005), on which the learner later will reflect upon.

There are several reasons why it can be assumed that TUIs support this type of learning activity. First, in compliance with the novelty of links discussed earlier, they are innovative media allowing constructions, that might result to be impossible with classical manipulatives. Second, the coupling to digital data, providing additional information to what is extractable only from the construction, can contribute to the effectiveness of the analysis of the external representation. Finally, by keeping track of the aspects of the learner's interaction with the manipulatives, TUIs can enable the passive construction of representations, allowing the learner to concentrate on another task. (Marshall et al., 2007) In current development, FiMs hold the main share of Tangible e-Learning Systems. (Zuckerman et al., 2005)

3.2.3 Exploratory Learning and Montessori Inspired Manipulatives

Still, researchers emphasize the need of expanding the presence of TUIs that support exploratory learning activities. (Zuckerman et al., 2005) In contrast to expressive learning, where representations are built from the learners personal knowledge, exploratory learning has its roots in a representation provided by a teacher or domain expert. The learner afterwards explores this representation by observing the effects of the manipulations he carries out, eventually concluding with the assimilation of information because of a conflict with the already existent knowledge, again leading to revision and rectification of this knowledge. (Marshall et al., 2007) Therefore, *Exploratory Tangible Systems*, also referred to as *Montessori inspired Manipulatives*, are as well building tools, but are intended to facilitate the modeling of conceptual and more abstract structures. (Zuckerman et al., 2005) Arguments that speak for the suitability of TUIs as support for exploratory learning consist, for example in the assumed high accessibility. If tangible interaction indeed conclcudes to be more intuitive and natural than interaction with other types of interfaces, it might create a particularly suitable learning environment by enabling rapid experimenting and feedback gaining. Through the assistance offered by the digital information and effects of manipulation, less cognitive effort is required and the focus shifts to the underlying domain. (Marshall et al., 2007)

3.2.4 Hybrid Systems

Not to be excluded is the idea of combining expressive and exploratory approaches in one Tangible e-Learning System. While giving learners the possibility of exteriorizing the explicit representation of their understanding of a topic through some physical structure or model, a TUI can afterwards encourage the exploration of this model in order to fill knowledge gaps, eventually even trigger a repeated re-building and refinement of the expressive representation and subsequent analysis. Considering hybrid tangible systems as holding similar potential in promoting learning thus seems plausible. (Marshall et al., 2007)

3.3 Learning Domains for TUIs

Frameworks kept identifying the possible domains where TUIs could come into operation for educational purposes. Fig. 1 briefly summarizes some of the results: molecular biology and chemistry(Marshall et al., 2003, 2007), programming(McNerney, 1999, 2004; Wyeth and Purchase, 2002), narration and rhetorics(Orth and Ishii, 1998) and finally systems dynamics(Resnick et al., 1998; Zuckerman and Resnick, 2003), latter being a particularly discussed domain in Tangible e-Learning research. When browsing through current research papers, there is a variety of other domains that additionally show up, like maths(Scarlatos, 2006; Girouard et al., 2007), more precisely arithmetics and geometry, computer systems(Crease, 2006), astronomy(Morris, 1999), also domains like music(McNerney, 2004) or art history(Döring and Beckhaus, 2007). The high flexibility of TUIs even make it possible to use one system to cover several domains(Terrenghi et al., 2006; Orth and Ishii, 1998).

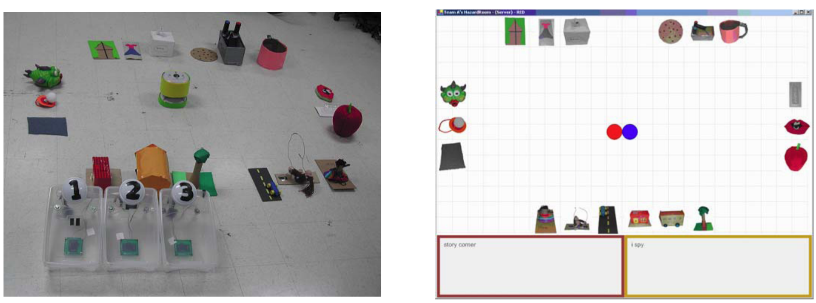
3.4 On the Effectiveness of TUIs in Learning Environments

While many frameworks for TUIs focused on conceptualization and classification(Xie et al., 2008), little of them adopted the challenge to empirically prove whether tangibles achieve better learning results than other interfaces. Technical development outran empirical work(Fails et al., 2005), leaving it far behind(Marshall, 2007). Therefore, there's an imminent gap and researchers calling for a greater focus on empirical work in order to close it(Marshall, 2007). The following sub chapters will describe the results of two empirical comparisons between desktop and physical environments in order to get an answer on which interface is better suited for learning.

Both desktop and physical/tangible environments have proven over the years to exert a positive effect on children's learning process. (Fails et al., 2005) While the effectiveness of desktop environments is empirically grounded and physical environments have received theoretical confirmation of a better interaction than in the two dimensional context of desktop environments(Fails et al., 2005), only little empirical work systematically explores the benefits of tangible systems(Xie et al., 2008). There is little work that explicitly engages in comparative studies of the two environments. (Xie et al., 2008; Fails et al., 2005)

3.4.1 Study Scenarios and Setup

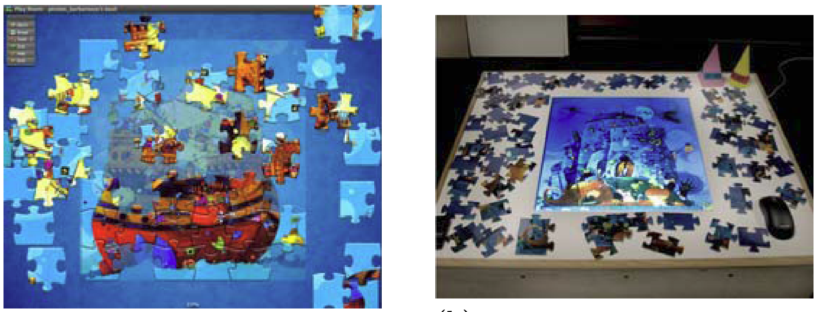
The two studies that will be discussed had different purposes. The first, consisting of a desktop and physical implementation of a game called "The Hazard Room" intends to find out which interaction provides more effective learning and better fixation of knowledge. The learning domain refers to environmental health hazards and knowledge is transmitted by telling stories about each hazard, what damage it causes and how to appropriately react in such a circumstance. Each story is connected to a sound segment, each sound segment being supported by the use of a certain prop. The same props, respectively pictures of them, the same hazards and the same stories are used in both desktop and physical environment. A detailed implementation is depicted in Fig. 2. The study was conducted on a quantitative as well as on a qualitative basis, by using measurable data, respectively by evaluating answers from interviews. For the quantitative data participants took pre and post tests and the quantitative data consisted of the difference amongst the scores. Children were given scenarios similar to those during the game and were asked what they would do and why. In the second part of the test, they were given a list of items and were asked to identify those that could be exposed to a given hazard. The qualitative analysis leaned on notes and video taken during the dialog between researcher and participant after each correct story sequencing. The children were asked to reproduce the story in their own words and to explain what the story taught them. The answers were analyzed in reference to whether a verbal response was given or not, the number of "I don't know" answers a child gave and the depth of response, according to its accurateness and inclusion of causal dependencies, the number of prompts required to obtain the information from the child, the frequency of interaction with the props (pointing and touching) and the subjective interest level of the child.(Fails et al., 2005)



(a) **(b)**

Fig. 2. The Hazard Room in tangible(a) and desktop(b) execution. (Fails et al., 2005)

The second study is oriented towards finding out which of the two environments releases more fun and engagement. It consists of a simple jigsaw puzzle without any further aim to facilitate a cognitive process. The desktop version of the jigsaw puzzle provided the interaction through a GUI and a mouse. Simple drag and drop manipulation changed the position of the puzzle piece, clicking the right mouse button enabled rotating it. The physical/tangible implementation, as shown in Fig. 2 (a), consisted of new versions of traditional puzzle pieces placed on tabletop prototypes, having an infrared web camera recording the participants' movements. Also this experiment collected both quantitative and qualitative data. Engagement was measured by the evaluation of time logs and counts of play times, enjoyment resulted from the statistical analysis of the results of a post questionnaire, whereas qualitative findings are based on data collected via observational notes, audio and video recordings. (Xie et al., 2008)



(a) (b)

Fig. 3. Jigsaw Puzzle in GUI(a) and TUI(b) execution. (Xie et al., 2008)

3.4.2 Study Findings

The findings from the Hazard Room Game study concluded with physical environments showing clear advantages over the desktop environments. The number of researcher prompts needed to receive the expected information from the children was fewer for the physical environment, as well as the number of "I don't know" answers. The answer depth increased in the physical environment and the average subjective interest was higher. A correlation between number of prompts, number responded and number of "I don't know " answers on the one hand and answer depth, intensity of interaction (number of pointing or touching) and the subject's interest on the other hand is observable. These two groups furthermore are negatively correlated, which means that in desktop environments, more prompts caused more "I don't know" answers insted of increasing answer depth, thus indicating the existence of disparity between the two environments. These qualitative results are also supported by the quantitative statistics reporting that the mean score differential between pre and post tests was greater in the physical environment than in the desktop one, in other words the contribution of physicality to the learning process is stronger. (Fails et al., 2005)

The Jigsaw Puzzle Game concluded that the children's self report of enjoyment was similar for both TUIs and GUIs. Still, measurings showed that they had more difficulty in solving the puzzle in the desktop environment, eventually due to single user access and also because of difficulties with indirect mouse interaction in combination with the constraint to 2D space. Engagement was lower in desktop environments, as 48% of the GUI players didn't manage to complete the puzzle even once within the given time, two of the pairs even quitting before the time elapsed. In comparison to this, TUI players not finishing consist of only 17% percent of the participants, with none of the pairs quitting before the end time. The number of repeat plays was significantly higher on TUIs than on GUIs. Qualitative analyze concluded that different collaboration stategies were taken on the distinctive interfaces. In tangible interaction each child actively participated, working on his own area of the puzzle, area which often was decided upon through verbalization. Although each participant was absorbed by his own part, collaboration also reflected in observing the other's actions and expressions and often copying them. Also in GUIs collaboration was noticeable, despite the single user access through mouse interaction. Commonly one participant would perform the interaction with the system, while his partner would collaborate by verbal suggestions or by pointing at the screen. Nevertheless, frequent verbal interaction, commonly arguing on the position of the piece, whether it is the needed one and looking for a certain piece, was present during the plays in both environments. When it comes to physical manipulation, GUI and mouse-based interaction caused difficulties in rotating the puzzle pieces, reflecting the need of a more direct style of interaction. TUIs provoked much more activity in terms of body movement and offered alternative possibilities of solving the puzzle, for example by moving around the puzzle itself instead of moving its pieces. Some participants made the puzzle from an upside-down perspective, which was not also supported by the GUI. Although arguments pro TUIs often state that having input and output integrated in space brings perceivable benefit, the study didn't confirm this assumption. (Xie et al., 2008)

3.4.3 Critical Examination of the Studies

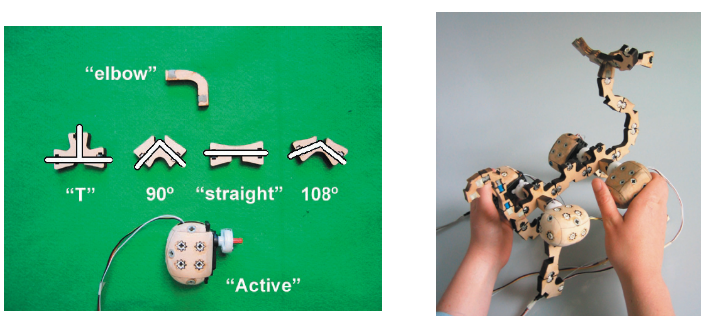
Especially the study using the Hazard Room Game shows several conceptualization errors that might have affected the results. In first place, the few participants, more precisely only sixteen, gives reasons to doubt on the significance of both quantitative as well as qualitative data. In contradiction to this, the Jigsaw Puzzle study had 132 participants. Second, the quantitative data from the Hazard Room Game study is based on the score differences between identical pre and post questionnaires. There is the issue, that the questionnaire results could be distorted by a learning effect among the participants, as they are always faced an identical questionnaire both before the game and inbetween the different sessions. These questionnaire scores are not independent data, like time measurement or repeated cycle count. The Jigsaw Puzzle study, instead, used quantitative data resulting from time measurement and counts of play, which seem to be more accurate for this purpose. On the other hand, the aim of the study was to identify the degree of enjoyment children experience and, in this context, it is doubtable that task time could give accurate feedback on enjoyment but rather on the cognitive difficulty of the game. Furthermore, some children reported to have felt pressured by the time limitation for completing a task. In some cases, this might have affected their performance. Despite possible distortion factors, these two studies set the foundation for the empirical comparison of GUIs and TUIs, as they are some of the very first of this kind and encourage more significant studies in the future.

4 Examples of Tangible E-Learning Systems

4.1 Expressive Systems: Topobo - A Constructive Assembly System with Kinetic Memory

The tangible system called Topobo is a 3D constructive assembly system coupled with kinetic memory that allows the recording and playback of physical motion. It is designed to facilitate modeling of both form and movement of dynamic structural systems in order to help understanding how balance, leverage and gravity affects moving structures. There are two type of assembly parts children can use when interacting with Topobo, as depicted in Fig. 4 (a): the Passives, these are just static components forming static connections("T", "90 degree", "elbow"), and the Actives, the motorized and networkable components that are able to record and replay motion.

When using the system, the child chooses his preferred components, snaps them together into desired shape, e.g. animals, regular geometrics or even abstract shapes, and connects the Actives with small cables. Usually, Topobo is designed to have every Active recording its own motion. After a button on the Active is pressed, the creation is twisted and moved to program a sequence of behaviors, that are saved in the kinetic memory immediately as the button is pressed again. In a creation with various Actives, pressing the button of one Active will activate the recording mode on all Actives, so that they all record at the same time and also can save information on the dependancies between components when motion occurs. Fig. 4 (b) illustrates the modeling and programming of a horse model with the Topobo system.



(a) (b)

Fig. 4. Topobo components(a) and modeling and programming with Topobo(b). (Raffle et al., 2004)

After finishing the motion programming and pressing the button on the Active, the construction automatically switches to the playback mode, reproducing the motion sequences over and over again.

Topobo is a typical illustration for an Expressive Tangible e-Learning System. As explained in anterior chapters, expressive systems are based on creating an external representation of existent knowledge and the subsequent reflection upon the accurateness of this representation. With Topobo, children create a physical model of how they think an object is supposed to look and behave. By snapping together the components they create the physical structure, by programming the Actives they set up a representation of possible motion behavior of this physical structure, all of this based on their own cognitive assumptions. In the next step, the playback mode triggers reflection on the previously built representation and the analysis of the degree to which the representation covers reality. With appearing dissonance between representation and reality, the children get the chance to rectify their assumption and by this increase their knowledge.

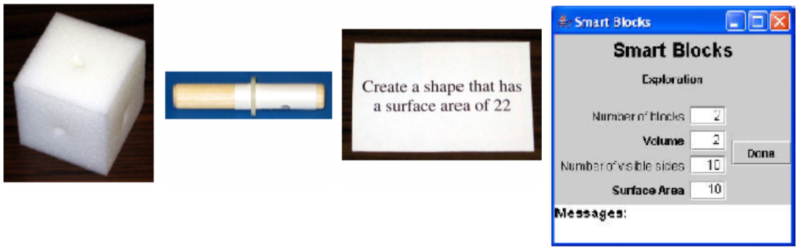
The evaluation of the system gave concrete hints on the concepts Topobo can help learning about. Students learn about the center of mass and gravity, when for instance a very tall creation tends to fall over when moving, find out on the difficulty coordination implies, when having a dog model supposed to shake its head and wagging its tail at the same time and get a notion on relative motion, finding out that movements in a connected system are relative to one's frame of reference.

As a further result from evaluations of the system, the researchers put together a set of six design principles that the Topobo System was iteratively improved after. First of all, the system needs to provide high accessibility on the one hand, by being ergonomic and intuitive for very young children, and yet still be sophisticated on the other hand, so that it supports employment also amongst children with higher cognitive level or even amongst adults. Other two criteria are robustness and expressiveness: children shouldn't get the impression that they might make "mistakes" that cause the system to break or malfunction or that the system prescribes them what activities are to be perceived as "wrong" or "right". Furthermore the system needs to keep its meaningfulness even without power supply, as it should extend a toy without sacrificing its good qualities and has to be scalable in the spirit of a modular system, meaning that every component has to be complete and extensible in aspects of physicality and computing performance. (Raffle et al., 2004)

4.2 Exploratory Systems: SmartBlocks - A Tangible Mathematical Manipulative

SmartBlocks is an augmented tangible manipulative enabling students to explore mathematical concepts on volume and surface area of 3D objects. The idea is to combine the benefits of physicality with real time feedback to support the learning process. It supports more than one user at a time and offers exploration through a trial and error process.

As illustrated in Fig. 5, the system consists of lightweight cubes(a) and dowel connectors(b), which are placed on a work space, question cards(c) and a display providing feedback via a GUI(d).



(a) (b) (c) (d)

Fig. 5. Components of the SmartBlocks system: lightweight cube(a), dowel connector(b), question card(c), GUI(d). (Girouard et al., 2007)

The idea of the system is that when the cubes are connected, they create a shape that is recognized by the computing system, which is able to calculate the volume and the surface area of that shape, providing them via the GUI. The system is built upon two modi: the exploration mode and the question mode. During the exploration mode, students assemble the blocks and the system automatically updates the feedback on volume, surface area and number of visible cube sides as soon as the assembly is placed on the work area. The question mode consists of choosing a question card an placing it on the surface of the work area, which disables the automatic feedback provision by the GUI. The question cards require two types of tasks: the first asks the user to create a shape that matches a particular surface area and/or volume, the second asks the user to create any shape and then estimate its surface area and/or volume. After each task is carried out, the system gives feedback on the correctness of the answer. (Girouard et al., 2007)

SmartBlocks fits the classification of Exploratory Tangible e-Learning Systems, as it supports the modeling of representations meant to describe the abstract concept of volume and surface area. By checking on the feedback provided by the GUI, the student can explore these abstract concepts by correlating them to the physicality of the cubes, getting an impression on the “size” of a certain volume or surface area. It is possible to explore the impact of a changing shape on its volume, surface area and even get an idea of the relationship of the number of blocks to volume and of the number of visible sides to the surface area.

The design of the system builds upon already existent but not digitally augmented physical manipulatives used in school for teaching mathematics. A main design factor was to keep costs as low as possible, in order to make the system ideal for usage in schools someday. Further empiric work is planned, which intends to compare a tangible execution of the System Blocks concept with the execution on a desktop environment. (Girouard et al., 2007)

5 Conclusion and Outlook

This paper facilitated a general understanding of e-Learning, TUIs and the way they can be brought together efficiently, so that they complement each other in their aims and purposes. There is a strong relation between cognitive anthropology and research, stating that physicality brings high benefits to the learning process and Tangible User Interfaces which provide physical access points to digital information. Still, the effectiveness of TUIs in supporting the learning process is rather being argued in favor of it by creating hypothesis leaning on general findings on the relation between cognition and physicality. There's a strong need for more empirical work and more detailed experiments, specifically examining whether TUIs are better than GUIs or just plain Physical User Interfaces lacking electronic enhancement.

Numerous experiments can provide new ideas on possible employment scenarios in the future of Tangible e-Learning. Also vice versa, the creation of these scenarios and subsequent experiments on their effectiveness for learning can improve tangible interaction Systems.

In future, we might encounter TUIs like the Cube to Learn in kindergartens and schools(Terrenghi et al., 2006; Kranz et al., 2006), TUIs in science museums and exhibits to simplify understanding factors that can affect the speed of a computer(Crease, 2006) or how a roboter can seem to have its own will and life by underlying a software(Horn et al., 2008). Why not explore our solar system and get to know more on the basic mechanics of planetary motion and the way it relates to the seasons in a lunarium enhanced with TUIs(Morris, 1999)?

Tangible interaction offers a variety of opportunities to learn more about the world we live in.

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Supporting Creativity in Group Sessions

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Abstract. Creativity is an important part of human life not only in arts but also in other domains like science and economy. Research about creativity started in the second half of the nineteenth century and since then several theories about the creative process have been developed. Moreover humans thought about ways to support individual creative work as well as creative team work. A number of researchers published their suggestions for the design of creativity support tools. In this paper two examples for applications that support creative group sessions will be presented and it will be contemplated to which extent they apply to the aforementioned design principles. Finally problems with the evaluation of creativity support tools will be discussed and the evaluation method of multidimensional in-depth longitudinal case studies (MILCs) will be presented.

1 Introduction

Even though creativity is often associated with arts, creative work is also important in science and economy. Moreover, creativity can be seen as a learning process and it can *"facilitate the learning of even the core concepts of a domain"* (Truman and Mulholland, 2003). Early research approaches focused on the support of individual creativity but over the last years interest in collaborative creative work has been growing. Design principles for software systems to assist with creative work in group sessions have been developed. The goal is to increase the benefits of creative work and to make it more productive.

In this paper, first, definitions for the term *"creativity"* are introduced and then an impression of the basic principles of creative processes is given by presenting several theories about it. Thereof general methods that help to support creative work are introduced. Afterwards the focus shifts to the special requirements of collaborative work and some design principles for groupware. These seemingly disconnected topics will be associated in the following part where design principles and examples for groupware systems that support creative work will be presented. The last part concentrates on the evaluation of such systems and the problems that occur.

2 Creativity

The term *creativity* is often used in everyday life. We call persons or their work creative and admire someone for a creative solution to a problem. Everybody knows what creativity is but nevertheless it is hard to define it because there are so many different aspects that belong to this field. This section provides several definitions as well as psychological theories that explain how creativity works and presents different techniques for creativity support.

2.1 Definition

The word creativity comes from the Latin words *creare*, which means *to produce*, and *crescere*, which means *to grow* or *to increase*. In spite of having its roots in an ancient language the term is relatively new (Piirto, 2004). It emerged around 1950.

In literature there are several definitions for it. The Handbook of Creativity (Sternberg, 1999) contains a collection of them from different authors. For example in the chapter written by Lubart it says *"creativity from a Western perspective can be defined as the ability to produce work that is novel and appropriate."* In another chapter Boden characterizes creative ideas by being novel and valuable. The definition: *"A creative idea is one that is both original and appropriate for the situation in which it occurs."* can be found in the chapter by Martindale.

Likewise Edmonds and Candy see creativity as a process with an innovation as a result (Edmonds and Candy, 2002).

All these definitions have in common that the product of creative work has to be a novelty, something not known or seen before. However, Boden (Boden, 2003) outlines that an idea is also creative if it is only new to the person who had the thought but is already known by other people. She uses the learning process of children as example: *"Children can come up with ideas that are new* to them, *even though they may have been in the textbooks for years."* In consequence she distinguishes between psychological creativity (P-creativity) and historical creativity (H-creativity). P-creativity means that the idea is new to the person who had it, H-creativity that it is not known that anybody has had this thought before.

2.2 Theories about creativity

The aforementioned definitions give a general impression what creativity is. Research has gone beyond those definitions and the theories about creativity have been amplified.

One way to describe how creativity works is to divide the creative process into different phases. In (Csikszentmihalyi, 1996) a five step model is illustrated. The first stage is a period of preparation. One has to get preoccupied with or fascinated by a certain problem at least unconsciously. This problem can transpire from personal experiences as well as within a particular domain. Established knowledge provides a basis for further inspiration. If somebody does not have any understanding of a domain he will not be able find a new solution to a problem of this domain no matter how creative he is on other domains.

The second step is a phase of incubation. In this period an unconscious process takes place. During idle time or sleep the brain does not stop trying to find solutions. However, the mind uses mechanisms, which have been learned consciously before, to come to conclusions. Cognitive theorists believe that during those periods associations between already existing knowledge are formed more or less randomly. Thus connections arise that are unlikely to be made while being awake. For example many people describe that after sleeping they found the solution to a problem they have been thinking about for a while.

The third step is often called the *Aha!* - moment. That is the moment when the solution to a problem becomes clear.

The fourth phase is evaluation. Now it has to be checked, if the insight gained in step three is really useful. It is a period of insecurity where the creative person is deciding how to go on from there and contemplates if the idea is really new or how other people will react to it.

The last step is elaboration where the idea is devised and realized.

Another approach divides the process of creative problem solving in four stages (Dacey and Lennon, 1998). The first phase is to find and define the problem. In the second step a mental impression of the problem is built. After that it is planned how to solve the problem and in a last step the performance on the problem is evaluated. Comparing this model with Csikszentmihalyi´s (Csikszentmihalyi, 1996) there are differences but also similarities. Csikszentmihalyi's model is more detailed and assumes that the creative process proceeds for the most part unconsciously whereas the four step model shows a rather active process by consciously planning a solution. In both the first step is the identification of a problem followed by a mental process and an evaluation.

The approach of Boden (Boden, 2003) assumes that creativity is always related to surprise. She differentiates three ways in which a creative idea can be developed. Firstly you can be creative by combining known ideas in an unusual way. Therefore you must already have an appropriate amount of knowledge to start with. This approach is similar to the second phase of Csikszentmihalyi´s model where unconsciously associations between already existing pieces of information are built. The second way is to explore conceptual spaces. That means to detect something new within a certain style of thinking. This style of thinking is often defined by the cultural background. The third way is to recognize the limitations of a given style of thinking and transform this conceptual space to make new ideas possible.

Similar to Bodens conceptual spaces where the way of thinking is influenced by cultural factors or the knowledge and rules accumulated within a certain domain, Feldman states that not only cognitive processes are part of the creative work but also outside influences like family and education (Sternberg, 1999). Altogether, he defines seven dimensions that are involved in creativity: cognitive processes, social and emotional processes, family, education and preparation, characteristics of the domain and field, societal and cultural aspects and historical influences.

2.3 Techniques for creativity support

Techniques for creativity support developed over the course of time. In the beginning no technology was used because there was none available. Pen and paper have been used to design something long before design software has been developed.

Visualization is an effective aid for creative work. Not only drawing sketches but also the visualization of information can be helpful in creative problem solving (Shneiderman, 2000). Getting a different view on known data can help to identify problems and inspire solutions. Depicting problems makes solutions sometimes more striking (Shneiderman and Plaisant, 2006). When the knowledge one already has is structured, relations and missing pieces can be found more easily (Shneiderman, 2002).

Another assistance for problem solving are so-called *What-if tools* (Shneiderman, 2000). Those are for example electronic spreadsheets that enable to explore different scenarios but also simulations. This technique can also be used without electronic aid but with paper and pencil the work is much slower.

Moreover discussions with colleagues and counselors can be inspiring (Shneiderman, 2000). Talking with somebody else about a problem brings you to view things form a different angle. Furthermore it is sometimes enough to spell out the problem in detail to find a solution.

Another method is thinking by free associations (Shneiderman, 2000, 2002), which Shneiderman equates with brainstorming. Brainstorming can be done alone, but usually it is done in groups. There are different forms of group brainstorming (Wilson, 2006). One way is that everybody is shouting out his ideas. However, for this form blocking effects have been observed. Sometimes members of a brainstorming group fear the reactions of their fellow group members to their ideas and keep them to themselves. Moreover rivalry about the time somebody is allowed to talk has been noticed. A second form is the so-called *brainwriting.* As the name already says in this technique the ideas are written down. That way blocking effects and rivalry about talking time are prevented. Moreover, the ideas can be reread at any time and thus previous ideas can stimulate new ones.

As the problems described in collaborative brainstorming already show, working together in groups can lead to difficulties. In the following subsection the conditions of group work will be further examined.

3 Collaborative Work

A team can reach goals an individual could not accomplish. Already in the early days of mankind humans learned that working together had advantages (Stewart et al., 1999). At that time aims were to find enough food or to defend oneself. Nowadays there may be different ambitions but collaborative work is still an important part of human life. For example, like shown in the previous section, collaboration can be useful in creative problem solving.

The domain can be divided into co-located work and distributed work where the members of a group are working on the same project but in different locations. Modern techniques like e-mail, telephones and videophones make it possible to stay in constant contact even if you are living in different parts of the world. In this paper, however, the focus is on the form of co-located work, which you can find in group sessions. First characteristics of collaborative work will be shown. Afterwards the focus goes to software systems for collaborative work, so-called groupware.

3.1 Conditions of Collaborative Work

Working alone one can play by his own rules. When working together in a team there are different conditions. Collaborative work has many advantages but problems can also occur.

In (Thiagarajan and Parker, 1999) you can find the following definition: *"a team is a group of people with a high degree of interdependence geared toward the achievement of a goal or the completion of a task."* It sums up the overall reason why people decide to work together: they want to reach a certain goal. The big advantage of group work is that it is possible to create something one cannot create alone. Moreover it is reported that a higher job satisfaction can be reached in comparison to working alone.

Nonetheless working together is not always easy. Team members may have the same goal but sometimes they have different notions of how to reach it. Different kinds of conflicts may occur during collaboration. There are relationship-oriented conflicts and task-oriented conflicts (Stewart et al., 1999). Relationship-oriented conflicts refer to personal conflicts between team members; task-oriented conflicts arise when there is a disagreement about the way of executing a task. The latter, however, may sometimes also be beneficial because it can lead teams to critical evaluation. The group has to dispute about the best way to finish a task. In the end compromises often have to be made.

Mandviwalla says that groups *"are delineated by context, time, behavioral characteristics, use of interaction methods and work habits"* (Mandviwalla and Olfman, 1994). Hence a group is more than the sum of its members. Outside influences like working conditions, but also the way people interact with each other have an effect on group work as well as the personalities of the team members.

In interdisciplinary teams language can also be a problem as the team members may have different professional vocabulary (Mamykina et al., 2002). If no shared language exists there is the possibility of misunderstandings. One way to solve this problem is to formulate a shared language. Another way is that the team members learn what a word in their colleagues' terminology means. The use of metaphors and illustrations to make clear what is meant can also be helpful.

Moreover in doing collaborative work communication between team members, interpretation and coordination of abilities are needed (Amabile, 1993). When working alone there is no need to exchange information but working together it is essential to trade knowledge in order to achieve a collective goal. This information communicated by others has to be interpreted by the remaining team members. As mentioned before that can lead to difficulties when a team does not share the same vocabulary (Mamykina et al., 2002). Furthermore the members of a team usually have different abilities. Working together on the same project coordination is crucial.

3.2 Groupware

In our society computers are used in many parts of everyday life. Consequently there have also been ambitions to use electronic assistance for support in the field of collaborative work . This area of research is called *Computer Supported Collaborative Work* (CSCW). Sometimes you can also find the term *Computer Supported Cooperative Work* as long form for CSCW.

Software and computer systems that support group work are often called Groupware. Mandviwalla and Olfman studied existing groupware systems and identified their limitations (Mandviwalla and Olfman, 1994). The tested systems only supported interactions between group members but did not support individual actions like note taking that can be helpful to prepare work before you make it public. Moreover it is criticized that by using different software for group sessions and the work done between meetings additional overhead is created. Using discrete systems means that data first has to be loaded into the groupware system before it can be shown to all group members. Furthermore there has to be constantly switched between the systems that support individual tasks like note taking or drawing and the groupware system. Systems also only support a special part of group work but not the whole work. Another problem is that there is a tendency to design for an *average group* the designer has in mind. However, there is no such thing as an average group as each group is defined by its members, surroundings and goals.

Based on their findings they suggest a list of seven groupware design requirements:

1. Support multiple group tasks: Groups may encounter different tasks in the course of a project, therefore groupware should support potential tasks to prevent switching between different systems.
2. Support multiple work methods: Members of a group may prefer different work methods. In order to help them to work together successfully, different methods should be supported.
3. Support the development of the group: Groups are dynamic. To support their development, techniques to increase consensus, define roles, redistribute power and increase interaction are needed.
4. Provide interchangeable interaction methods: Different forms of interactive group communication such as face-to-face meetings or e-mails, as well as different degrees of interaction, should be supported.

5. Sustain multiple behavioral characteristics: The users should be able to adjust the system to their behavioral needs.
6. Accommodate permeable group boundaries: Groups have to work together, share information and work on complementary projects. Therefore permeable group boundaries are needed.
7. Adjustable to the group's context: The needs of a group change over the course of time due to contextual factors. Hence groupware needs to be customizable.

A special form of groupware are systems that support creative work in group sessions. Such systems are the subject of the next section.

4 Creativity Support Tools

Software systems that assist with creative work are called creativity support tools. They aim to help users to be more innovative. In this section several design principles and suggestions for additional features for creativity support tools will be presented. Afterwards two examples for such tools will be introduced and it will be analyzed to which extend they follow the aforementioned design principles.

4.1 Design

Several researchers contemplated about the improvement of creativity support tools. They suggested a number of design principles and additional features that in their opinion can be helpful when using such tools.

4.1.1 Design Principles

In literature there are some suggestions and principles for the design of creativity support tools. Shneiderman, who is an expert for these kind of tools and has published his thoughts in different papers, has established twelve design principles together with a team as the result of a workshop (Shneiderman et al., 2006).

These principles are:

1. Support exploration
2. Low threshold, high ceiling, and wide walls
3. Support many paths and many stiles
4. Support collaboration
5. Support open interchange
6. Make it as simple as possible - and maybe even simpler
7. Choose black boxes carefully
8. Invent things that you would want to use yourself
9. Balance user suggestions with observation and participatory processes
10. Iterate, iterate - then iterate again

11. Design for designers
12. Evaluate your tools

The second principle has to be seen metaphorically. Low threshold means that the application should offer easy access for newcomers, high ceiling stands for the possibility to use the system for gradually more advanced projects, and wide walls symbolize the support of a variety of possible explorations.

The participants of the workshop believe that software tools for creativity support can be improved if designers are geared to these principles.

In (Prante et al., 2002) requirements for CSCW tools that assist with idea generation and structuring are presented. They were developed on the basis of a formative study. The first requirement is to prevent turn-taking. Especially for brainstorming sessions the efficiency is reduced when people only can make inputs one after another. For creative work it is necessary that people are able to add simultaneously items to the shared workspace. A second requirement is to structure the idea space. The analysis of the study showed that structuring ideas promotes the achievements of creative work. Finally the authors explain that there should be no process constraints because groups do not follow fixed phases in their work. For instance it is not natural to firstly accumulate ideas and not to associate and evaluate them until later in a second phase.

Greene formulated in collaboration with an interdisciplinary team a list of seven characteristics for creativity support tools (Greene, 2002). Firstly *"support pain-free exploration and experimentation (a 'sandbox' mode)"*. Users should have the possibility to explore their ideas without being afraid to spoil their previous work. Therefore undo and redo functions are necessary. Further characteristics are: *"Support engagement with content to promote active learning and discovery." "Support search, retrieval, and classification." "Support Collaboration." "Support the domain-specific actions that must be done. " "Support iteration." "Support and perhaps encourage instructive mistakes."* The last point sounds at first strange since people normally try to avoid mistakes but the research team found out that instructive mistakes can get people to reconsider their theories and to learn something new.

Comparing these design principles from different experts one can see that some principles appear not only in one listing. Both Greene and Shneiderman mention the support of exploration as well as collaboration. Moreover Shneiderman and Prante emphasize that you cannot foretell how users work, that they use their own techniques and that it is therefore important not to restrict them. Whereas Shneiderman's team concentrates more on advice on how to proceed when developing a creativity support tool the other groups rather focus on characteristics the completed system should have.

4.1.2 Additional features

Moreover there are suggestions for additional features creativity support tools could benefit from. Shneiderman explains that the possibility to review session histories can have advantages (Shneiderman, 2000). With the help of session histories one can reflect on his work and thus draw conclusions for further work. In simulations it is possible to save the results of runs with different parameters to compare the effects.

In 2002 Shneiderman provided a list of eight tasks he considers as helpful for creative work. These eight tasks are (Shneiderman, 2002):

1. Searching through media such as photos, videos et cetera, digital libraries and other sources of information. Search functions help to gather information by speeding up the finding process and enabling to find specific pieces of information.
2. Visualization. As already described in 2.5 by visualizing ideas, one can structure his thoughts to find connections and maybe also see if he is missing something.
3. Consulting with peers and mentors. To exchange information and talk about problems gives intellectual as well as emotional support. Electronic aids like e-mail and instant messengers enhance communication.
4. Thinking by free associations. To form new combinations between ideas can channel thoughts to a new direction. Software can help with this process for example by providing tools that show related words to a given expression.
5. Exploring solutions. For this task simple support tools like spreadsheets as well as more complex "what-if"-tools like simulations can be helpful.
6. Composition. Especially in graphics and music compositing is a central task but also in other domains like for example teaching or in private projects composition tools can assist with creative work.
7. Reviewing session histories. By recording user actions and giving the possibility to review them users can analyze their performance, go back to a certain point of their work and carry on in a different direction from there on. Moreover by sending session histories to colleagues one can ask for assistance.
8. Disseminating results. Publishing the results of creative work is important. It can aid other people by finding suitable data in point 1. searching. Furthermore friends and colleges that helped with the creation but also people that were simply interested in the topic can be informed.

These tasks are an extension to the so-called *genex framework*. *Genex* stands for *"generator of excellence"* (Shneiderman, 2000). The framework consists of four phases: Collect, relate, create and donate. In the *collect*-phase one is gathering information about earlier works that are stored somewhere in libraries or the Web. The *relate*-phase consists of consultations with others. In the *create*-stage solutions are invented, explored and evaluated and at last in the *donate*-phase the results are made public and added to the libraries. Shneiderman points out that these four steps do not have to be carried out in a linear way but rather intertwine with each other. During creative work one must sometimes return to a previous stage.

4.2 Examples

Below two examples for creativity support systems for group sessions will be presented and it will be analyzed to what extend they follow suit to the aforementioned design principles. The two systems were chosen because they implement two of the most common techniques for creativity support, which were mentioned in subsection 2.3. The EBS in subsection 4.2.1 is a system for brainstorming, whereas TEAM STORM (subsection 4.2.2) is a tool for visualizations.

4.2.1 Electronic Brainstorming System for an instrumented room

The first example is a brainstorming application for brainwriting developed at the Ludwig-Maximilans-Universität in Munich (Hilliges et al., 2007). The idea behind this system is the idea card method where you use post-its to write down your thoughts. The electronic brainstorming system (EBS) that is discussed here does not use personal computers but a so-called *instrumented room* that is equipped with a table top display and several displays on the walls. This set-up can be seen in Figure 1.

Fig. 1. Using the brainstorming application in the instrumented room (Hilliges et al., 2007)

The users can write down their ideas on the table per pen-based input. By drawing a square on an empty part of the table a yellow form looking like a post-it appears. This form is now the area to write something down. By tapping on a special part of the virtual post-it the form will be minimized and can now be moved. For example users have the possibility to shift it from their personal area to another person on the other side of the table where it turns around so that this person can read it or arrange it in a certain way. By tapping in the middle of the minimized post-it it can be maximized again and be edited by everybody. If you draw a line around a group of notes you create a cluster. Clusters can be moved, united, and dissolved.

Moreover the screens on the wall show the content of the table display the whole time. On these displays the post-its are orientated upright so that everybody in the room can read them.

In the following there will be contemplated to what extent this system follows the design principles presented in chapter 4.1. Not all principles will be taken into account (for example the point *"invent things that you would want yourself"* is hard to assess) but only the most important ones, especially principles that have been mentioned in more than one list.

All three characteristics suggested by the team of Prante are fulfilled. Users can write down their ideas whenever they have new thoughts without any regard to a certain order. They do not have to wait until another team member has finished the input of his thoughts. Hence there is no forced turn taking that could restrict people during their work. Secondly the application offers the possibility to structure the workspace as notes can be arranged and clusters can be built and connected. Moreover groups can work in their own mode of operation. Although it is mentioned that users would use the table for a generative phase and the wall displays for a structural phase there is no constriction. People can switch between these modes whenever they want to or even use them in a totally different way.

Furthermore the system supports exploration as ideas can be analyzed, combined or be separated again. Thus engagement with the content is encouraged. However it is not really a sandbox mode as Greene suggests because not all steps can be easily undone and redone. For example it is not mentioned what happens if somebody deletes a post-it, whether it can be retrieved again without writing the idea down again. Some kind of virtual waste paper basket in analogy to real life, where a discarded post-it would be thrown into the trash bin but could easily be retrieved, would be useful.

The second principle of the list of Shneiderman et al. has been mostly achieved. Since the interaction gestures are easy and adopted from real world gestures (for example skidding a sheet of paper over a table) the threshold is relatively low. However without an introduction to the basic functions an accurate use for novices is unlikely. But as the system does not constrict the field of work it can be used in many different approaches and also advanced projects.

The application also supports collaboration. Using a table and wall displays instead of personal displays the software rather is a means of computer-mediated human-to-human interaction than of human-computer interaction. Sliding notes across the table to other people seems like a promising way of interchange.

Since the system uses pen-based input users can keep their own style during their work. Consequently many different styles are supported.

Like Shneiderman et al. demand the software has also been evaluated. In a user study with 30 participants several teams tested the software.

It is not mentioned if there has been any involvement of user suggestions into the design process. However, as a result of the conducted user study a list of design considerations emerged. Yet it is not mentioned if these principles will be implemented in a second iteration.

Contemplating the genex framework the EBS could be used for the first two phases. The system is designed to accumulate ideas (*collect*). The electronic post-its can be used to write down complete new ideas as well as to gather information already known. However there is no possibility to look for information in libraries or the internet. Previous knowledge has to be present in the users' mind or notes he took with another system. The second phase *relate* is supported by the displays on the wall that encourage discussing the content of the notes shown there.

4.2.2 TEAMSTORM

The second example is a design tool called TEAM STORM (Hailpern et al., 2007). This system can be used in an early stage of a design process to sketch ideas. Up to five designers can work with it. They have the possibility to deal with several design ideas in parallel. The system is conceptualized to be used with a big display that every team member can look at and personal devices for each user, for example tablet computers. However, it is also possible to use it without the large display. It is convenient to use devices that can be operated by pen-based input as personal devices because then it is possible for the designer to directly draw his sketches on the device.

Each team member has a personal workspace. This workspace is shown in the lower half of Figure 2. There are canvases that equate pieces of paper. You can draw onto them but unlike paper you can not only arrange them but also scale them. Moreover, there is a shared workspace, the so-called group workspace (upper half of Figure 2). Every user has direct access to this workspace using his own computer and can edit the design ideas shown there. Additionally the group workspace is shown on the large display.

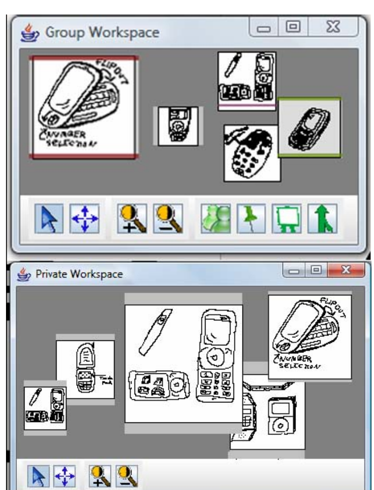

Fig. 2. Group workspace and private workspace of TEAM STORM(Hailpern et al., 2007)

Just as the EBS from section 4.2.1 TEAM STORM satisfies the three characteristics proposed by the team of Prante. Since being able to work in parallel is the major design goal of this system the users are not forced to take turns. Seeing as all important functions and all canvases are available all the time groups are not coerced to work in a certain way but can operate in their own manner. Moreover the idea space can be structured by arranging the canvases within the workspace or by weighting them through different scale sizes. However, users missed a function to group items so that they can be moved, shared and scaled jointly. Hence there still seems to be a need for improvement.

The system supports collaboration in different ways. Firstly the shared workspace allows efficient sharing of ideas. Canvases can be moved to the shared workspace to show them to others. As long as a canvas is in *show mode* only the designer himself can change it. The canvas can also be removed by dragging it back to the personal workspace. The owner of a sketch also has the possibility to *share* it. Once a design is shared everybody can work with it. It is possible to do that in private by copying a sketch to one's personal workspace or in public shown on the big display. A shared design cannot be deleted by anybody but only be scaled to a very small level so it hardly requires space. That way conflicts between group members, if for example designer A deletes the image created by designer B, can be avoided.

Moreover there is a *gesture mode* where strokes of different people are shown in colors assigned to the persons. These strokes vanish after a short time. That way it is made easier for designers to explain something and show it by pointing to something. For discussions about specific sketches canvases can also be shown in full screen mode to draw the attention of all team members to it and to make it easier to manipulate it while showing it on the big screen.

By using interfaces with pen-based input everybody can draw in his own style. Additionally canvases can be arranged in a way suitable for the group or in the personal workspace for a person. That way many different styles are supported.

Looking at comments made by designers testing the system the functions for exploration seem to be not developed enough. Exploring the workspace was described to be tiresome when there is a larger number of designs. Moreover it is not mentioned if there are undo and redo functions that enable a sandbox mode as suggested by Greene (Greene, 2002). Such functions would be useful since mistakes can happen when you draw something. For example one can slip during the drawing process. However the exploration of different paths is fostered. It is possible to test several continuations for one design by copying it and working then on a duplicate while the original stays unchanged and can be used as blueprint for further copies.

Since there are not too many and complex functions starting to work with this software should not be difficult for novices. However, an introduction to the system will be needed. As advanced design processes need mainly advanced sketches they can also be done with the system. So the claim *"Low threshold, high ceiling"* (Shneiderman et al., 2006) is fulfilled, but not the demand for *"wide walls"*. According to the designers who tested the system, there should be a possibility to import other objects like pictures or website contents to expand the variety of design options.

Observations as well as user suggestions have been taken into account for the design. Before the system was created a total of six groups have been observed fulfilling a design task with non-technical means to learn more about the way groups work with several design ideas in parallel. Moreover, after executing the task the members of the team had to fill out a questionnaire where they among other things should sketch a work environment they would like to have.

Additionally after the system was finished it has been evaluated in an informal user study with three groups of designers. Thus the developers got a first impression what is good and what has to be improved. There are plans for a longer-term study.

Furthermore it is intended to go into the second iteration and improve the system on the basis of the user comments.

If you want to categorize TEAM STORM on the basis of the genex framework you have to look at two different levels. Firstly there is the structure within the team. Each member can *collect, relate, create, donate*. Every individual team member has the possibility to *collect* design ideas in his personal workspace by either getting copies of already existing ones from the group workspace or creating new ones (*create*). To *relate* with the rest of the team he can show them his sketches in *show*-mode to talk about it and can also take it back to his personal workspace to further explore the design possibilities. In the end he can *donate* by sharing his sketch so that it is now available for the whole team in the group workspace.

In the second level the team can be seen as one unit that interacts with the outside world. Here the phases *relate and donate* are not supported as there is no way described how to transmit the designs to persons who are not part of the team to get their opinion. Moreover there is no method to get the finished designed to a library where people, who are not part of this special design team, have access to use the designs for their own *collect*-phase.

5 Evaluation of Creativity Support Systems

Why is it important to evaluate creativity support systems? Shneiderman states that *"there is a legitimate argument that computers can interfere with creativity"* (Shneiderman et al., 2006). To find out if certain software tools can really support creative work or if they rather are obstructive to creativity, accepted evaluation methods are necessary. In the following it will be shown why the evaluation of creativity support systems is difficult and the evaluation method of multidimensional in-depth longitudinal case studies will be introduced.

5.1 Difficulties

Evaluating creativity support tools is even more difficult than the evaluation of other software. Some critics even believe that you cannot study creativity because creative potential is immanent and cannot be altered.

The problem is how to measure creativity. Mostly this is done by assessing the product of creative work. However it is hard to evaluate creativity in laboratory conditions. Using simple standard problems to test creativity support tools is hardly adequate. Seeing as creativity has to do with finding new ideas that have not been thought about before typical problems are not the right way. Shneiderman's statement that *"specifying tasks is somehow at odds with the goals of supporting innovation or discovery"* (Shneiderman and Plaisant, 2006) is a good summary for these difficulties.

Additionally creative processes may include domain specific characteristics. An architect needs knowledge about construction plans whereas a musician needs to know about clefs and notation. However, there exist also skills that can be helpful in several different domains.

Moreover the short time span of usual user tests is problematic. Using the tested tool in a controlled environment only for a few hours users cannot discover the whole potential of a tool and investigators have no chance to detect if there are strategy changes or learning effects (Shneiderman et al., 2006).

5.2 Multidimensional in-depth longitudinal case studies

In order to avoid the problems mentioned in 5.1. Shneiderman et al. suggest using methods based on multidimensional in-depth longitudinal case studies (MILCs) to evaluate creativity support tools (Shneiderman et al., 2006). *Multidimensional* is a reference to the use of several different investigation methods. To assess how helpful and how efficient a tool is interviews and surveys are used in addition to observations and automatic logging procedures. By using several different methods the handling of the evaluated application can be assessed from distinctive points of view. The term *in-depth* displays the deep involvement of the researchers and their close contact to the expert users. *Longitudinal* expresses that the studies are conducted over a longer time period. The user's way from a novice to an expert is tracked. Finally *case studies* refers to reports about the experiences of a few individuals(Shneiderman and Plaisant, 2006).

Moreover ethnographic field study methods are applied to prevent misinterpretations of observations and to help not to miss important information (Rose et al., 1995; Shneiderman et al., 2006). In (Rose et al., 1995) guidelines for the execution of such studies can be found. To prepare an ethnographic field study the researcher should make himself familiar with the user's work environment and also with the system to be tested. The goals of the evaluation should be defined, questions prepared and permissions for the execution of the study obtained. During the field study the users are observed and questioned. Not only how they directly interact with the system but also further information like their daily routine or their previous experience with computers should be gathered because these factors can influence the way a user interacts with the system. The observations should be recorded in some way. For example a camera or a tape recorder could be used. If participants are feeling uncomfortable being recorded it is better to just write the findings down. For the analysis the collected data should be organized. Then it can be quantified and interpreted and problems can be identified. Analyzing should already begin during the field study. Throughout the conduction of the study the goals should be refined. The report of the results should be created with regard to different types of readers with different goals. Quantitative data and anecdotal evidence help to illustrate problems.

Shneiderman and Plaisant state that there are basically two categories of outcomes for MILCs (Shneiderman and Plaisant, 2006): *"the refinement of the tool and an understanding of general principles or guidelines for the design of such tools"* or *"the achievement of the expert user's goals by way of their use of the tool"*.

6 Conclusion

Creativity research began in the middle of the last century. Since then different approaches how creative work can be supported have been developed. Not only personal creative work but also collaborative creative work has been in the center of several studies. In the course of an increasing level of technology software systems for creativity support have been developed as well. In order to improve the effectiveness of such systems several lists of design principles and required characteristics for creativity support tools have been suggested. In this paper a collection of them has been presented and it has been analyzed to what extend these design principles were already taken into consideration in the design of two creativity support systems that have been developed in the last year. The result is that both analyzed tools already follow quite a lot important design rules like the support of collaboration, structuring the work space and evaluation of the system. However, there is still room for improvement.

Since the efficiency of creativity support tools is often questioned and critics even claim that the use of technology is obstructive for creative work there is a need for accepted evaluation methods.

As creative problem solving becomes more and more important especially in scientifically research and in economy as a means for increased productivity it is a high possibility that the deployment of creativity support tools will spread and the demand for new advanced and perhaps also more specialized tools will rise.

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Web-Based Training and E-Learning

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Abstract. This paper gives an overview about the technological development of Web-Based Training and why a static set of web pages is not enough to effectively deliver educational content. Learning Management Systems are introduced which are more flexible and adapt the experience to the individual user. Blended Learning shows the potential benefits of a hybrid approach, combining traditional presential courses with virtual courseware. Examples of E-Learning in a corporate as well as an academic context are given. The tools of E-Learning 2.0 are introduced and their potential educational uses explained.

1 Introduction

The unparalleled rise of the internet over the last two decades changed the way people think about information. Not only did it change the way we think about business and entertainment, it also changed the attitude of the people using it. Everything has to be instant and on-demand. The most important ability in today's fast changing world is to adapt and never stop learning new things. Web-Based Training seems to be the perfect substitute for traditional face-to-face education in modern society.

The concept of learning by means of online technologies is approximately ten years old. There is no specific event which can be seen as the start of Web-Based Training (WBT), instead it is more of a philosophy. The idea of learning *anytime anywhere* is central to understanding the benefits of WBT. Being independent of time and space means learning can be achieved in a much more self-determined way. In today's society *lifelong learning* is very important and WBT can be an ideal method for supporting this attitude. The world we live in is a very dynamic environment and many people do not have the time to go to a physical place to learn new things.

When comparing Web-Based Training and Computer-Based Training (CBT) they are similar in concept but differ substantially in delivering the learning content. While CBT is coupled to a specific supporting medium, WBT uses remote technologies to access the content. When we look a little bit closer there are further benefits to utilizing online technologies for delivering content (Ellis et al., 1999). The defining characteristics of WBT can be classified into three categories.

Technological: the most obvious benefit is the use of online technology instead of CDs or DVDs. This means the content is platform independent. The only requirement is the existence of a web browser for the platform. In a corporate environment this also means, that there is no security thread by enabling optical drives or disc drives on every workstation to install the CBT software. As web technologies continue to evolve, the courseware can evolve with them at a faster pace than CBT software can. Mobile devices can access web documents and Mobile E-Training can extend the functionality of the courseware. It is difficult to use a CBT solution on a mobile device because of its limited storage especially with video content. The streaming of data via a website is more suited to mobile use. Because the content is always up to date, the learner benefits from errors being corrected and new material being added. The drawbacks include the unavailability and the potential slow response time of an online system. This may deter the user from just-in-time learning. Not all browsers may be compatible with all courseware so the platform independence is not always guaranteed.

Economical: E-Learning is financially beneficial for large companies. There is no need to install and maintain the software on the workstations but instead users can access the courseware via the intranet and are automatically using the most recent software version. This means it is easier to administrate and update the software. In private use it can be cheaper to buy individual modules you would like to use instead of paying for all the educational content on a disc. When learning an instrument like an electric guitar for example, you can just pay for those songs you want to learn. If there is a subscription model in place, you pay a monthly fee and are able to access all the content that will be available in the future. The downside of WBT are the online time and traffic costs if the user has no internet flat rate.

Psychological: learning in groups online by means of chat or instant messenger can have a positive impact on the learning experience and result. When a student explains a topic to a fellow WBT student, it can have positive effects on him understanding the issue as well. While in a traditional CBT environment the users feel rather isolated, in a connected WBT system they can exchange experiences which leads to them being more motivated. Users want to communicate and learn from one another. The users want to access the content when they want and where they want. This self-determined and intrinsic way of learning is preferred by users.

The terms Web-Based Training and E-Learning are often not clearly defined. E-Learning sometimes can also refer to traditional Computer-Based Training. For the purpose of this paper however, both terms will be used synonymously. Web-Based Training can be defined as **the process of learning with tutor and learner separated by time or space where this gap is bridged by online technologies**. The evolution and growth of the World Wide Web

(WWW) played an integral part in developing new E-Learning methods. The expression *Courseware* will be used for a set of documents containing educational content as well as a navigational structure to access them. With these definitions in mind, any WWW site containing educational material could be considered a WBT system. This is however not the most effective way to learn.

The goals of this paper include giving reasons why traditional HTML-documents and static links between them are often unsuitable to effective learning in chapter 2. Following the drawbacks of traditional HTML-documents will be the solution to many of its drawbacks: The Learning Management Systems (LMS) in chapter 3. Chapter 3.1 explores if blending traditional face-to-face communication and WBT can lead to better learning results. In chapter 3.2 we take a look at different South African companies as well as Japanese universities and show how they integrated E-Learning into their processes. Finally chapter 4 looks at E-Learning 2.0 and how Web 2.0 tools and applications can be integrated into WBT. The conclusion tries to reflect on the findings of this paper and give a brief outlook of future trends.

2 Shortcomings of HTML and Hypertext Navigation

This chapter describes why web sites, that are composed of traditional HTML documents and a static linear navigation have drawbacks for all users of the WBT system. Learners, tutors and authors are introduced and their role within a WBT system is presented.

While a set of HTML-documents (nodes) and static links between them could be considered courseware this system has several inherent flaws (Denis Helic and Scherbakov, 2000). These stand in the way of effectively delivering new learning content. The major drawback is the lack of meta-data. This means that there is no internal logic to the documents. This is especially a problem when authoring the data. Every time a node is added the entire navigational structure has to be restructured and links have to be added to every node in its vicinity. When the data is not stored in a consistent fashion the presentation of the data can be incoherent and chaotic. This is distracting to the user and draws his attention off the informations themselves. When incorporating links to external educational nodes, they can become outdated or the referenced document could have been removed. The learning experience is the same for every learner no matter what his demands are. It is not possible to customize the courseware for the user neither by the system itself nor the tutors. The potential of reusing educational content in the same context (customization) or an entirely different context is wasted. There are three different *user roles* when talking about WBT systems. The following list explains each different user role as well as their personal drawbacks:

Learners: they use the WBT system to improve their knowledge and skills and are motivated by a *Learning Goal*. These goals can be intrinsic or extrinsic in nature. An example for intrinsic motivation would be a student at a university or a person at home trying to learn a foreign language. Extrinsic on the other hand could be a work related security seminar in a corporate environment. Learners are the main users of the courseware and the system should be customizable to their needs and wishes.

There are several problems with static courseware for the learners. Users can be affected by two different negative effects. The *tunnel effect* occurs when the educational content is not spread far enough over the learning subject and the learner has no possibility to think outside the box and explore certain topics. The strictly linear navigation leads to a very narrow and rigid experience. The user has no chance to connect the new informations to previously acquired knowledge and therefore most of the new knowledge is lost. The user has to be given the option to dig deeper into certain topics where previous knowledge is lacking. Topics where the learner has extensive knowledge can be skipped entirely. The exact opposite would be the *getting lost in cyberspace* effect. When the user has too many options and hyperlinks, which are not customized to his needs he may jump from one link to the next and lose track of the learning topic entirely. This can be disorienting for the user and can lead to a negative backlash on his motivation. While surfing from node to node the learner may feel isolated and overwhelmed while trying to absorb as much information as possible.

Tutors: they manage the learning process and bridge the gap between learners and courseware. They provide explanations when the users need them, answer questions and customize the learning experience for the learner when the courseware does support such customization. In an ideal Web-Based Training environment these tutors would not be necessary, because the system itself adapts to the user. However in today's E-Learning these tutors are still required and they should have a reasonable interface to interact with the courseware.

Traditional data structures like HTML-documents offer limited to no customization possibilities to cater to different users. Every user is presented the same learning contents in the same order. Because every student has a different knowledge foundation to begin with, this is not effective. A lot of time is wasted, because questions, that are posed by multiple students have to be answered every time. When answering common questions in a FAQ, the original context of the question is lost, which can lead to user confusion. It is difficult for the tutor to see the individual progress of the students as personalized and learner-centered tests are difficult to generate. The tutor may lose track of how the learners are doing and therefore can not use his acquired skill to cater to different learners strengths and weaknesses to the full extend.

Authors: they create and publish documents to the courseware repository. All educational material is generated by authors. After generating the content itself, they combine the documents into a navigable structure.

If several authors are involved in a project, they may use different data structures, although for an effective courseware system they should use a unified approach. Because of the lack of meta-data the navigation structure has to be modified from the ground up every time a new document is added to the navigation. There is no inherent structure to the documents and it is entirely up to the authors to create a hierarchy, that is reasonable for most learners. There is no possibility to modularize the learning content into small reasonable units which could be reused in other learning contexts. For example a particular part of an article about Web 2.0 might be usable for a computer science as well as an economics course.

These problems needed to be addressed and thus from approximately 1997 on Learning Management Systems were established.

3 Learning Management Systems

This section is about Learning Management Systems and their advantages over traditional HTML courseware. The concept of a learning framework as well as the technical implementation with XML documents are introduced. At the end of the chapter the results of two different studies comparing open and closed-source learning platforms are presented.

The primary idea of *Learning Management Systems* (LMS), sometimes called *Virtual Learning Environments*, is to offer a unified platform for delivering educational content in the most effective way possible (Darbhamulla and Lawhead, 2004). This is achieved by a combination of modularizing the content and fostering user communication and collaboration. When an author publishes new content to the repository, it is stored without its presentation. By detaching the presentational layer from the content it is easy to reuse and syndicate the content. Learning Management Systems provide a unified Framework comprising of educational modules so that content can be accessed in different sequences which are adapted to the individual user. The use of an attractive front-end as well as introduction of pictures and video make the experience for the user more fun and engaging. Because this user interface is coherent across all web pages, the confusion of the user is minimized. The system should adapt to the learner's performance and learning progress. This is called *adaptivity.* Intelligent agents analyze the user's progress and customize their individual learning experience. The concept is implemented with varying degrees of success. The adaptivity of the courseware is difficult to achieve but holds the most promise. The learning path can also be adjusted by either the tutor or the learner himself which leads to a more dynamic and learner centered experience. Both features combined, intelligent agents and user choice, can make the learning process more effective than a static and linear sequence of documents. Another important function of an LMS is the integration of multiple communication tools. This can help to prevent the user feeling lonely and isolated. The communication tools include Forums and brainstorming sessions which are a method for asynchronous one-to-many communication. Learners and tutors can talk about learning successes or set backs and the whole conversation is visible even if somebody joins the discussion later. This is especially useful because the context of a question and its answers is preserved. A quick and easy way to achieve a realtime one-to-many communication can be achieved by utilizing a chat. If a learner needs an answer prompt because he is not able to continue working without it, several users and maybe a tutor in a chat is the ideal solution. The conversations are also more fluid because queries can be answered immediately. Personal remarks and questions about the progress with the learning material should not be discussed in a public environment such as a forum or a chat. Instead learners and tutors can use personal messages and mail to speak about problems with the learning progress. This one-to-one communication method ensures that students do not feel embarrassed when asking a potentially trivial question where other learners can see it. Cooperative and collaborative learning is encouraged by the integration of these tools into the LMS. The centralized user-management component of an LMS ensures, that the personal data of all users are secure and can not be accessed by other users or third parties.

Technically an ideal LMS should use a unified data-structure (Figure 1): Educational content is stored in a database. From there the data is preprocessed to Extensible Markup Language (XML) data. This XML code is similar to HTML code but has much more possibilities to embed meta-data and is therefore the preferred data structure to store data without the presentational layer. XML (Source: http://www.w3.org/TR/xml/), as described by the World Wide Web Consortium (W3C) provides a class of data objects which are called *XML documents*. The logical structure of the XML document is defined in the Document Type Definition (DTD), which consists of user definable elements and their respective attributes. An element can contain different kinds of data, for example string-text or picture-data. This XML data is transformed by Extensible Stylesheet Language Transformations (XSLT) into standardized HTML-documents which all have the same layout and design. XSLT (Source: http://www.w3.org/TR/xslt/) replaces the Cascading Style Sheet (CSS) of traditional HTML documents and adds the presentational layer to the structures data. An XSLT-Stylesheet transforms a source tree like the XML source document into a result tree which is specific to the output medium. This is achieved by *template rules*, which consist of a pattern that is matched in the source tree and instantiates a template as part of the result tree. This allows to adapt the presentation of the same data set to different devices, for example desktop computers and mobile phones and makes it easy for the user to grasp new information because the presentational layer stays consistent.

Several open and closed-source Learning Management Systems are available. Darbhamulla et al. (Darbhamulla and Lawhead, 2004) examined the WBT systems BlackBoard, ELM-ART (Brusilovsky et al., 1996), ELM-ART 2, InterBook and WebCT. They found the Blackboard and WebCT platforms to feature a very static learning experience. They provide the basic framework and interactivity of an LMS but lack in adaptivity, so they do not generate a dynamic learning path for the individual learner according to his progress or personal choice. ELM-ART and InterBook feature a better adaptivity as they provide intelligent links with annotations for the user to choose his next step in the learning path as well as linear next and previous buttons. Brusilovsky et al. (Brusilovsky and Eklund, 1998) discovered in a study, that the users primarily use the linear buttons instead of using the intelligent links provided by the system. The performance of the learners, who followed the linear path was also better than the performance

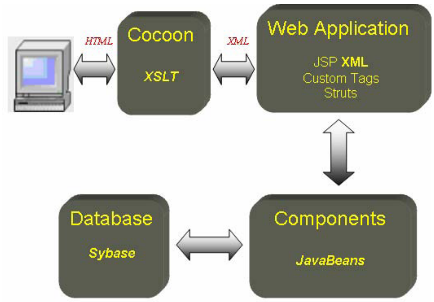

Fig. 1. Unified data-structure of an LMS. Storing educational content without its presentation but with extensive meta-data and transforming it with XSLT into HTML. Source: (Darbhamulla and Lawhead, 2004)

of those, who used the user-centered optimal path. ELM-ART 2 does not let the user decide his next step, but instead adapts the learning path completely to the user. This removes the control from the learner. The study by Brusilovsky shows, that this is not the most effective way of learning. Darbhamulla et al. came to the conclusion that none of these LMS meet all the requirements of adaptivity and intelligent path generation.

Graf et al. (Graf and List, 2005) evaluated nine different open-source learning platforms and compared their Adaptability, Personalization, Extensibility as well as their Adaptivity:

- **Adaptability:** the possibility for the user to customize the platform to his needs. For example different front-end languages or skins.
- **Personalization:** the ability to hide certain front-end elements.
- **Extensibility:** indicates the existence of a well documented application programming interface (API) and a good programming style of the developers. This makes it easier to add custom components to the platform.
- **Adaptivity:** the ability of the LMS to adapt the content to the learner's progress.

The study shows, that Moodle (Figure 2), which has a user base of more than 20 million users in 1.9 million courses worldwide (Source: http://www.moodle.org/stats) is better in almost every category than its competitors ATutor, Dokeos, dotLRN, ILIAS, LON-CAPA, OpenUSS, Sakai and Spaghettilearning. Moodle's adaptive feature called *lesson* customizes the learning path by a question at the end of every page. Depending on the answer, the appropriate educational material is selected which makes the learning experience more dynamic. Moodle supports a high degree of extensibility due to the API being well documented. Guidelines and templates make it easy for a programmer to add new functionality. There are more than 60 themes available to personalize the front-end and the student can choose from more than 40 languages. All the basic features of an LMS are present like several communication tools to foster

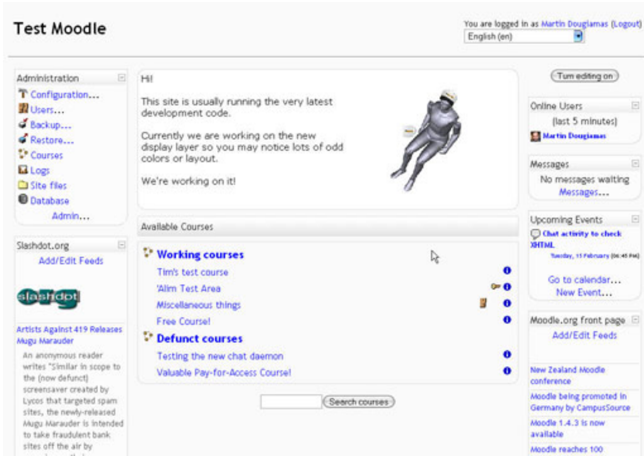

Fig. 2. Open-source Learning Management System Moodle. Source: moodle.org

user collaboration. There is still some progress to be made in the adaptivity sector however. The idea of an automatic learner evaluation and adaptation is still not realized. The course should adapt to the individual strengths and weaknesses as well as the personal learning goals. The conductors of the study are working on this component and due to the software being open-source, it is possible to integrate future developments into the existing system.

3.1 Blended Learning

The following chapter introduces Blended Learning as a hybrid approach to E-Learning. A study is presented that shows, if the learner's performance or motivation can be improved by combining WBT with face-to-face lectures.

One of the psychological problems of E-Learning is the feeling of isolation, if the courseware does not cater to the learner's desire to communicate and exchange experiences. This can lead to a diminishing motivation of the user. The most humane solution to this problems seems to just add a human touch to the learning experience. This can be achieved by the concept of Blended Learning. Traditional face-to-face sessions utilizing slides are combined with virtual E-Learning courseware. This can be beneficial for the learners as well as the tutors, as they get to know their students and do not interact solely with their online persona. The personal conversation is the best solution to elaborate the learner's questions or problems. A study conducted by the Computer Science Department of the Universidad Carlos III de Madrid (Dodero et al., 2003) compared two groups of 50 students respectively. The first group took a course on Object Oriented Programming (OOP) and was learning using the blended approach of traditional presential sessions with slides as well as virtual courseware. In the virtual environment the students were organized in groups, each specializing in a different part of the course. A forum served as the primary method of communication. This allowed the teacher to supervise the progress of the group as a whole and the individual students themselves. The second group consisted of students taking a course on OOP Basics using only virtual courseware and no presential sessions at all. Figure 3 shows, that the percentage of user partici-

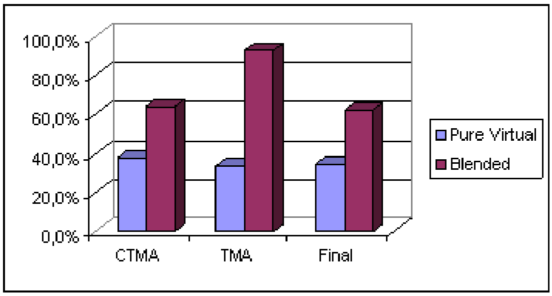

Fig. 3. Percentage of students from both groups that completed Compulsory Tutor-Marked Assignments (CTMA), Optional Tutor-Marked Assignments (TMA) and Final evaluation. Source: (Dodero et al., 2003)

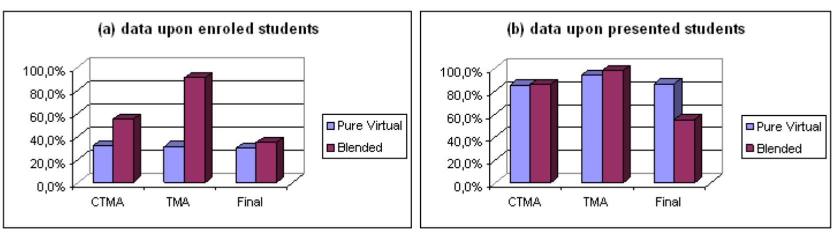

Fig. 4. Percentage of students from both groups that passed Compulsory Tutor-Marked Assignments (CTMA), Optional Tutor-Marked Assignments (TMA) and Final evaluation. Figure (a) shows the results of all enrolled students and (b) only of the students participating in the particular test. Source: (Dodero et al., 2003)

pation in tests and exams was higher when using a blended method of learning. However the results of the exams of the students who did participate are no different from one another regardless of all-virtual or blended learning (Figure 4). This means that blended learning users did not have a performance plus over the purely virtual users, just their motivation to take part in assessments was higher. The performance of the blended learners in the final exam shows a surprisingly lower percentage of students who passed this exam.

In conclusion can be said, that the user-motivation but not the user-performance can be boosted by combining virtual and presential courses. There were even some negative influences on the blended learners' performance, as seen in the results of the final exam. If these results are representative however should be confirmed in a follow-up study with more participants. Both student groups were not taking exactly the same course. This could potentially skew the results. The purely virtual learning group took a course about OOP Basics and not about OOP like the other group. Maybe their motivation was not as high to begin with. Perhaps that study can then clarify the situation of user-performance which was inconclusive in this study.

3.2 Use Cases

After looking at the most important aspects of Web-Based Training, a few real life applications of E-Learning are presented in this chapter. The first study shows the results of incorporating WBT into the workflow of different South African companies while the other study talks about die academic use of E-Learning at two Japanese Universities.

3.2.1 South African companies

A study by the University of South Africa and the University of Witwatersrand (Dagada and Jakovljevic, 2004) analyzed 15 different South African companies and their use of E-Learning in a corporate environment. The results are qualitative in nature and were gathered using interviews of individual persons, interviews of entire focus groups, the analysis of documents and general observations. Participants included trainers, managers and trainees and the study tried to involve companies from as many different fields as possible: energy, mining, insurance, banking, telecommunication, and services industrial sectors. The following aspects of an LMS were used in the study:

- Delivery of online learning materials and tutorials as well as technical simulations.
- Communication tools like voice and text chat, mail, forums and message broadcasting.
- Online assessment tools like tests and surveys.

Facilitators noticed a boost in motivation and positive attitude due to the enhanced individualization of online learning. Facilitators in a mining organization were successful in delivering customized and dynamic online learning content to the workers. They also noticed a successful change of work performance when using collaborative and cooperative learning by means of WBT. As a result the facilitators observed for example less fatal accidents at a mining company or more frequent contract closings at a bank. They paid attention to a reasonable and not overwhelming use of multimedia. This is especially important because of bandwidth constraints in South Africa. The interactivity of the learning experience was stressed by the facilitators as an integral part of engaging online training. They chose to almost exclusively use a Blended Learning approach particularly for very complicated or security related matters. Online simulations were used when real life demonstrations would be too dangerous or dull for the participating learners. As an example an air transport company used WBT to successfully deliver tutorials including facts about a new fleet of airplanes and a simulation about certain aspects of the new airplanes. In conclusion, the study shows that the use of WBT in South Africa is still in the early stages but the first results look promising.

3.2.2 Japanese universities

A serious problem at Japanese Universities are the large classes (Koike et al., 2005). The personality of the individual are often lost because the teachers cannot care as much about every single student as they could in small classes. This holds especially true for the mandatory subject Computer Literacy at Sapporo Gakuin University. As every student has to participate in this course the classes often consist of 200 to 260 students with six classes a week. This means that the teachers face a total of more that 1000 students a week. Because the rooms are not big enough, they are often spread over several classrooms. To manage so many learners the teachers utilize cameras, projectors and acoustic equipment which enables them to manage two or three classrooms at the same time. To assess the current state of learning progression of the individual students they use a number of short tests almost every time the course takes place. With that many learners it is difficult to test and give marks to the students. It cannot be guaranteed that the same student is graded by the same tutor every time which leads to issues related to consistency and reliability.

Because of these problems the university developed an automated marking system to process Word- and Excel-files and mark each student's test accordingly. This program can be downloaded online and transmits the results to a specific network folder. In a last step the grading tool makes it possible to export all results from all the students into an Excel-spreadsheet or database. The approach of Sapporo Gakuin University is different from the WBT we have looked at before. Not the learner is the center of attention but WBT tools like the online grading tool are used to unburden the teachers and tutors of some of their workload. The indirect benefit for the learners are the improved consistency of marking results.

At the Japanese Hokkaido University about 100 students that participate in a course which discusses programming languages use a variant of this tool via a web page. The web server calls the automated marking system as a CGI program. The programs are being compiled and checked for errors. The University's online learning system also features:

– **Online teaching material distribution:** the students can access web pages with PDF and HTML based texts and instructions. While the students are encouraged to learn at their own pace, the order of the assignments is static. There is no customization to the individual's learning pace. This is one area which can be improved.

- **Scheduler:** it indicates what every individual student has to do next. This includes deadlines for the next tasks as well as an overview of the completed tasks.
- **Forums:** they are used to compensate for some of the troubles of having large classes. Users have a semi-anonymous way to express their feelings, problems and questions. There is a problem though because not every student feels comfortable about using the bulletin boards. The university should think about further communicational tools.
- **Performance monitor:** this tool shows the personal progress in relation to the other students' progress while preserving the individual user's name and privacy. This stimulates certain students according to the study while others students seem not affected by it.

The Hokkaido University uses the online grading tool as well as multiple other WBT features. There are however several fields like the learners' communication which can be be improved. The results of the performance monitor can be used to customize the order of the online learning materials for the individual user. The discrete WBT features already in place would be even more effective when integrated into a unified framework.

4 E-Learning 2.0

This section introduces E-Learning in the context of the Web 2.0 and its tools. The individual tools as well as their current and future educational use are evaluated.

The Internet and the people using it have changed over the last couple of years. E-Learning is lagging a bit behind when it comes to being creative, sharing information and content as well as collaboration between users (Downes, 2005). Web surfers approach work, learning and play in new ways. They absorb information quickly, from multiple sources simultaneously. They operate at high speed and expect instant response and feedback. They prefer on-demand access to media and expect to be in constant communication with their friends. They also like to create their own media and not just consume somebody else's media. Can these new ways of interacting with the World Wide Web also lead to a new way of thinking about delivering educational materials? The following tools of the Web 2.0 could be used in an educational context.

- **Wikis:** enable every user to actively manipulate the content of a web page. When using sites like Wikipedia to convey learning content the interaction of the user with the material can foster the learners motivation. In an ideal situation the community behind the wiki tries to make it as top-quality as possible. The drawback however is that the editorial integrity of the information is no longer assured and without back-up mechanisms the content is subject to potential vandalism.
- **Educational blogs:** these websites have developed a great deal over the last few years. They went from being personal, often informal diaries to

being a serious threat to certain news outlets. A more recent development uses the blog as a way to deliver learning materials to a community. What makes them interesting for learning purposes is the simple and approachable design as well as the possibility for the users to comment on every blogpost. Some professors already maintain their own educational blogs and post new content as well as respond to the users' comments.

- **Podcasts:** audio-files which are being distributed to an audio enabled RSS-reader like Apple's iTunes are called podcasts. Similar to blogs they started as personal diaries and are now being used for different purposes: from conveying news, to promotional uses and most recently education. There are foreign language tutorials and workshops for many different topics available. Apple started in 2007 to aggregate educational podcasts of American Universities under the name *iTunes U*. These include course lectures, language lessons and lab demonstrations. Podcasts share some characteristics with audio books as they make it possible to learn even while driving a car or cooking a meal. They have however the additional benefit of being free and often more up-to-date.

- **Virtual worlds:** like Second Life from Linden Research or Google Lively could become another meaningful communication tool. Learners interact in a visual environment and collaborate to reach a common goal. There are several problems though. The application is very game-like and might distract too much from the learning material. There are also problems with user harassment and Second Life features mature content not appropriate for children. The concept of a visual virtual classroom is still viable.

These developments point to online learning ceasing to be a medium and becoming more of a platform, where content is not only consumed but also created. It resembles more a dynamic conversation than a static textbook. Learning is integrated into daily workflows and private life. Different Web 2.0 tools become the nodes instead of just static HTML-documents. Content is syndicated and learners can aggregate different RSS-feeds in their feed reader (Walther Nagler, 2007). RSS-feeds use a standardized XML format which makes this technology crucial for aggregating educational material from a Learning Management System or interlinking multiple LMS. Every learner arranges his own portfolio of tools and feeds. To be able to manage all this, the learners need a unifying framework to counter the infinite possibilities and potential confusion. The lack of tutors in this self-determined learning environment is a grave problem. All but the most technically savvy are guaranteed to be *lost in cyberspace* and without guidance, they cannot profit from these advances in technology at all. Only when integrated into existing or new frameworks and Learning Management Systems can most users benefit from these new tools. The methods of E-Learning 2.0 are promising but have not realized their full potential yet.

5 Conclusions

This paper presented an overview of the basic technologies and concepts of Web-Based Training and E-Learning. At first, the key differences between Computer Based Training and Web Based Training were shown. The positive characteristics include the platform independence, better scalability and the emphasis on cooperative and collaborative learning. On the flipside the online connection required for E-Learning can lead to additional fees or the service being unavailable. Plain HTML documents and simple hyperlinks between them possess multiple drawbacks to the learners, tutors and authors. As a result the educational material should be modularized and integrated into a Learning Management System. This system has to foster communication and collaboration, so the user does not feel isolated. It should also adapt to the user's performance, one area that has the most potential but this potential is not yet fully realized. The detachment of the presentational layer from the content layer helps to minimize user frustration and makes it possible to change the font size or color for partially sighted people. The study about Blended Learning showed that combining presential courses with virtual courses can boost the learners' motivation. If and how the performance is affected has to be determined in another study. We saw the different applications of E-Learning in the corporate and academic environment. The learners of the South African companies particularly enjoyed being able to learn at their own pace as well as where and when they want. The Japanese Universities used E-Learning tools to unburden their teachers and allow them to concentrate more on the interaction with the learners. The performance monitor which generates competition among the learners seems to be a feasible tool to boost user motivation. E-Learning 2.0 shows great promise but has yet to prove that it can be a viable learning platform. Successes like Wikipedia show the potential but also the dangers of user-driven educational content. If the tools of the Web 2.0 are integrated seamlessly into existing Learning Management Systems, they could prove a valuable component for more user interaction and involvement. RSS-feeds are one of the key technologies, which make the networking of distributed information possible. As it is today, it is entirely up to the individual learner to make the most out of the innovative tools that are available. The mobile applications of E-Learning are virtually untapped at the moment. Using WBT tools on the go would be the ultimate implementation of the *anytime anywhere* philosophy. Modern cell phones have a web browser and by storing the content media-independent as XML-files they can be transformed easily via XSLT to the cell phones screensize. The remote delivery of educational content will enrich and complement the traditional face-to-face courses and classes, but not substitute them in the near future.

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Adaptive Hypermedia: A closer look on Student Modeling in e-Learning Systems

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Abstract. Personalized support in e-Learning systems becomes more and more important also due to the fact that evaluations of adaptive systems showed their advantages compared to the "one-size-fits-all"- approaches. Student modeling analyzes the user's behaviour, tries to find out the status of his knowledge and then adapts to its findings. The goal of this paper is to show the purpose of such systems and to give an overview on how student modeling is realized. It discusses the methods and techniques of adaption first and then takes a closer look on the topic of student modeling. Over the years of research some user characteristics turned out to be useful to analyze and to adapt to. We will take a look at them and then show how they are represented in different user models, for example the overlay or stereotype model. Different architectures of user modeling systems are presented and their advantages and disadvantages are spotted out. In the end two examples of educational adaptive learning systems are explained and the future hazards and challenges with regard to the topic privacy are shown to round up the overview.

1 Introduction

As personalization becomes a larger topic in connection with computers and software the field of adaptive hypermedia systems gained importance over the last years. When talking about adaptive hypermedia systems we mean

> *"all hypertext and hypermedia systems which reflect some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user"* (Brusilovsky, 1996).

According to the definition there are six main kinds of adaptive hypermedia systems: educational hypermedia, on-line information systems, on-line help systems, information retrieval hypermedia, institutional hypermedia, and systems for managing personalized views in information spaces (Brusilovsky, 2001).

In this work we focus on educational hypermedia and for the most part how the user modeling - in the range of educational system also called student modeling - is realized. Even though there are some difficulties in evaluating such systems, research showed how effective the adaption to the users‘ individual traits can be. Esposito (Esposito, 2004) in this connection points out that adaptive personalized e-learning systems can accelerate the learning process by revealing the strengths and weaknesses of each student, as well as plan lessons and personalize communication and the didactic strategy. Inspite of the widespread “one-size-fits-all”-approach the individual stands in the foreground. The system accommodates to his characteristics and supports him to reach his goal on the best way.

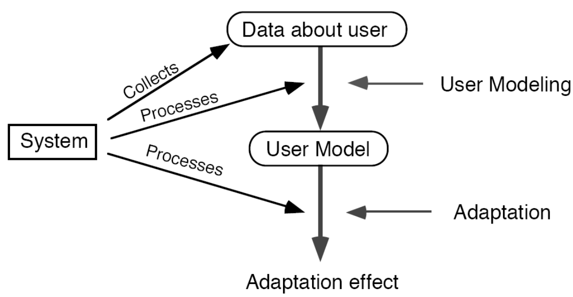

Fig. 1. Classic loop “user modeling - adaption” in adaptive systems (Brusilovsky, 1996)

In figure 1 you can see a rough overview on how a adaptive hypermedia system (AHS) works. This paper discusses the methods and techniques of adaption first and then takes a closer look on the topic student modeling. Over the years of research some user characteristics turned out to be useful to analyze and to adapt to. We will take a look at them and then show how they are represented in different user models, for example the overlay or stereotype model. Different architectures of user modeling systems are presented and their advantages and disadvantages are spotted out. In the end two examples of educational adaptive hypermedia systems, the AHA! system and the KBS Hyperbook system, are explained and the future hazards and challenges with regard to the topic privacy are shown.

2 Adaption Techniques

First of all we have to find out how adaption in a hypermedia system can be realized. On the one hand there is the possibility to change the navigational links of the documents according to the user‘s needs. This technique is called adaptive navigation support. On the other hand the content of the documents can be adapted as well. Here a differentiation between simple textual and multimedial content can be made.

2.1 Adaptive Navigation Support

The goal here is to help the user to find the best way through hyperspace according to his individual traits. Therefor **adaptive navigation support** (ANS) - *"a new direction of research within the area of adaptive interfaces"* (Brusilovsky and Pesin, 1998) - is used. Many ANS techniques have been deployed in various systems but not all achieved acceptance over time. In figure 2 you can see a current overview of all adaption techniques used in adaptive hypermedia systems (AHS). We will only take a closer look on the ones which mainly come into operation in educational hypermedia systems.

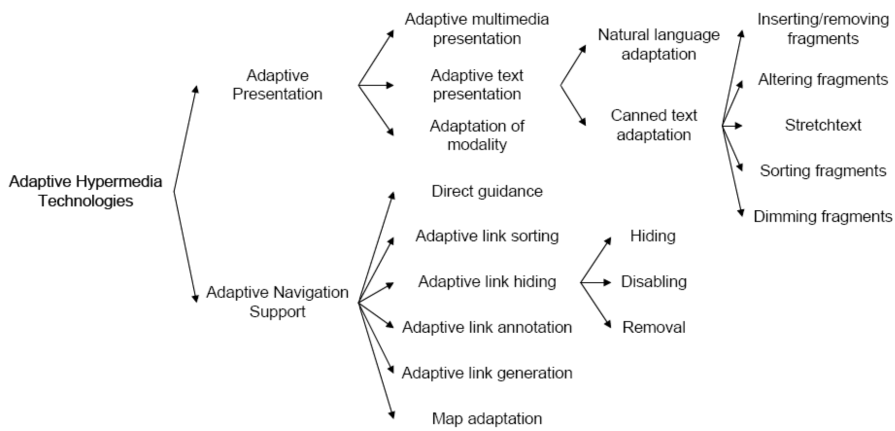

Fig. 2. Overview of adaption techniques in AHS (Brusilovsky, 2001)

The first one, **direct guidance**, is the simplest, however one of the most relevant form of adaptive navigation support. It presents the user - based on the results of the user model - the most important link which should be visited next by him. Usually its visual appearance is something like a "Next"- or "Continue"-Button. The technology is very easy to implement and gives the user a certain direction to follow. On the other hand this implicates a disadvantage, too. Only limited support is provided for the user: *"follow me or no help"* (Brusilovsky, 1996). Hence direct guidance alone is not sufficient.

Another technique is **Link sorting**. Here all continuative links are ordered by importance, from the most relevant to the least relevant. It is problematic that the order may change each time the user visits the page, caused by the user model. This instability may lead to confusion of the user and especially for novices a stable order is important.

Link hiding can be separated into three different subsets again: Link hiding, disabling and removing. According to the user model links in documents can be hidden, if the linked document is not relevant for the current user. If the link is integrated into a text fragment the link can not be simply removed. So it can be disabled, which means that the user only sees the text of the former link, but the forwarding function is eliminated.

Link annotation can either be visual or textual. Icons can be used to show the user the importance of the current link. Another possibility would be the color or the font-size of the link. For example the more useful the link is, the bigger it is displayed. Additionally each link can hold a description that gives the user a brief insight of the linked page. All in all it is a powerful technology and contrary to link sorting the stable order of the links is always ensured.

Link generation presents the idea that the system may find new useful links between pages, generates them automatically and adds them to the navigation. The basis for the creation could be a former navigation path of the user or from other users.

Link sorting, hiding, annotation and direct guidance present the most common and important technologies for adaptive navigation support. Normally they are used in comibination in AHS and in section 6 we will see in which way they are deployed in current e-learning systems (Brusilovsky, 1996; Henze, 2000; Bra et al., 1999; Stash, 2007).

2.2 Adaptive Content

Additionally to the navigational links, the content of hypermedia systems can be adapted, too. The techniques here are quite similar to the ones used for ANS. The content itself can be separated into simple textual fragments and multimedia content like videos or pictures.

2.2.1 Adaptive text presentation

Text sections can be - just like links - **inserted or removed** dynamically. The decision lies - as always - on the user model. Brusilovsky (Brusilovsky, 1996) calls this technique “Conditional Text”. For example if some information parts are too detailed and specific for a novice user, but on the other hand interesting and important for experts it is very useful to have the chance for showing or not showing them dynamically.

Altering fragments is quite similar to the first technique. Here several variants of text parts are stored inside the systems. Depending on the user the right text part is chosen and displayed (Henze, 2000).

Another useful possibility is **Stretchtext** and is definded by De Bra (Bra et al., 1999) as following: For each information fragment a visible small place holder is created. The systems then determines - based on the user model - which fragments should be stretched - which means shown - and which should be shrunk. Shrunk means that only the place holder is shown. This decision only determines the initial presentation of the fragment and can be changed by the user. The system then analyzes when a user stretches or shrinks a page and then tries to apply its findings to future pages.

The text fragments can also be **sorted**. Just like at ANS the fragments are ordered from the most relevant to the least relevant, depending on certain criteria.

Dimming fragments is described by Stash (Stash, 2007) as a technique used to dim, shade or deemphasize fragments in a certain way to indicate that the fragment is less or not relevant for the user.

2.2.2 Adaptive multimedia presentation

Adaptive hypermedia systems can also contain media files like videos, pictures or sounds. There are several possibilities to adapt these files. On the one hand media fragments can be **sorted, inserted or removed** depending on the users individual traits, too. On the other hand the adaption can be arranged because of specifics of the output device. For example the **file size** or the **quality of the media** can be leveled. The parameter therefor could be the screensize of the output device or the speed of the used connection for transmission. As the user modeling stands in the foreground of this paper we won‘t work this out in more detail.

3 User Data

So far we know what can be adapted in hypermedia systems. The next big question is: What is the adaption based on? Over time many different characteristics of the users have been analyzed for adaption. Some turned out to be more useful some less. Again only the most important ones for current AHS are listed and explained below.

3.1 Indirect

Let us start with the **user‘s knowledge** which is the most important user characteristic for educational adaptive systems and is used in one third of all existing AHS. Refering to Henze (Henze, 2000) the changing of the knowledge state of a user is a very critical part for adaptation in educational systems. Therefor the system has to recognize the knowledge state of the current user and update the user model when changes occur. In normal adpative hypermedia systems the knowledge about a user is assumed indirectly for example whether he has read a page or not and how long he stayed on it. This works fine for some kinds of AHS, but for e-learning systems that is not sufficient at all. The solution of the problem lies in direct input from the user and is described in the next topic (Brusilovsky, 1996).

Every user tries to attain certain **goals**. The system has to find them and consider them which is not that simple, because they can change rapidly. For that reason systems differentiate between low-level and high-level goals. Brusilovsky (Brusilovsky, 1996) mentions the “learning goal” in educational systems as a high-level goal, whereas the “problem-solving goal” is a low-level goal which can change from one educational problem to another several times within one session. The term “goal” also contains the user‘s individual wishes and it is obvious that if the user has to fulfil a certain task these two characteristics might be contradictionary. So the personal goals can only be respected as long as no conflicts occur (Henze, 2000).

According to Brusilowsky (Brusilovsky, 1996) the user‘s previous experience outside the subject of the hypermedia system is summarized as the **user‘s background**. It could for example include his profession, his point of view or his experience of work in related areas. For example if the system is about learning the computer language Java then it would be useful to know whether the user already knows other object-oriented programming languages.

Contrary to the user‘s background the **user‘s experience** means how skilled the user is in working with hypermedia systems. Has he ever worked with such a system before? Is the structure and the navigation familiar to him?

The next user characteristic is the **learning speed**. Some people simply understand things faster and need less time to keep it in mind. This depends of course on the topic and how advanced the user is. The learning speed can rise when the user is more familiar to a system due to habituation.

The last and least important topic are the **user‘s preferences**. They mainly concern the visual appearance of the system like font-type or coloring and Henze (Henze, 2000) notes they can not be estimated by the system without any input from the user.

3.2 Direct

Indirect, interpreted data alone is too unreliable for user modeling in e-learning systems. Direct data from the user is needed to guarantee reasonable adaption. To get the data **excercises** or **questionnaires** about the topics are integrated into the system. So the knowledge of the user can be tested directly by questions or tasks about the completed topic. His answers show how much he understood and learned about the topic and also contain information about his learning speed. Intelligent solution analyzers even can diagnose solutions of educational exercises and then help the student to resolve the problems (Brusilovsky, 1996, 2004).

> *“Second, users can make the desired adaptation themselves, directly showing the system what they would like to see on the screen in the given context”* (Brusilovsky, 1996).

This can be used for adaptive navigation support as well as for adaptive content.

The third and last idea to get direct data is the so called **collaborative user modeling**. Here the user can take a look on his user model and apply changes. This can have the advantage that he can remove false assumptions, but on the other hand he can also make false inputs and then the system does not give the right support anymore. It is always the question how good a user knows and can rate himself (Brusilovsky, 1996)?

In addition the adaption can not only be based on user characteristics but on his **environment**. This contains for example the time, location or computing platform. Location based services are subject of many researches at the moment since the Internet becomes available almost everywhere by using mobile devices (Brusilovsky and Maybury, 2002; Stash, 2007).

4 User Models

When you take a look on figure 1 you can see a classic process in adaptive systems. Data about different user characteristics is collected and then processed to build or update the user model. Based on this user model the whole adaption takes place. There are different models and several ways to update the user model. Should the user be informed when the model gets updated or should he even be asked for permission? We already discussed if the user should have the chance to apply changes in his user model.

4.1 Overlay Model

In most adaptive e-learning systems the overlay model is deployed which has its origin in the field of intelligent tutoring systems. As precondition the knowledge that has to be learned has to be represented in a so called domain model. The domain model includes all the concepts of the system. With concept a certain part or topic of the knowledge is meant. The concepts are linked among each other. For each attribute of the user a attribute-value pair is established and saved.

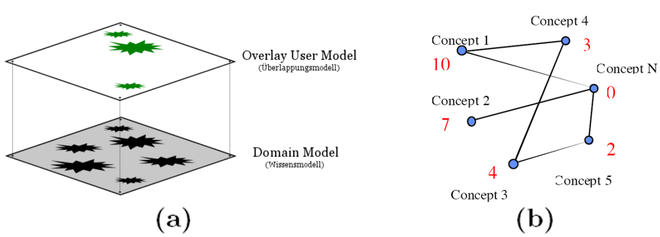

Fig. 3. The general Overlay (a) and a simple Overlay Model (b) as graphics (Schneider, 2006; Brusilovsky, 2003).

> *"The overlay model is commonly used in the adaptive hypertext field because the content of the adaptive hypertext itself can be considered as a description of the entire domain knowledge. This involves that the student can be represented simply overlaying the hypertext structure"* (Bonfigli et al., 2000).

In figure 3 you can see a simple overlay model. The circles represent the concepts which are different kinds of knowledge elements or objects. The lines between the concepts mean that they are linked with each other and together they form the domain model. The values are quantitive here and together they represent the overlay user model (Brusilovsky, 1996).

There are three possibilities of how to save the value about a concept:

1. Qualitative: The user is classified for example in good, average or poor.
2. Binary Value: The binary value 0 or 1 stands for whether the user knows the concept or not.
3. Quantitative: A quantitative value includes a more fine-grained information. For example it could be a probability that states the chance that the user knows the concept.

(Brusilovsky, 1996)

Although the overlay model is widespread it implicates some disadvantages. The system has got a problem in finding a suiting initial value. Additionally, according to Sison and Shimura (Sison and Shimura, 1998), it can not diagnose misconceptions, for example incorrect (as opposed to missing) knowledge.

4.2 Deviation Model

This disadvantage does not appear by using the deviation model. To its big advantage counts that also the false knowledge of the user can be modeled. The knowledge of the user here is described as the difference from a expert‘s knowledge (see figure 4).

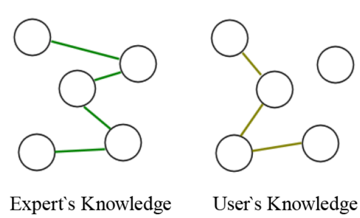

Fig. 4. The deviation model (based on (Schneider, 2006))

Here again the circles stand for the concepts and the lines are links. The system can clearly detect the user‘s problem and help him to achieve the expert‘s knowledge.

4.3 Stereotype Model

The stereotype model affirms that the user belongs to a group of users with common characteristics. On account of this it is more simple compared to the overlay model. According to Stash (Stash, 2007) a distinction is made between:

– pure stereotypes, indicating only that the user belongs to a group, without giving characteristics of the group,
– mixed stereotypes, which point out group characteristics through attributes,
– and multiple stereotypes in which a user can be associated with different groups at the same time.

Accessorily to this distinction they again can be split into two different types of stereotype modeling. In the first one the users are classified into groups with certain criteria (for example novice , advanced and expert). This means that the value can only be “true” or “false” whether he belongs to a certain group or not. In the second type the user is not only classified, but also a value is stored which gives information about probability that the user belongs to this stereotype (Brusilovsky, 1996).

Generally Kobsa (Kobsa, 1993) describes three steps a developer of a user model has to accomplish to develop a stereotype user model:

1. User subgroup identification: First he has to identify subgroups within the expected user population whose members own certain homogeneous characteristics which are relevant for the application.
2. Identification of key characteristics: Second some key characteristics which assign a user to one of the subgroups have to be found.
3. Representation in user models: Last but not least he has to formalize the application-relevant characteristics of the identified user groups in an appropriate representation system. All characteristics of a subgroup together then are called a stereotype for this subgroup. For the representation either a linear hierarchy - which is more widespread - or a more complex tree hierarchy can be used. There the deeper the children are, the more specific the characterisations of the users get. (Kobsa, 1993)

On the one hand the use of a stereotype model can give a fast classification of a user. On the other hand Henze (Henze, 2000) mentions the following problem: The stereotypes can get too specialized so that they become obsolete and consist of maybe only one member or some users can not be classified at all.

4.4 Mixed Approach

To sum up the advantage of the overlay model it provides an individual, fine-grained adaption, but the initial values make some problems. Stash (Stash, 2007) highlights that stereotype modeling is reasonably reliable and works well if the users can be splitted into different classes by certain characteristics. Nevertheless it fails when the individual adaptation requires a fine-grained description of the user or when specific help is required. So to find a way to solve both problems and keep the advantages of both systems a combination often is used. In the beginning of the use the user gets classified by a stereotype model to set the initial values. Then the model is changed to overlay and the adaption can be continued more individualistic (Brusilovsky, 1996).

5 Architectures

Now it is clear how adaption works, but to realize an AHS a basic architecture is needed. So in this topic we first take a look on the early beginning of AHS and the User Modeling Shell Systems. Then the spreading and more actual User Modeling Servers and a short outlook on how future Agent Based User Modeling Systems could work is presented. For each system its advantages and disadvantages are spotted out.

5.1 User Modeling Shell Systems

In the beginning of AHS research and in the first adaptive systems a clear distinction *"between system components that served user modeling purposes and components that performed other tasks"* (Kobsa, 2007) lacked. The development of user modeling components is very time consuming and so components were developed to facilitate the user modeling. The so called "Shell Systems" support the user with different mechanisms for example maintain the representation of the user model, the interference or the stereotypes. A shell system stores the values coming from the application,

> *"verifies the consistency of a new fact with currently held assumptions, informs the application about recognized inconsistencies, and answers queries of the application concerning the currently held assumptions about the user"* (Kobsa, 2007).

The first shell system was developed in 1986, called GUMS. As the first of his type the system was never used in combination with an application, but many other ones followed. Here GUMAC, BGP-MS or MT can be mentioned. Kay (Kay et al., 2002) points out that these systems explored many issues in building generic tools that help the developer to manage the user models. Nevertheless shell systems do not make user models reusable for other applications. So there is still a redundancy in collecting and storing the data (Kobsa, 1993).

5.2 User Modeling Servers

In contrast to shell systems, user modeling servers provide a lot of advantages. As privacy becomes a more and more important topic in the world wide web and due to the fact that the user model contains many private features of a user it is reasonable to store it on a central server. *"A server makes sense for the provision of the required security at the same time as ensuring user access and control"* (Kay et al., 2002). The security can be ensured by clearly defined points of access, methods and tools for system security, identification, authentication and access control (Kobsa, 2007).

The second big advantage is the possibility to share the same user model with different applications. So far the user model mainly has been integrated directly into the application. So when the user changed the application the modeling had to start from scratch again. Especially when the hypermedia systems deal with related topics it would be extremely useful to use the existing user model for further adaption. Centralized user model servers can support user modeling components for more than one application - maybe for all applications a user works with (Kobsa, 1993).

Another point is that the user can directly take care of his user model and apply changes because there‘s only one and not one for each application. That would mean a big time saving. The costs to develop an adaptive hypermedia system would strongly decrease because the user model component would drop out and only a gateway to the server has to be implemented.

> *"The internet and the Web with its trend towards platform-independence and standardization bring this dream to reality. The most important part of the work towards component-based architectures, is the development of user model servers and protocols for inter-component communication"* (Brusilovsky, 2001).

The server can reside on the same platform as the application system but more commonly they will be part of a local or a wide area network. To communicate with the application there has to be a permanent connection which can not always be ensured. As the server may serve for many applications at the same time it can be a bottleneck and thwart the whole system. The transmission of the data to the server is moreover a security leak and encoding also does not solve this problem one hundred percent. Additionally if the server breaks down there has to be another one with redundant actual data who compensates it. Also the applications must all stick to certain standards because for example only one file system can be used for the storage. Examples for user modeling servers are Cumulate or Personis (Kobsa, 2007; Kay et al., 2002; Brusilovsky et al., 2005).

5.3 Agent Based User Modeling Systems

Processors get smaller and still more powerful and even today‘s mobile devices are as fast as older PCs. Due to the increasing spread of such handhelds and mobile devices and the availability of the internet almost everywhere a new architecture for user modeling arises. The idea behind agent based user modeling is that these systems are made up of

> *"conglomerates of independent and autonomous services (or agents) which collaborate with each other as the need arises (those services may have even been developed by different parties)"* (Kobsa, 2007).

Unlike user modeling servers these systems can interact more dynamically and the interaction would not be so determined by design. This idea originates from the field of ubiquitous computing. So far this architecture is mainly used for personalized and location based systems.

6 Existing Systems

Now that we have learned a lot about the design of AHS, the adaption techniques and how the user model is implemented we want to get to know some existing systems. Therefor we will take a look at the AHA! and the KBS Hyperbook system.

6.1 AHA!

AHA! - Adaptive Hypermedia Architecture - is a free web-based system to construct adaptive lessons or courses. It was developed at the University of Eindhoven in the year 1996 and over the time many changes have been applied so version 3.0 is reached by now. The whole system is based on XHTML (XML based Hypertext Markup Language), furthermore AJAX (Asynchronous Javascript and XML) is used to guarantee adaption. To alter fragments of a document *"preprocessor commands in the HTML pages are used by CGI-scripts"* (Henze, 2000).

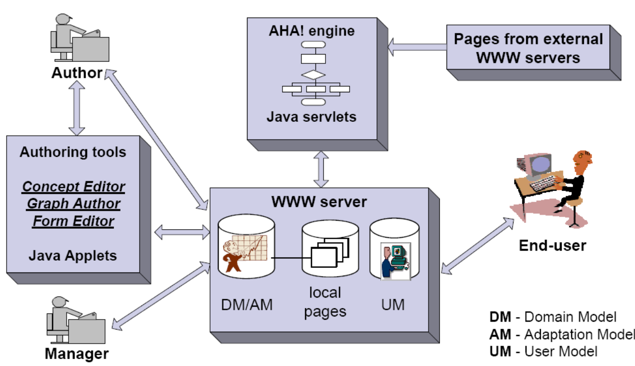

Fig. 5. Overview of the AHA! architecture (Stash, 2007)

Because of the architecture (see figure 5) the system can not only work on local but also on remote webservers. As storage format for the adaption model and the user model you have the choice between the xml file format or a mySQL database. The user model is based on the overlay model and only adapts to the knowledge of the user. For this purpose it observes which pages the user already visited and the user has to accomplish tests about certain topics.

It supports adaptive presentation, navigation support and layout adaption. Layout adaption means that you can chose a certain layout and it then is applied to all concepts. However it does not change during usage. In the field of adaptive navigation support a lot of techniques are supported by the system. So it comprehends link hiding, link annotation, link removal and link disabling. It also supports direct guidance, but the possible link destinations are not generated by the system so the author has to declare them on his own. That means that there is no openness to the world wide web for example as supported by KBS Hyberbook. Links can be annotated for example by color balls and are classified into good - meaning “desirable and not previously visited”, neutral - meaning “desirable but previously visited” and bad - meaning “not desirable”. The colors for the classes are chosen by the author but can be changed by the user afterwards. For this the links get a certain class and the visual appearance is then described in a CSS (Cascading Style Sheet).

The knowledge in AHA! is divided into small fragments which can be conditionally inserted, removed or altered. Even stretchtext can be used indirectly by using AJAX. However sorting fragments or natural language adaption is not possible. Additionally it supports multimedia adaption by using SMIL formats. The user model is updated by event-condition-action rules, so when a change appears the model gets updated when the user requests the next concept. There is no goal support implemented so the adaption can not be applied on the users preferences (Stash, 2007; Bra et al., 2006).

6.2 KBS Hyperbook

The KBS Hyperbook system is a framework for designing web-based adaptive hypermedia systems, developed at the “Institut für Rechnergestützte Wissensverarbeitung” in Hannover, Germany. The big difference to the AHA! system is its openness to the world wide web. It can automatically integrate distributed pages from the world wide web and not only the given stored ones. This is granted by using an indexing approach.

The whole system also is based on an overlay model. So a hyperbook consists of certain units which are indexed with some knowledge concept as already described above. The user model takes care of the user‘s knowledge, his learning speed, his goals and how much he wants to learn next. So the user can select his own goal or alternatively get a proposal from the system.

> *“In addition, suitable projects are selected and an information index is presented which contains both documents from the hyperbook itself and documents located anywhere in the internet”* (Henze, 2000).

The algorithm therefore considers the user‘s actual knowledge and how much the project matches his goals.

To ensure adaption the system supports direct guidance, link generation and link annotation. The annotation also uses the visual appearance of a traffic light. Whereas green stands for “suggested”, red for “too difficult” and grey for “already known”. The links between the units are based on a semantic relationship like in UML (for example “is-a”- or “instance-of”-relationship).

The user model gets its information from direct feedback which is realized after each project unit. Therefore the user hast to answer questions about how hard it was for him to understand it. Compared with AHA! page visits or the path of the user is not taken into account. The user model is updated everytime the user has finished a project and the user then gets advanced topics. Unlikely to the use of baynesian networks in general this technique is used here for modeling and propagating the knowledge domain (Stash, 2007; Henze, 2000).

7 Privacy

In the world of the Internet and the web 2.0 where a lot of personal data is in use privacy becomes a very important topic. AHS are often web-based and so are also exposed to attacks and target of potential misuse. The protocols between servers must be encrypted and a central storage of data also poses a thread. But not only the storage can be misused but also the adaptive system itself. Examples of systems exist which do not really adapt to the user‘s needs, but try to influence him according to interests of a company. This is inconsistent with the basic idea of a AHS to help the user. To reduce these dangers in early stage Kobsa (Kobsa, 1993) proposes to observe certain guidelines both in research and in practical applications.

In addition Kobsa (Kobsa, 2002) advises to clearly inform the user when a system contains user modeling so he can decide whether he wants that or not. This may also include information on the data that is to be collected, processed and transferred and the purposes the data is used for. The information should also include that the system might make errors when drawing assumptions about the user. Therefor the user should have the possibility to take a look on his user model and maybe apply changes. As we already said this is kind of critical because on the one hand the user could apply false changes and on the other hand it is not always that easy to translate these assumptions into ordinary English. Another idea is that the user can simply turn off the user modeling but hence the adaption gets lost.

> *"Long-term user characteristics should be modeled with caution since their misuse is probably more serious than the misuse of transient user characteristics. Moreover, long-term user characteristics are often regarded as more personal than short-term user characteristics"* (Kobsa, 1993).

If all these topics are considered in AHS the user will have more reliance in the system and his privacy will be ensured (Kobsa, 1993).

8 Conclusion

The goal of this paper was to give an overview on how user modeling in AHS is realized. We have shown the most important techniques to support adaption and the mainly deployed user characteristics that are analyzed by the systems and how they are represented in various user models. Here the overlay, the deviation and the stereotype model were presented with their individual advantages and disadvantages. Additionally a possibility to compensate the disadvantages by using stereotype and the overlay model in combination was shown. Afterwards the development of the architectures from the user modeling shell system to the user modeling servers and finally to the new idea of an agent based modeling system was illustrated. To show how all these techniques are applied and nevertheless how different the approaches can be, we analyzed the AHA! and the KBS Hyperbook system. As a last point the importance of ensuring privacy and preventing misuse of adaptive hypermedia was worked out and also some proposals for resolving the problems are listed.

For future trends the immense collection of knowledge in the world wide web is very interesting especially for educational AHS. The system therefor has to be designed open to new content that can be found in the Internet dynamically, filtered and integrated at a suiting position. The term **semantic web** often is mentioned in this coherence. The idea behind this is to represent the data in a way that is understandable for humans as well as for machines. With RDF and the markup language XML this would be possible but it is still hard for machines to interpret this data. So the W3C organisation standardized the web ontology language (OWL) in the year 2004. So far this idea hasn‘t been practically conversed yet and for sure will still take some time. Nevertheless it is very exciting what is yet to come (Dolog et al., 2004; Aroyo and Dicheva, 2004; McGuinness and van Harmelen, 2004).

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Serious Games

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Abstract. The so called "serious games" offer more than just pure entertainment. Video Games, because of their highly developed technologies like 3D engines and artificial intelligence, are used by more and more industries. There are different types of serious games. Learning games can be used at home or in school to encourage children's education. The design of a learning game is not unproblematic. There are examples of insufficient integration of the learning content. Also the teachers have to accept computer games as a form of education and find a reasonable way to integrate them into the school curriculum. The military has used simulations for a long time. Now also video games can train soldiers and communicate a positive image of the army. In healthcare computer games are used to prepare healthcare professionals, in therapy, and as a form of exercise. Video games can be a persuasive technology and communicate a message. Artists use computer games as a medium of expression.

1 Introduction

Video Games are a relatively young medium. They only came up in the early 70s of the bygone century. Nevertheless they experienced a huge development in the last thirty years. They went all the way from simple reaction tests (like "Pong") to complex 3D simulations with life-like graphic.

Used in the right way games can offer more than just entertainment. They can be used for learning, training, helping ill people, persuasion, or as a form of artificial expression.

In this paper I will first give a theoretic explanation of how games can be used in serious ways. Then I will present and analyze the main types of serious games which are learning games, military training simulations, persuasive games, health games and art games.

2 Definition of Serious Games

It is not easy to define what a serious game is. Game developers and professional game players might say that all computer games are serious. The rest of the population might even wonder, how a game can be serious. The words "game" and "serious" seem like a contradiction in terms (Michael and Chen, 2006).

A simple definition of a serious game is: *"A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment."* (Michael and Chen, 2006). That does not mean that a serious game can not be fun or entertaining. However, the main purpose is another one.

The following definition might be more sufficient, because entertainment is not especially excluded and the purpose is explained in detail: *"Serious games are games that use the artistic medium of games to deliver a message, teach a lesson, or provide an experience."* (Michael and Chen, 2006).

3 Games in society

In his "Game Impact Theory" Roger Smith explains why game technologies are adopted by other industries such as the military, medicine or economics (Smith, 2007).

The computer game industry in 2007 made a turnover of over ten billion dollars, which is two billion dollars bigger than the turnover of Hollywood. It became this big in only ten years. The gaming industry created new software, which uses the full capacity of the fast growing hardware technology. When games became more and more socially accepted and the technology improved, companies realized that they could take advantage of the cheaper costs of development.

According to Smith game technologies will be used by more and more industries because of the following five core forces.

- **Cost advantage of hardware platforms:** In contrast to simulation software produced by serious industries like the military for example, computer games are designed to run on already existing systems which are available to as much customers as possible. Therefore it is much cheaper to use them than build professional workstations. The hardware costs drop from a \$20.000 to \$50.000 range down into a \$2.000 to \$5.000 range. If the games run on a console platform, the costs are even lower (\$200 to \$500 range).
- **Sophistication of software applications:** Computer games are developed in a way that the user can easily understand how to handle them. Therefore the user interfaces are designed to have a high usability. In the best case providing a manual is not necessary, because the customer learns while playing. Also the artificial intelligence is very high developed in the video game industry. The behavior of the system can easily be modified by scripting languages. Another advantage concerning software are the improvement of 3D engine, physical models and global networking.
- **Social acceptance of game tools:** For a long time games used to have a bad reputation in society. They were considered only as toys. Now the children who once played them are grown up and the social acceptance of games increases. Games are a part of modern culture and sometimes even

considered art. 3D simulations of environments can be seen for example in museums, architecture or military systems.

– **Successes in other industries:** Game technologies are adopted by other industries. The first of these industries were the military and the television industry. Their example motivates other industries to use game technologies as well.
– **Innovative experiments in the adopting industry:** When the personnel of industries experiment with game technologies, they find useful ways to improve them for their specific needs.

4 Types of Serious Games

In this section the five main types of serious games are introduced. At first learning games are described. Then the use of games in the military and in health care are discussed. The last two subsections are about persuasive games and art games.

4.1 Learning Games

This subsection first gives an overview about the history of learning games. Then the learning effect and the design of an educative game are discussed. After that the acceptance of video games by teachers is described. Then four examples of learning games are presented. At last problems ,which can occur if a game is not designed properly, are illustrated by four examples.

4.1.1 History of Educative Games

In the middle 1980s personal computers (like the Commodore 64 or the Apple Macintosh) were first used in schools. In the 90s the multimedia aspects of the PCs grew. They now had high-color displays, quality sound, music playback, and large secondary storage in the form of hard drives and CD-ROM drives. Because of this and the falling hardware prices computers were adapted by many households and also schools. Educational software was very successful and there were lots of typing games, math games, reading games and chess games. There was little time to use these games in schools, so the main target were the homes and especially the parents. Because children can choose what they want to do in their free time this games had to have a certain degree of entertainment and fun to be able to compete with television and other video games. In the year 2000 the Internet started to be very successful and educational games evolved into what is known as "edutainment", which first was accepted by parents then after a short time also by teachers. Now game developers work together with teachers to design games which can be used in the classroom. Serious Games even may become a standard part of the school curriculum (Michael and Chen, 2006).

4.1.2 Learning Effect

Young children have an inherent curiosity to learn. They want to explore the world around them and make sense of sights and sounds. Learning in their view is not work but play. When they get to school a different attitude towards learning emerges. Schoolwork and play are clearly separated. Schools have to struggle to capture a child's attention and motivate it to learn (Barab et al., 2005). If the learning content is integrated into a video game which children enjoy to play, the motivation is encouraged and play and learning are reunited.

In school students learn separated from each other, whereas in games players are brought together in competitive and cooperative ways. Because of the large game-playing communities, playing a game has become a social phenomenon. These communities are organized by the players themselves. The students can develop social skills and work together to achieve shared goals (Williamson et al., 2005).

Margulis (Margulis, 2006) arguments that games present an attractive psychological backdrop, and in this way motivate the players. The highly developed multimedia technology allows the simulation of complex and motivating environments.

Learning from a video game is different from regular ways of learning. Students learn by doing instead of reading books. The structure and format of formal instruction is ignored. The learning process has a high contingent of trial and error, where failures have no dramatic result. One knows, what one did wrong and the error can be corrected immediately. Just learned knowledge can be demonstrated and rewarded right in the game (Michael and Chen, 2006). Computer Games make it possible to develop situated understanding, because in virtual worlds words and symbols are no longer separated from the things which they refer to. The concrete reality which words and symbols describe can be experienced virtually. Therefore complex concepts can be understood with the learner keeping the connection between abstract ideas and the real problems they are used to solve (Williamson et al., 2005).

Not every game that claims to be educational fulfills this promise. The question if students are able to learn as much with video games as with traditional methods has not been answered yet. Instead of learning the material the students maybe only learn how to play the game. The research of the learning effect of games is still in the beginning, but some studies already show the potential of games. It turned out that students are more motivated when learning with a game. The areas in which research mainly is being conducted are assessment of learning, cost per student and the potential use of serious games (Michael and Chen, 2006).

Wee Ling Wong et al. (Wong et al., 2007) conducted a study to measure the learning effect of the educative game "Metalloman". This game wants to teach undergraduate college students about physiology concepts. The main questions of the study were if an interactive media format can provide better learning experience ("learning effects of interactivity") and if enriched interactive multimedia format is better than interactive hypertext format ("learning effects of a combination of both interactivity and media richness"). In order to answer these questions, the participants were presented four different conditions with different degrees of media richness and interactivity. Condition I was playing the game itself (high media richness, interactive). Condition II was a replay of another person playing "Metalloman" (high media richness, non-interactive). Condition III was a hypertext version of the game including the narrative context and screen shots from the game (moderate media richness, interactive). In Condition IV the participants were presented a text document, which included educational text fragments from the game and pictures (low media richness, non-interactive). To measure changes in knowledge the participants had to answer multiple choice questions. They were also asked to rate the usability in a 5-point Likert scale. The text version got the highest average rating in usability (4.02), the game the lowest (2.00). However, the game had the highest effect on knowledge gain. The replay and hypertext had also a similarly high effect, whereas the text version had a very low effect (figure 1). Also the game had the highest effect on gained interest in topic whereas the text version had only a small effect on this. An astonishing result is, that interactivity is not as important as expected. The replay had a similar learning effect as the game, although it is completely non-interactive.

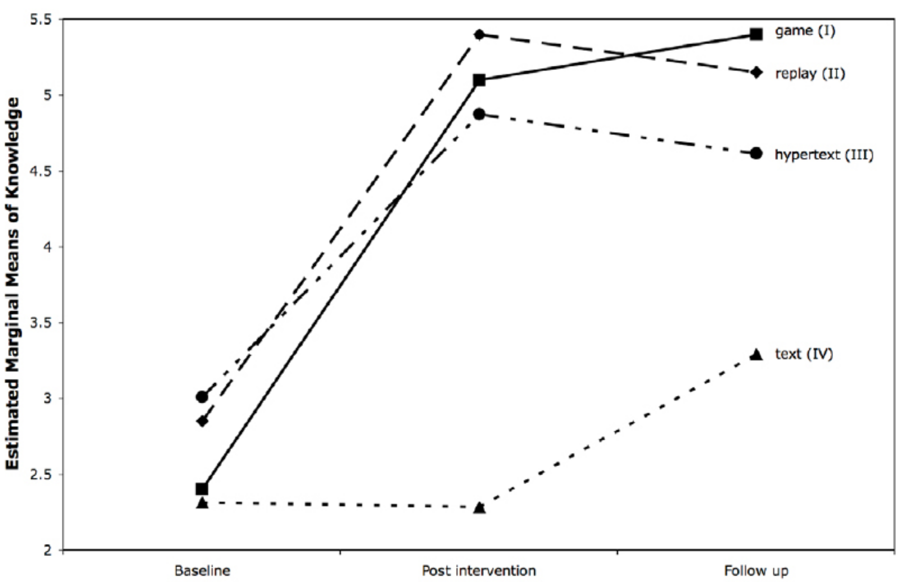


Fig. 1. Knowledge gain in different media formats (Wong et al., 2007).

4.1.3 Design of an educational game

It is not easy to develop a game which has a learning effect. The design is different from a regular game. If a game shall be able to be used in a school lesson there are important guidelines to consider. The game should not have long full motion video sequences or cut scenes which interrupt the game play. The teacher should have the possibility to start the game at every point which is useful for the day's lesson. The information which is presented in the game has to be absolutely correct. Also, the game needs to be fun and entertaining so the students are motivated to play it (Michael and Chen, 2006).

According to Stapleton (Stapleton, 2004) the focus in designing a serious game should be on *"creating environments and opportunities for players to learn, rather than creating products that aim to teach"*. That means that the educative content should be integrated into the game in a way that the player can receive it during his activity in the game play. The learning should happen voluntarily instead of forcing the students to do it in a predetermined way.

Games designed for learning purposes usually do not have a budget as big as the budget for normal blockbuster games. Therefore the quality of the 3D engine or physical effects can not be very high (Michael and Chen, 2006). To reduce the budget and keep a certain quality, there is the possibility to modify existing games or work together with other organisations (Stapleton, 2004).

It is also important to consider if a game is really the best solution to support a certain field of learning. There may be other options which could work better in the specific case (Stapleton, 2004).

4.1.4 The acceptance of video games by teachers

Mass culture media has always had difficulties to be accepted by teachers. Movies, television, comic books and rock-n-roll-music received harsh criticism when they came up. Now video games are the newest medium. There is the fear that games keep teachers too busy to do their job and that the teacher would become a coach and a research director instead of being a lecturer. To use games in an effective way teachers also need to be trained new methods (Michael and Chen, 2006).

According to Williamson et al. (Williamson et al., 2005), games have the potential to provide a high degree of education, but it is hard for educators to see this potential. Unlike the students the teachers are also not familiar with video games, because most of them have never played one.

In school it is the teacher who decides what the students have to do. So Stapleton (Stapleton, 2004) calls traditional education a "teacher-centered approach". Games are designed to be experienced interactively through playing. The player, as a learner, is in control. Therefore it is a "learner-centered approach".

According to Margulis (Margulis, 2006), teachers should try to profit from the advantages of learning games and find a reasonable way to integrate them into their schedule. By doing so a more amusing and interesting form of learning can be created .

4.1.5 Examples of learning games

"Power Politics III" (http://www.powerpolitics.us/) is a simulation of a presidential election in the USA. It has the goal to teach the students how the election system of the USA works. The game was mainly designed to be entertaining, but it also shows a detailed view of the political system and the electoral process. It is available to educators for free. Each player chooses a candidate and manages his campaign from the start to the final election. There are certain tasks to achieve, like hiring staffers, overseeing advertising, and trying to control the topic of the campaign. Aside from playing the game students are encouraged to write a report on how the campaign was planned, how the campaign progressed, and why they choose certain strategies (Michael and Chen, 2006).

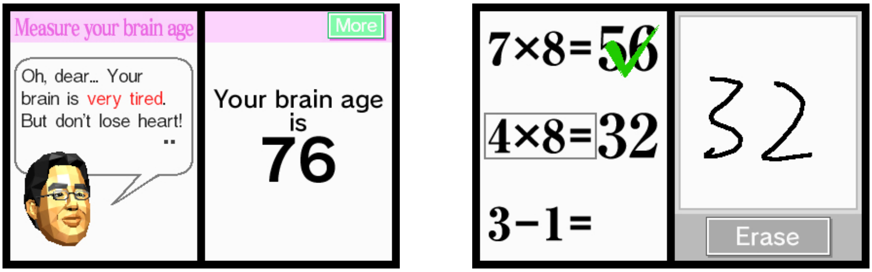
"Supercharged!" wants to promote learning about physics, especially about electromagnetism. The player has to use the physics of electromagnetism to steer a spacecraft by controlling its electric charge and navigate through a 3D-environment to reach a goal. In order to do so, they have to understand the relationship between charge and distance of particles to predict which way a certain particle would go, and how charged particles interact with each other (Stapleton, 2004).

Barab et al. (Barab et al., 2005) developed the three-dimensional multi-user game "Quest Atlantis" (http://atlantis.crlt.indiana.edu/). The players travel to virtual places and perform educational activities. These activities are called "Quests". Like in regular Massive Multiplayer Online Role Playing Games (MMORPGs), each player builds his individual virtual personae. There is the possibility to chat and work together with other players. To increase the children's motivation, a rich back story was invented during the design process of the game. A user study conducted by the designers of "Quest Atlantis", showed that children liked "Quest Atlantis" significantly more than they liked school. Also they did not rate school significantly higher than "Quest Atlantis" on the learning dimension. So at least children are more motivated to play "Quest Atlantis" than going to school, but the actual learning effect of "Quest Atlantis" has still to be explored in independent researches.

Unlike the other examples mentioned here, "Dr. Kawashima's Brain Training" does not want to teach specific school learning content. It rather offers exercises to train certain functions of the brain. The user has the possibility to determine his so called "brain age" (figure 2 (a)). Then the player can try to improve his skills by doing short exercises each day. These exercises can be solving simple arithmetic problems in a short time (figure 2 (b)) or memorization tests. Doing them only takes one or two minutes. It is recommended to do one to three exercises each day. Since the game is designed for the "Nintendo DS", a mobile system, it can be used everywhere in between, for example during a subway ride or in the lunch break.

4.1.6 Problems caused by insufficient design

As mentioned before, the learning effect of a game that claims to be educative is questionable. If the game is not designed properly, several problems can hinder



(a) (b)

Fig. 2. "Dr. Kawashima's Brain Training" screenshots (Source: Nintendo). (a) "brain age", (b) solving simple arithmetic problems in short time.

the learning. Jantke (Jantke, 2006) has analyzed the german learning games "Physikus", "Brand im Hafen", "Genius Unternehmen Physik" and "Genius Task Force Biologie".

"Physikus" (1999) wants to teach the student about five branches of physics. It is a point & click adventure in which the player walks through a 3D environment in a first person perspective. The Player can interact with objects via the mouse and pick them up or use them. To simplify tasks and riddles, the learning section of the game can be consulted, which provides learning material from the different branches of physics. The problem here is, that this section is clearly separated from the game. Therefore the game is only a motivation to learn the lessons, but the learning is not integrated into the game play.

In "Brand im Hafen" (German for "Fire in the Harbor") (2002) the player has the role of a female detective who has to solve a crime. It is also a point & click adventure, but this time it is viewed from the third person perspective. The game does not want to teach particular school subjects, but everyday knowledge. This knowledge, however, is not really taught during the game. The player has to have a certain degree of knowledge to solve the riddles (for example how a magnetic compass works), but the knowledge has to exist already. The game only works as training environment for existent knowledge rather than teaching new one.

"Genius Unternehmen Physik" (2004) is a real-time development game. The player has the task to build and establish an enterprise. To get economic advantages, there is the possibility to solve exercises in physics. Without doing these exercises, the game can not be won. Whatever the player does can not save him from bankruptcy. This learning part therefore feels like a punishment and again is separated from the real game. During the physic lessons there is even the text "game is paused" displayed on the screen.

The game "Genius Task Force Biologie" (2005) is similar. As in the last game, the player can do biology exercises in order to get benefits for the actual game. This time the impact of solving these exercises is not so significant and not clearly displayed to the player, so there is no motivation to do them. The game can also be played completely without the learning part.

In all four examples, the learning was not properly integrated into the game. The learning seemed to be a disturbance of playing the game or was not even implemented in the game at all.

4.2 Military Games

This subsection starts with on overview of the history of military games. Then it explains, why computer games can be useful for the military. After that four examples of military games are presented.

4.2.1 History of games in military use

The military has used games for a long time. Games are abstractions of elements of physical reality with explicit rules. With proper guidance the skills learned in games can be transfered back into the real world. The first war games were "Chaturanga", "Wei Hei" and "Chess", which provided a way for officers to see how different troops could be used and learn about the right use of strategy and counter strategy. Modern war games came up in the 17th century. At first they were simple variations of chess, later more sophisticated and complex simulations (for example "Kriegspiel" in the first half of the 19th century) evolved (Michael and Chen, 2006).

The developing of computer technology allowed the games to gain a higher degree of complexity. In the 1960s computer simulations of air battles, space missions, missile exchanges, disarmament inspection systems and international political-economic competitions were build. At the end of the 20th century the growing 3D technology allowed the development of realistic simulators. Vehicle simulators, especially flight simulators and tank simulators, became an important part of military training. Other combat situations could be simulated in a computer game as well (Michael and Chen, 2006).

In the late 1980's the SIMNET project was created. The goal of this project was to develop all major simulation systems (virtual and constructive war games) as networked devices, so they can cooperate with other simulations to create a richer representation of the battlespace (Smith, 2006). The SIMNET was designed for specific task-training like docking a space capsule or landing a jet on the deck of an aircraft carrier. The battlespaces simulated by SIMNET were simulations of actual places with a size of 50 square kilometers or even more, where battles were fought in real time (Lenoir, 2003). It was the first time, that an entire platoon of tanks could be simulated and the drivers could work together as they do in the real world. As the technology expanded, other ground vehicles and helicopters were added. A large part of the virtual training industry was built on this foundation because it provided a low-cost, standardized platform. Therefore the SIMNET was a prototype of future virtual training devices (Smith, 2006).

The game "Spearhead" (created in 1998) was the first attempt to transfer the SIMNET experience onto a desktop computer. It showed that high quality graphics, realistic physical models, networking, and team training could also work on a desktop computer. After several years and a number of simulators similar to Spearhead, finally also military customers were convinced that a PC-based game could provide valuable training (Smith, 2006).

The possibility to move simulators to the PC presents high cost savings on the hardware platform. It drops the costs from tens of thousands of dollars to two thousand dollar. If the simulators can be played on consoles like the Playstation and XBox series, the costs can drop even more (Smith, 2006). Also military simulation games do not always have to be developed completely new for the army. Existing commercial games can be modified or even used as they are to serve a military purpose (Michael and Chen, 2006). With the level editor of the commercial game "Doom", a group of Marine simulation experts were able to adapt the game as a fire team simulation which could be used to train Marines. "Marine Doom" was provided with realistic images of weapons, soldier action characters and military features like fighting holes, bunkers, tactical wire, and friendly fire (Lenoir, 2003).

4.2.2 Why video games are useful for the military

There are certain benefits of video games which the military has discovered. As players have to keep track of many different happenings in action video games, their multi tasking abilities improve. They learn to stay calm and controlled in chaotic circumstances. Mulitiplayer games help to develop team work skills. The willingness to take aggressive action increases because of the die-reload-try-again cycle of video games. First Person Shooters enhance the ability of correctly identifying friend from foe. They also help to practice target prioritization. In a game the player has the opportunity to experiment and learn in which order enemies are eliminated in the best way (Michael and Chen, 2006).

4.2.3 Examples of military games

The most popular game created by the military is "America's Army" (http://www.americasarmy.com/). It was built in 2002 based on Epic's "Unreal Tournament" engine and therefore has (for that time) state of the art 3D graphics (figure 3), physic models and artificial intelligence. The main goal of the game is not only to train combat situations, but also to motivate civilian players to join the U.S. Army. Therefore it is available for free via the internet. Two years after its release, the game had been downloaded over 17 million times and had a community of four million registered civilian and military players. 30 percent of these players are not Americans and so the game is also a way of promoting American values. Although the game is designed to be highly authentic, there had to be made some sacrifice in realism to make it more entertaining. For example the player can hide behind cars to cover from enemy fire, which would not be a good idea in reality. A positive effect of the game is that new recruits, who played it before joining the army, are already familiar with the layout of the training camp and have a certain degree of understanding how the training will proceed. In 2005 the game was also realized for PlayStation 2 and

Fig. 3. "America's Army" screenshot (Source: Modeling Virtual Environments and Simulation Institute).

Xbox. Modifications of the game are used to prepare active soldiers for missions. Besides soldiers, the player can also pick virtual medical classes and take the role of a combat medic (Michael and Chen, 2006).

"Full Spectrum Warrior" is a commercial game for PC and Xbox. It is based on a U.S. Army training simulation. The task of the player is not only to blow up everything on the screen, like in an ordinary first-person shooter. To win the game also learning to think and act like a professional soldier is important. Therefore the player can give orders to two squads of soldiers, consult a GPS device, and communicate with commanders in the rear. In order to win the game, the player has to select the best positions and optimal movement formations for the different soldiers. During the game skills are developed, like they are distributed in real military practice (Williamson et al., 2005).

There are not only games which train combat. "Tactical Iraqi" has the goal to teach Arabic to U.S. soldiers and help them to understand the different culture. The game works with a speech recognition technology, but since this technology is not fully developed yet, a human person is needed to watch the learning process. Thus the game does not completely replace traditional methods, but augments the training process (Michael and Chen, 2006).

The commercial flight simulator "Falcon 4.0" is so complex that it was adapted by the military. It is a network-based game that supports single player or multiplayer modes. The simulation of the airplane is so detailed that the game's manual has 600 pages. Players even consulted a real-world manual for the F-16 aircraft (Lenoir, 2003).

4.3 Games in Health care

This subsection describes three types of games which can be used in health care. First fitness games are introduced. Then games which can be used to train health care professionals are described. At last the use of video games in therapy is explained.

4.3.1 Fitness games

The term "exertainment" describes the combination of video games, fitness and medicine. These games have the goal to make physical exercise more attractive and entertaining by adding elements of video games (Carolipio, 2005).

An example is "Dance Dance Revolution". It uses a special input controller, a so called "dance pad", which is based on Nintendo's "Power Pad" for the Nintendo Entertainment System from 1988. This dance pad has four panels, up, down, left, and right, arranged around the standing position of the player (figure 4). Arrows show up on the game's screen synchronized to the rhythm of a song which is played. The player has to press the right panels with his feet according to the arrows on the screen. The game was created only for entertainment and fun, but as the player has to move very fast, the game is like an exercise and can even cause loss of weight (Carolipio, 2005).

Fig. 4. "Dance Dance Revolution" dance pad (Source: Konami).

"Yourself!Fitness" offers a virtual personal trainer who supports the player (Liddane, 2005). The user can put in information about his personal fitness level and the game creates a personalized fitness program. In this way the game offers more than traditional home fitness DVDs.

Florian Mueller and Martin Gibbs (Mueller and Gibbs, 2007) designed "Table Tennis for Three". This game is based on traditional table tennis and can be played by three persons at different locations. Each player needs a table tennis table, which is set up so that the ball can be hit against the vertically positioned opposite half of the table. Also a video conference is shown on this half, so the other players can be seen (figure 5 (a)). The goal of the game is to break eight semi-transparent targets, which are projected on top of the video conference, by hitting them with a table tennis ball. These targets are synchronized across the three tables so every player is in the same state of the game. The impact point of the ball is detected by eight piezoelectric sensors on the back of the table (figure 5 (b)).

(a) **(b)**

Fig. 5. "Table Tennis for Three" (Mueller and Gibbs, 2007). (a) Table with video conference projection, (b) impact detection mechanism.

4.3.2 Training games for health care professionals

A study conducted by J.C Rosser et al. (Rosser et al., 2004) found out that surgeons with video game experience perform better in a standardized laparoscopic skill and suturing program. 33 surgeons participated in the study. The focus were the doctor's non-dominant hand, two-handed choreography, targeting, and 2D depth perception skills. Before the test, the participants had to fill out a questionary concerning their surgery and video game experience. The result of the study was, that surgeons who had played video games for three or more hours per week were 42% better in laparascopic drills and suturing. They had 37% fewer errors and were 27% faster than those who never played video games.

Game-like simulators can be used to train medical personal. In "Auscultation" the player has an electronic stethoscope and a headset. The stethoscope can be placed on different areas of a man's chest to listen to heart murmurs and other sounds in body organs (Michael and Chen, 2006).

"Pulse!" is a virtual learning space for health care professionals. It is an interactive environment which provides virtual patients with artificial intelligence. Medical personnel can practice clinical procedures or even prepare for bioterrorist events (Michael and Chen, 2006).

4.3.3 Games in therapy

Virtual Realities can be used in the treatment of phobias. The patients are confronted with models of their fears in a controlled but realistic environment.

These games do not always have to be developed new, they also can be created by modifying existing games (Michael and Chen, 2006). "Unreal Tournament" was modified to be used in treatment of arachnophobia (Stapleton, 2004). Even unmodified games can be used. The driving game "Midtown Madness" is used to help people with phobias related to driving cars and fear of open spaces (Michael and Chen, 2006).

At the Virtual Reality Medical Center (VRMC) in Los Angeles therapists use virtual realities to treat panic and anxiety disorders. They treat specific phobias like fear of flying, fear of heights, fear of public speaking, fear of thunderstorms, claustrophobia, agoraphobia, social phobia, panic disorder, and post-traumatic stress disorder. The simulations are used to expose the patient to the fear stimulus. As in regular phobia therapies the patient is not confronted with his fear to the full degree at the beginning. If a patient has fear of heights, for example, only a virtual elevator might be shown in the first visit. During the course of the therapy then, the patient is brought deeper and deeper into the scenario. In about 5000 therapy sessions which used computer simulations, there was a success rate of over 92 percent. Simulations might not replace regular therapies, but they are an excellent addition (Michael and Chen, 2006).

Games can also be used to distract patients during certain procedures. For example if painful dental work has to be done, the patient can try to focus on a video game (Stapleton, 2004).

4.4 Persuasive Games

This subsection deals with persuasive games. At first it explains why video games can be used as a persuasive technology. Then three examples of persuasive games are presented.

4.4.1 Games as a persuasive technology

Games can not only be used to transfer knowledge or train skills. They also have the ability to persuade and transport a political, religious or cultural message. Games have as much power as other mediums like books or movies. The difference is that in games the user is put right into the action. The player is not a passive observer but has to be active. So there is fewer distance to the message (Michael and Chen, 2006).

4.4.2 Examples of persuasive games

The game "Howard Dean for Iowa" (http://www.deanforamericagame.com/) was created by Gonzalo Frasca and Ian Bogost (Bogost, 2007) to support the Howard Dean election campaign. The target group of the game were Dean sympathizers, which should be motivated to become active supporters and engage in campaign activities. There are two parts of gameplay: a strategy part, in which the player has to place supporters on an abstract map of Iowa and three minigames, which are simplified representations of outreach activities like going from door to door and canvassing for votes or waving signs. Different players can communicate with each other by sending short messages and their actions effect other players. In this way the game should also create a sense of community among the Dean supporters. According to Bogost's informal analysis of online responses, the game was able to increase the interest in the election campaign. On the other hand, the game failed to distinguish Dean from any other political candidate. The fact that the game is especially about Howard Dean's campaign is only shown in the title and in textfields, but not integrated into the gameplay. The player gets no information about Dean's goals or political program. Therefore the name "Howard Dean" could easily be replaced with another name of a political candidate.

"September 12th" (http://www.newsgaming.com/games/index12.htm) came up after the attack on the World Trade Center to critcise the U.S. war against Afghanistan. Here the task of the player is to shut cruise missiles at terrorists. The destruction caused by the missiles makes civilians angry and morphing into terrorists. In this way more and more terrorists emerge and the game can not be won and never ends (Michael and Chen, 2006).

"Peacemaker" (http://www.peacemakergame.com/) deals with the Middle East conflict. The user can choose between playing the Israeli Prime Minister or the Palestinian President, and try to find a peaceful resolution to the conflict before his term of office is up. Interaction with other political leaders and social groups is necessary, as the player is faced with events like suicide bombers or diplomatic negotiations. The goal of the game is to inform teenagers about both sides of the conflict and how peace can be achieved through cooperation (Michael and Chen, 2006).

4.5 Art Games

Video games are also used by artists as a medium to express their feelings and believes. Since there are no commercial organizations behind them, they are usually developed by a single person or a small team (Michael and Chen, 2006).

The australian artist Jason Nelson designed "Game, Game, Game And Again Game" (http://www.secrettechnology.com/gamegame/gamegame.html). It is a 2D Jump and Run with 13 Levels filled with hand drawn enemies, items and backgrounds. Each level represents a different believe system, like Christianity, Buddhism, or Capitalism. The theme of a level is shown by the background, collectable symbols (e.g. fishes in the Christianity level, dollar symbols in the Capitalism level), and poetic texts which appear if the symbols are touched (figure 6). The main goal of Nelson was not to criticize specific believe systems, but to protest against web-art which is designed to be clean and smooth.

"Velvet Strike" (http://www.opensorcery.net/velvet-strike/) is a tool for the famous game "Counter-Strike". It is a collection of graffiti which can be sprayed on the walls in the game. The spray paint images are anti-war protest, social and political commentary, and explicit anti-American posters. Players can join

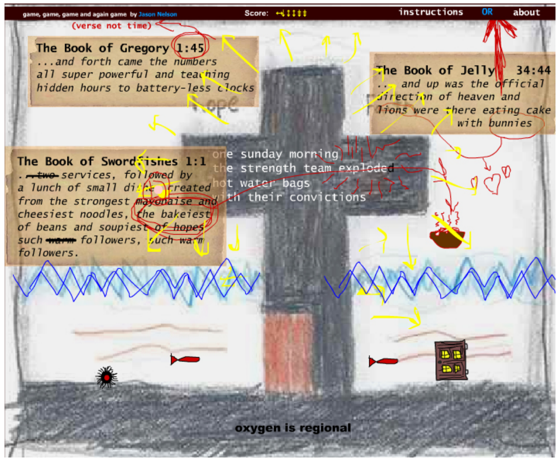


Fig. 6. "Game, Game, Game And Again Game" screenshot (Source: www.secrettechnology.com).

regular Counter-Strike matches and spray their graffiti on the walls (Michael and Chen, 2006).

The artist Joseph de Lappe (http://www.delappe.net/) also uses an existing video game to protest against a war. He joins "America's Army" under the nickname "dead-in-iraq" and types the names, ages, service branches, and dates of death of soldiers, who died during the iraq war, into the chat log. Lappe started this project in 2006 and is still continuing with it. At March the 3rd of 2008 he had already entered 4002 names. He is planning to keep ongoing until the end of the war.

5 Conclusion

Through cost advantage of hardware platforms, sophistication of software applications, social acceptance of game tools, games have become interesting for more and more industries. The power of their 3D engines and artificial intelligence make them useful tools for learning, military, health care and persuasion.

In education, games have the benefit of being known and accepted by the children. In contrast to traditional education, children enjoy playing games and do not consider it as work. Therefore it is easy to motivate children to learn with games. On the other hand the learning effect of computer games is questionable. The learning content is not always integrated properly into the game and the teachers are not fully convinced that games can be a sensible enhancement of their lessons. Concerning the learning effect of games, there has to be done more research and user studies that show a significant impact. If these studies show a positive effect of learning games, it is likely that they will be used in the education of children in a higher degree.

The military has a long tradition of using games in their training. With nowadays technology they are able to create complex simulations, which run on low cost systems. Popular games like "America's Army" are also a commercial success and communicate a positive image of the army or in best cases make players join the army. On the other hand these games glorify war and have a high degree of violence. It is very questionable if it is positive, that the players become interested in handling weapons and killing other people.

In health care video games are used for fitness, training of health care professionals and in therapy. There they are used to fight phobias or to distract patient during painful procedures. Still doing real sport is better than playing a video game. Massive video game players should not get the opinion that playing a fitness game once in a while is enough to keep a healthy life.

As a persuasive technology computer games are even able to deliver a political, cultural or religious message like criticism on war or to support election campaigns. The question is, if these games really succeed in convincing people. It is likely, that only people, who are interested in a certain subject and already made up their minds about it, play a game which deals with it. For example only people, who are against the American war on Afghanistan, will play "September 12th". A person who is pro war will not take the game serious and is unlikely to change his opinion. So persuasive games might rather confirm existing opinions than changing them. There need to be taken studies in this area to investigate the effect of persuasive games.

The capabilities of computer games are widespread. Entertainment is not the only goal any more. Therefore the negative reputation they still have in society might disappear completely in the near future. Then video games will be accepted as a part of culture like every other medium.

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Getting in Touch with History through Mixed and Virtual Realities

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Abstract. There have been manifold approaches to use virtual or mixed environments in order to enhance historical education. The spectrum reaches from highly detailed unique virtual ancient places, which can be explored with head-mounted displays, to less immersive web-based applications, which allow everyone with access to the Internet to come together in virtual museums, libraries or classrooms. On the one hand, virtual reality and augmented reality systems try to enable an environment as realistic and historically coherent as possible. On the other hand, desktop-based VR applications are more accessible and offer extensive interaction possibilities. This paper intends to give an overview over realized projects and discuss their particular chances and limitations.

1 Introduction

The introduction of immersive 3D environments dates back some time. Meanwhile, the use of virtual environments for educational purposes has been realized and researched in a variety of projects reaching from pilot simulators to medical role plays. With today's general availability of powerful hardware and high-speed Internet connections, virtual realities can be networked and rendered on PCs. The first big virtual worlds were established by the computer games industry. Meanwhile, there exist open-end scenarios that are mainly constructed and designed by their users and attract educators with their freedom of action. Given this variety of approaches, it is easy to loose the overview over the current educational activities in the field of virtual reality. The first section introduces the concept of virtual reality, gives an overview over technologic components and motivates its educational potential. In section two, state-of-the-art technologies in the field of cultural heritage will be introduced. In contrast to that, the following section will be about desktop-based virtual realities. Section four will sum up the main differences between the different approaches and show future trends.

2 Overview

In this section the concept of virtual and mixed reality is introduced and a description of the technologic components deployed in this field follows. Finally, the educational potential of virtual and mixed reality applications is discussed.

2.1 Definition of Mixed Reality and Virtual Reality

> *"Virtual reality (VR) is the use of computer graphics systems in combination with various displays and interface devices to provide the effect of immersion in the interactive 3D computer-generated environment."* (Pan et al., 2006)

While many authors defined VR essentially as a technology (Heim, 1998), it is more coherent to define it as a human experience (Steuer, 1992); *"the essence of VR is the inclusive relationship between the participant and the virtual environment."*(Fitzgerald and Riva, 2001) The crucial concept is presence and relies on two factors: Immersion and interaction (Mantovani, 2001).
Mixed reality is a superordinate concept both for augmented reality (AR) and augmented virtuality. Augmented reality deals with real three dimensional scenes complemented with virtual computer graphics objects, while augmented virtuality means the inclusion of real world elements into a virtual environment (Pan et al., 2006).

2.2 Technologic Components

The most famous technology associated with virtual realities is CAVE (Wikipedia1, 2008). It stands for cave automatic virtual environment and refers to Plato's allegory of the cave, where Socrates clarifies the education of philosophers and reflects on perception, reality and illusion. It is an accessible cube where high-resolution projectors are directed to three or more walls of the cube. The person within the cube wears special glasses allowing a 3D perception of the generated graphics. The first CAVE was introduced on the 1992 SIGGRAPH by the university of Illinois. Due to the high costs the CAVE did not become a widespread technology. Instead, researchers are looking for other ways of communicating a 3D experience by using only one screen and special glasses. Such an approach is used by the project described in section 3.2.2.
Another important technology is the head mounted display (HMD) (Wikipedia2, 2008). Already in 1970 Ivan Sutherland invented a special head worn device, which allowed the immersion in 3D environments. His *"fundamental idea behind the three-dimensional display"* was *"to present the user with a perspective image which changes as he moves"* (Sutherland, 1968). Since then, the HMD developed further in different directions. There are approaches which exclude the real view and immerse the wearer in a completely computer-generated 3D environment. Others follow a see-through strategy, which allows the simultaneous perception

of real and virtual environment and are developed for augmented reality applications.
Desktop VR systems base on subjective immersion and do not necessarily provide a 3D perception. Thus, a simple PC with an appropriate application can be considered a desktop VR system.
Concerning input devices, there is a variety of concepts. Standard keyboard and mouse, joysticks, data gloves or very specific controls as for example in a flight simulator can serve as input equipment.

2.3 Potential of MR/VR for Education

There is no general theory how to use the concept and the technologies of VR and AR, but the *"constructivist theory provides a valid and reliable basis for a theory of learning in virtual environments"* (Winn, 1993). The connection between the constructivist theory and VR can be made because based on the concepts of immersion and interaction, students can learn through first person and non-symbolic experiences. In immersive virtual environments knowledge is constructed from direct experience instead from mediation through teachers or books (Mantovani, 2001).
The cornerstones of the constructivist learning theory are *Constructionism*, *Exploratory learning* and *Collaboration*. The term "constructionism" describes knowledge construction based on physical interaction with objects in the world. Exploratory learning circumscribes that "students assimilate knowledge more effectively when they have the freedom to move and engage in self-directed activities within their learning contexts". Collaboration is considered important in order to promote social interaction of learners which can finally lead to a consensus of meaning (Mantovani, 2001).
There is a range of possibilities provided by VR and AR applications which hold potential for education and training (ibid.):

- Experimental and active learning
- Visualization and reification
- Learning in contexts impossible or difficult to experience in real life
- Motivation enhancement
- Collaboration fostering
- Adaptability
- Evaluation and assessment

An important point is learning in contexts that are impossible or difficult to experience in real life. This paper partly concentrates on projects in the area of cultural heritage where mostly the original context is not preserved. But also in other fields, this is a crucial point. VR/AR applications are for example employed in military training (Hughes et al., 2005), where it is hard to simulate fights in real life. Another application area is medical training, where specific tasks can be trained such as the debridement of a gunshot wound or a simulator for temporal bone dissection (Mantovani, 2001).

In order to apply VR/AR applications to historical learning processes, motivation enhancement as well as experimental and active learning processes are essential factors especially with material considered "boring" (ibid.) by a lot of people such as museum exhibits or important historical literature.

3 Immersive VR Projects in the field of cultural heritage

This section introduces three state-of-the-art applications in the field of cultural heritage.

3.1 About Models and their Educational Use

Already in the 1980s, archeologists made use of 3D-computer graphics in order to reconstruct ancient sites. Elaborate models were built, which should provide an overview over the excavation. Building models is nothing new in archeology, though. In museums one can find complex models made of wood, plastic or other materials, which help the visitor to get an idea of the general context of the site. What these hand-made models cannot provide is photorealism and the possibility to explore the place by "diving in". It is also easier to model bigger areas like Leonardo da Vinci's "Ideal City" computer-based (Barbieri and Paolini, 2001), since less space will be needed to expose it. Nevertheless, using the power of 3D-graphics or even virtual reality techniques just to produce a model does not meet the possibilities these techniques provide. Another real life example might clarify this: In Egypt exists a theme park where extras illustrate what life was like in old Egypt (Pharaonic-Village, 2008). Obviously people are interested not only in historical places, but also in their context. As long as the models are as "dead" as the original sites, they cannot provide an insight in this interesting question. By making use of modern VR and AR techniques, people could be taught about the context of a place by showing it to them instead of leaving it to their imaginations. Another disadvantage of handmade models is that they can only show one time-frame. A connection between different times - there might be several models, which illustrate different stages - always has to be done in the head. Computer-based models can help to facilitate this task.

3.2 DentroTrento

The DentroTrento project (Conti et al., 2006) uses virtual reality techniques in order to enhance historical, artisitic and cultural heritage in the area of Trentino. The idea was to create an edutainment system which explains to visitors the story and the evolution of the Roman town Tridentum. The archeological site has been discovered only recently during renovation works in the museum. Since it is located below an important square and between the foundations of a theatre, the visitor is confronted with a lot of fragments belonging to different objects. Therefore he suffers from some kind of spatial disorder making it difficult to understand the place. Especially the old Roman road is interrupted by concrete walls a lot of

times and cannot be grasped as one single road. Due to this, the local authority of Trent pushed the project. The goal was to create a content-rich, high-quality 3D environment capable of high emotional impact. An interdisplinary team consisting of 3D modellers, VR specialists as well as archeologists worked together in order to implement high-end stereoscopic visualization technologies within the premises of the museum, which are enriched with sound and commentaries.
Within the museum there is a projection room with a wide high resolution projection screen. Up to 30 people can sit in front of it. Loudspeakers play environmental sound and commentaries are streamed via multi-lingual headsets. Navigation is carried out with a joystick, whereby both free navigation and a guided tour is possible. The 3D experience starts in a virtual copy of the projection room. In the beginning, the virtual environment is the same as the real one: The modern parts interfere with historical fragments from different times. Then the visitor can push a button and make the modern parts blend away. In this way he can always make a local connection between the present and the past, but does not face the difficulties a normal visit brings along. He can "virtually walk around the Roman street" and get an overview of the town (ibid.).
The visitor can switch between two historical phases and interact with the environment (e.g. open/close doors). His experience is enriched with environmental 3D sounds, which are not sent to the headsets, in order to raise the level of immersion. Features supporting the visitor during his 3D experience are the so-called hotspot and a help interface. The hotspot system provides information units that are placed at prominent places within the virtual environment and are labeled with the tourist information sign. By pushing the joystick, the additional information can be accessed. Through the headset, the visitor will hear the information in his preferred language (ibid).
The help interface, which can be faded in, provides information about both the usage of the joystick and the visitors current viewpoint including local and temporal information (ibid.).

3.3 Aspendos/ERATO

The ERATO project (identification Evaluation and Revival of the Acoustical heritage of ancient Theatres and Odea) is part of an EU-project aimed at a collaboration of EU-countries and mediterranean countries in order to preserve and use cultural heritage. The focus is on the acoustic qualities of ancient theatres. Due to these qualities, some of these theatres are still in use for all kinds of shows. In order to preserve the sound qualities and also to provide guidelines how to use the old theatres today, acoustic measurements in several ancient theatres went into the reconstruction process. Especially interesting in this respect is the theatre of Aspendos (Turkey) because it is one of the best preserved ones (ERATO, 2006).
In collaboration with the VRLAB at the Swiss Federal Institute of Technology, the ERATO project features a full VR simulation. The focus is on a high quality of the visual and acoustic characteristics of the reconstruction, which includes virtual life and therefore overcomes earlier cultural heritage projects that were

limited in this respect. The reason for such limitations can be seen in the complexity such a project implicates and which can only be mastered by a well cooperating interdisciplinary team. In order to reconstruct larger sites, architectural plans as well as topographical data are needed. In addition to that, archeological sketches and extensive on-site surveys are necessary. The sources that are needed to create historical coherent virtual humans include knowledge about societal and functional aspects such as social rules, dress codes or hairstyling (Magnenat-Thalmann et al., 2007).
In the theatre of Aspedos, the virtual humans are enacting excerpts from greek dramas such as Antigone of Sophocles or a choral song of the Iliad. The technical and production matters will be discussed in the next section about a tavern in Pompeii, as it describes a comparable approach. By exploring a theatre where greek citizens follow original shows and where importance is attached to convey an original ambience including light, sound, music, voices and behavioral rules, the visitor experiences a level of immersion that not only exceeds earlier approaches, but also enables a learning process by putting the visitor into an authentic scene, which conveys a holistic impression that is otherwise hard to get (see figure 1). The actual exploration of the theatre is based on a stereo projector and a polarized screen, which offers the visitor a 3D perception of the theatre. Input devices are a standard keyboard and a mouse (ibid.).

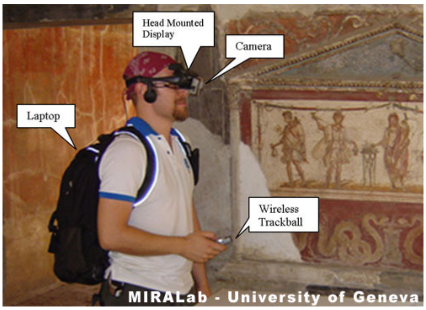
(a)

(b)

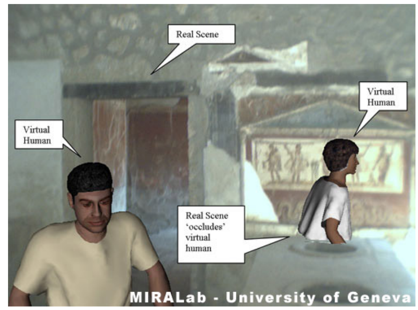
Fig. 1. (a) and (b) show rendered images from theatre reconstructions including virtual actors and audience.(ERATO, 2006)

3.4 Pompeii/LIFEPLUS

LIFEPLUS (LIFEPLUS, 2002) is a project, which wants *"to push the limits of current Augmented Reality (AR) technologies, [...]"*. The idea is to capture a video of a real scene in real time and add realistic real time rendered 3D simulations of virtual humans, animals and plants to the scene. Visitors are equipped with a see-through HMD, earphones as well as a mobile computing unit. Their location within the site is determined by a tracking system and both the audio as well as the visual information presented to them is dependent on the particular context, which is their current view of the site (see figure 2 for such a setup).



(a)



(b)

Fig. 2. (a) shows a fully equipped visitor and (b) shows a real scene with added virtual humans.(LIFEPLUS, 2002)

The AR-setup we describe is installed at the Lucius Placidus Thermopolium in Pompeii, a well preserved roman tavern named after the original owner.

> *"Taverns were common and characteristic social gathering places in ancient Pompeii. They were public establishments where hot food and drinks were served, and where many people used to meet in order to eat, drink, play or simply talk."* (Magnenat-Thalmann et al., 2007)

Two scenario-based simulations have been prepared in order to describe daily life in Pompeii taking place in the tavern.
As well as in the example in the previous section, this task implies a high complexity. Content has to be collected from all available sources in order to create historically coherent visualizations of the humans, the furniture and other objects placed in the environment. A professional team of screenwriters, archeologists and specialists in ancient Pompeian life prepared the scenarios and cared for the historical validity of the result. The scenes and costumes are based on specific scenes from frescos and the dialogues are taken from original inscriptions (ibid.).
The animation of the virtual actors is based on motion capturing. All the events and dialogues have been reenacted by professional actors, filmed and recorded. The video sequences are used both for the motion capture based animation process and the synchronization of the animations with the voices and sounds (ibid.). Under the supervision of historical consultants, the Latin spoken dialogues have been recorded in an anechoic chamber and the English caption lines have been designed. Position-dependent acoustical simulations of the sound sources were created by employing the geometrical 3D Model of the site, surface material data and impulse-response measurements. Through interactive area triggers linked

with the sound files, the visitor can freely move around and experience the simulated voices like he would be surrounded by real people (ibid.).
As described above, the visitor is equipped with a mobile computer on his back, which is the main processing and control unit. It handles sensory data, communication with the server, user profiling, image tracking and rendering as well as user interaction. Further features of the mobile computer are a GPS system responsible for calculating the visitors position and a digital compass, which is able to recognize his orientation. In order to see the augmented virtual objects, the visitor is provided with a see trough HMD, which is combined with a camera that captures real time video material from the environment. Additionally, he holds a tracking device in his hands that enables accurate positioning in the absence of GPS signals (Vlahakis et al., 2003).
Equipped like this, the visitor can start his exploration of the tavern and for example watch Lucius Placidus baking typical Pompeian bread or watch the guests enjoying their meal. The animation of the virtual actors depends on his position and his point of view. In this way the AR application introduced by Lifeplus represents a powerful interface between the visitors and archeologists, historians, scientists, educators and artists as it is pursued by other research groups as well (Gaitatzes et al., 2001).

4 Roleplays and Online Virtual Worlds

In section 2.2 desktop VR systems have been mentioned. Nowadays, there are plenty of applications, which provide whole virtual worlds and can be accessed via the Internet. One may think of “World of Warcraft” [1] or open-end scenarios such as “Second Life” [2]. These applications are not immersive in the sense of a 3D perceived experience, but in the sense of being present and active in these environments. In order to understand the relevance of role playing for educational purposes, a real life approach will be introduced. After that, it will be discussed how electronic approaches can extend real life role playing and which chances they hold for education.

4.1 Real Life Role Plays

Real life role plays have nothing to do with virtual realities or virtual worlds but they show that the constructivist learning theory works. As we have pointed out, constructionism, exploratory learning and collaboration are the cornerstones of the theory. In 1995, a teacher at New York’s Barnard college realized that his class about historical literature did not evoke the desired learning experience with his students, who could not get into the matter. The teacher decided that not the material, but the methodology is the crucial point: He turned the seminar into a series of games, in which his students recreate debates that have shaped

[1] URL: http://www.wow-europe.com/de/index.xml, last accessed: 08.07.2008
[2] URL: http://secondlife.com/, last accessed: 08.07.2008

history. Instructors give introductive lessons and provide game packets, which include the rules and the relevant literature. Then the students take over the assigned roles and start the game. In this way they have to use the literature in order to manage the debates and explore the historical context in a way that makes philosophy and mindsets from other times accessible. As successful this concept turned out to be at Barnard College, as limited is the chance for students from other colleges to profit from such concepts. It needs a lot of factors bundled in one place to realize a role play like this: A willing teacher, the educational freedom to follow such an approach, a good community among the students and the time to come together regularly (Fogg, 2001).

4.2 Electronic Approaches

Until recently, worldwide networked virtual worlds were not in the center of attention, as the technical development was not mature enough and technologies like 3D glasses or data gloves seemed more exciting. With today's general availability of high Internet bandwidth and the further increased performance of PC hardware, sophisticated applications with thousands of worldwide distributed users at a time are reality. A classification of these applications is not easy. The term MMORPG, which stands for massively multiplayer online role-playing game, covers a lot, but is restricted to role plays such as "World of Warcraft" or "Final Fantasy" [3]. However, a newer tendency towards virtual worlds can be observed, which do not exist for a game scenario, but offer the user a space, where he is free to decide what to do. The purpose of the presence in such a world has to be defined by the user himself, who therefore faces a bigger bandwidth of possible interactions (Pätzold, 2007).
At the moment "Second Life" is the most important of these worlds (ibid.). The product of Linden Labs is elaborately designed and content is created by its users to a large extent. By using the particular software, they can construct their own artefacts and place them within the world. The possibilities of interactions are little restricted and there is no game idea. In fact, different scopes of actions are formed such as gambling, porn, lifestyle or education.
A similar concept is shown by "Active Worlds", which offers a 3D environment, where users also can buy land. A feature that is also available in "Second Life" is the possibility to create own worlds which are not connected to the main world. This feature might be interesting to educational concepts, since it allows to profit from the application's possibilities on the one hand, but blocks uninvited other users. The "Active Worlds Educational Universe" (AWEDU) (Activeworlds-Corporation, 2008). gives an overview over central educational activities, whereby a couple of the listed worlds was not reachable until recently (Pätzold, 2007).
"Moove" [4] is another 3D interaction environment and follows a different concept. The interaction takes place in houses, while every user owns one house and can

[3] URL: http://www.square-enix.com/, last accessed: 08.07.2008
[4] URL: http://www.moove.com, last accessed: 08.07.2008

invite other users. A public space as in the sense of "Second Life" or "Active Worlds" does not exist. Therefore, the possibilities for educational applications are limited.
ConstruiRV, a non-commercial research project represents a similar approach. A distributed system of "rooms", which contain single lessons to learn such as the visualization of physic laws shall help to ensure a certain educational quality where teachers lack qualifications and equipment. Users of this system can create new rooms and expand the network (Peruzza and Zuffo, 2004).
An important concept in the area of virtual worlds is the avatar. An avatar is the representation of the user in the world and is a computer-generated body which can be chosen or even designed by the user. It is the interface which can be used to communicate with other users. Communication is a central point in these worlds. Similar to the MUDs [5], which originally were designed for special purposes such as gaming and then used as communication platform mainly (Pätzold, 2007), these worlds seem to enable all kinds of communications: text-based chats, audio and video conversations, sharing of pictures and movies etc..
Pätzold tried to analyze the educational potential of the above mentioned virtual worlds. As orientation for judging the particular potential, he considered the criteria of multimedia-based learning environments established by Bloh and Lehmann: Multimedia ability, interactivity and networking aspects (Bloh and Lehmann, 2002). Further criteria are according to Pätzold the possibility to act as a social space, the development and existence of communities, and integration. Integration means the chance to integrate the experiences made in the community into real life's thinking, feeling and acting. The discussion of the results in detail is not part of this work, but the overall conclusion of his research shows that there is a high potential to enhance previous computer-mediated communication and community building, which is not fully exploited yet. A lot of the appearances of educational institutions in those worlds can be ascribed to publicity surplus. But they are also suited for testing new educational forms. The facilities of simulation games, which also contain role plays (as described in the previous section), seem to be increased in virtual worlds (Pätzold, 2007).

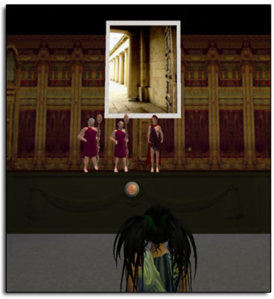
4.3 Second Life

As described above, "Second Life" is the most important virtual world at the moment and has been discussed in public extensively (Hamann and Ühlecke, 2007; Kerkmann, 2008). Central educational projects are documented in the "Second Life Community Convention" (Livingstone and Kemp, 2006). Unitl now, the majority of these projects is based on traditional formats such as museums, exhibits and simulations. Another interesting list of educational projects within "Second Life" is maintained by Jokay Wollongong and Sean McDunnough on their website (Wollongong and McDunnough, 2008), which was nominated for

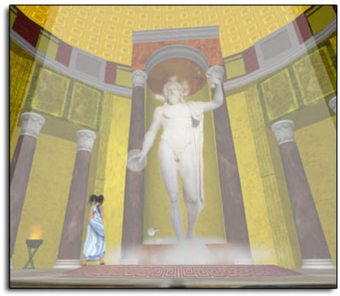
[5] MUD stands for multi user dungeon or multi user domain and refers to a mostly text-based interaction environment. See (Turkle, 1998)

the edublog awards 2007 [6]. They also provide their own learning environment in “Second Life” where educators and students can learn how to use the “Second Life” interface. Their collection shows that there are already a couple of history-related educational projects. There are libraries such as the “Second Life Library 2.0” project, art galleries and museums, roleplays and historical re-creations such as the “Temple of Isis” or “Roma” (Wollongong and McDunnough, 2008).
“Roma” (Wollongong, 2007) (see figure 3) is a very interesting place in “Second Life” in order to get in touch with history. A couple of ancient sites are rebuilt and it is suited for being compared with some of the the above-mentioned projects because it follows some similar goals.
Visitors arrive at the so-called “Customs House”, a place where they can access information about the site and what to explore. They can pick up a free toga and learn some basics of the latin language. “Roma” consists of four quarters, each divided into districts with various interaction possibilities and places to explore. One of these districts is for example the arena district, which includes the Flavian gladiator arena. Here, one can follow or take part in gladiator games and access background information.
We have talked about real life role plays and the problem of their limited accessibility earlier. In “Roma” there is a community called the ROMA Citizens (SPQR), which regularly arranges ancient roman role plays and exhibitions. Residents of “Second Life” can join the group and go to the Fort Legio VII Augusta in order to get involved (ibid.).
Although the supervision by a teacher is lacking in this specific case, it shows that concepts like the one from Barnard College can be enhanced by displacing it from the classroom to an originally appearing place. Additionally, it makes such a role play available to a larger amount of students.
In section 3.2.2 we introduced the ERATO project, which provided a reconstruction of an ancient theatre containing virtual actors performing original plays and music. Something very similar is possible in “Roma” as well. In another quarter, the “Theatre of Dionysus” is situated. Also here an ancient greece tragedy is performed (“The Bacchae“ by Euripides) by scripted virtual actors (ibid.).
In contrast to the ERATO project ,however, the dialogs are delivered via the text chat and the audience is missing. Therefore, the VR application of the theatre in Aspendos is clearly the more sophisticated application which communicates a more authentic experience to the user.
In another quarter the Roman Forum and the Capitoline Hill can be found. One can visit the Capitoline Museum with its collection of ancient Roman artifacts, changing exhibitions and the Librabry of Alexandria, where a few scrolls are available and can be unrolled and read in the reading room (ibid.).

[6] URL: http://edublogawards.com/2007/best-educational-use-of-a-virtual-world-2007/, last accessed: 08.07.2008



(a)



(b)

Fig. 3. (a) Watching an ancient greek tragedy in the "Theatre of Dionysus" (Wollongong, 2007) (b) Worshipping Jupiter at the "Temple of Jupiter Optimus Maximus" (Wollongong, 2007)

5 Questions, Topics and Trends

After introducing immersive VR and AR scenarios in section two and role plays and virtual worlds in section three, we will now have a look on the basic differences between the different approaches. The educational use of such technologies is promising and in some cases already tested but on the whole still in a experimental phase with a variety of different applications. Therefore, it is necessary to consider which features of the deployed technologies are crucial for the learning processes. A further problem for a broad use of this technology is the creation of content, which today still has to be done by people with 3D modeling skills. Strategies for easy and efficient preparation of high-quality 3D models are needed.

5.1 VR/AR vs. Desktop-based Virtual Worlds

The most obvious difference between VR/AR applications and desktop-based virtual worlds is the technically supported immersion. While the examples in section 3 establish a feeling of presence in the virtual reality by the use of technologies like CAVE or HMDs, the immersion in worlds like "Second Life" is a rather subjective one (Mantovani, 2001). It is based on the interactivity in those worlds. Users can create own artifacts in case they have sufficient 3D modeling skills. With some additional programming skills, one can set up nearly everything from a playable piano to a fully functional discotheque. In VR/AR applications situated at cultural heritage sites or museums the feeling of presence is established by the illusion of physically being there. As we have seen there are a lot of trends to design these applications in an interactive way, for example by giving the user the chance to open doors or by employing script-driven virtual humans, who react to the user according to the situation. However, there are very different levels of activity, which mainly result in the concepts. VR/AR applications are always built upon a scenario. The scenario of the LIFEPLUS project (see section

3.2.3) is the Pompeian tavern and the social life there. This scenario is limited. In "Second Life", there is no scenario. On the one hand, the visitor of the Pompeian tavern is surrounded by people, who allow him an insight in their lifestyle, but on the other hand, these people do not notice the presence of the visitor. Through the various communication channels and the fact that the other virtual people are actually avatars with intelligent users behind them, virtual worlds create social spaces, where experiences can be shared and where meetings can be arranged. Therefore, there can be a strong immersion into desktop-based virtual worlds, although they cannot provide photorealistic experience with a physical feeling of presence.

Today, only desktop-based virtual realities can offer a long-term learning support which is for example needed in role plays. The high hardware requirements as well as the lacking of a wide network of available applications make other technologies unfeasible at the moment.

Another striking difference between the two approaches are the costs and the effort, which are necessary in order to create the particular application. We have seen that in elaborate VR/AR projects highly qualified experts from different fields of research are working together. Mainly because of that a broader use of these technologies in education but also in other fields did not happen until now. In contrast, the establishment of applications within "Second Life" or "Active Worlds" is quite easy. Land has to be bought and the required 3D modeling skills are not comparable to those of VR/AR projects, where on the basis of architectural and topological plans, archeological sketches, high-quality photo material and modern shading and light concepts an exact reproduction of an ancient site is created. However, the professionalism deployed in order to create virtual worlds also reflects the quality of the virtual world itself. VR/AR applications consistently created by professionals can be expected to have a higher quality than online virtual worlds, where everyone can create content.

5.2 Which Features are Important for Education?

In the preceding sections different technologies dealing with virtual realities have been discussed and concrete examples of applications have been introduced. A lot of projects realize different approaches in order to enhance traditional education. But while the *"point is no more to establish whether VR is useful or not for education"*, *"the focus is instead on understanding how to design and use VR to support [the] learning process"* (Mantovani, 2001). We have seen for example that immersion can be created in different ways and that interactivity can mean different things.

> *"Unfortunately, although researchers have many ideas concerning how VR might facilitate the understanding of complex concepts, the field has little information concerning which of virtual reality's features provide the most leverage for enhancing understanding[...]."* (Salzman et al., 1999)

Therefore it is important to look at the concept that is being learned. For example the effectiveness of physical immersion (e.g. via CAVE) for role plays is

not researched yet.
Other important criteria for shaping the learning process are learner characteristics such as age, domain experience, spatial sense, computer experience or motion sickness history (Mantovani, 2001).

5.3 Main Problem: Content Creation

As already pointed out, VR technologies retrieve a great potential for educational uses. As the interest in these technologies increases, more and more applications need to be developed. For instance the museum sector realized early that they can profit from VR/AR applications. In 2003, about 35% of museums in Europe started the development of three-dimensionally presented objects. Most of the projects are at an initial stage, but the number is growing and expresses the increasing awareness of the possible benefits (Wojciechowski et al., 2004).
The main difficulties that a wide adoption of VR/AR technologies cause for the museums are efficient creation of 3D models and building the virtual exhibitions based on these models. This is a problem which is not only encountered by museums, but also by schools, universities and other institutions which aim at a broader application of these technologies. The preparation of virtual learning environments will not be able to be done by interdisciplinary teams of specialists. Due to this, research focused significantly on the area of 3D model creation recently and it is expected that there will be affordable high-quality 3D scanners available during the next years. Nonetheless, there will be a need for both easy-to-handle methods in order to create VR/AR applications based on the 3D models and an adequate presentation of these applications, which provides "an intuitive human-computer interface based on well-known metaphors". (Wojciechowski et al., 2004)
The ARCO project (White et al., 2004) - *Augmented Representation of Cultural Objects* - provides a system for museums that covers creation, management and visualization of content. It consists of three components: content production, content management and content visualization. The production process includes all tools for the digital reproduction of museum artifacts. Both state-of-the-art modeling plugins for applications such as 3ds max addressing the development of objects with simple geometries and a more complex stereo digital camera setting for more complex objects are provided. After the production, the contents are stored in a database and can be managed via a special content management tool, which organizes the media objects and the associated metadata. Media objects can be 3D models, descriptions, sounds and videos. The content management system also allows the creation of virtual exhibitions. A designer can pick an exhibition space, assign media objects to it and apply visualization templates. The visualization of the objects is performed by VR/AR interfaces. The interfaces combine a web-based presentation with either VR or AR virtual exhibitions. While a web browser integrates the virtual exhibition in a well-known interface, the VR/AR presentations give users the chance to examine the virtual reproductions. Due to the fact that exhibitions are created dynamically in the end-user interface based on a specified visualization template, they can be customized for

particular users or even be created in response to a user query (Wojciechowski et al., 2004).

5.4 Trends

Although the approaches in the sections three and four are quite different, we have also pointed out some parallels such as the scripted actors, which are employed both in the VR application of the ERATO project and in Second Life's "Roma". In the future, VR/AR applications will probably focus on a more realistic presentation and "intelligent" abilities of the virtual humans in order to advance the interaction capabilities with the user. Discussed features are for example voice recognition and speech synthesis. It is assumable that future results on this fields will have influence on desktop-based virtual realities as well.
With increasing hardware capabilities, VR and AR application developers will presumably focus on an improvement of real-time animation and rendering and create very realistic clothes, hair etc.. Other improvements can be expected concerning lighting, where the implementation of high dynamic range image methods is going to be extended. As the power of PCs and graphics devices increases quickly, an application of results in these fields can be expected in the nearer future.
Lately there have been several projects which focused on the controller of the game console Wii by Nintendo. Johnny Lee, who does research in the field of Human Computer Interaction at the Carnegie Mellon University at Pittsburgh, used the controller in order to realize head tracking for desktop VR displays (Lee, 2008). Using his head tracking glasses, the displayed 3D content adapts to the position of the user. This "low-budget project" shows that there are possibilities to create affordable immersive VR systems in the future. Due to the technological progress, new ways of creating immersive systems will need to be discussed.

6 Conclusion

We have seen that virtual environments are already employed for educational purposes. While immersive VR/AR applications can enhance cultural heritage education and museums by "beaming" the user into another time where he can explore original contexts, online virtual worlds can provide social spaces where role plays and many other forms of interaction can be arranged. Although the user does not feel a physical presence, he can feel immersed into the environment because of the high possible degree of interactivity. Due to the diversity of the different approaches, it has to be researched which features of the different technologies are suited for which learning concept. As many educational institutions have already started to engage in VR and AR technologies, ways of efficient content production have to be found that do not require the help of specialists. It also has to be questioned, if trends in the development of hardware will lead to a wider distribution of end devices allowing an immersion of the user into virtual environments.

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Virtual learning environments as supportive element in schools

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Abstract. Throughout the past years, virtual learning environments have matured to a state in which they can be applied beyond scientific research. Latest technology is used in some cases to provide the user with an immersive virtual reality, whereas others get along with modest forms of visualization and focus on creative construction of content. This paper intends to provide a general view of current applications of virtual learning environments applied at schools. For this purpose some selected case studies will be particularly regarded and evaluated along their technical implementation and pedagogic approach. Moreover the capability to be applied in everyday school life of these projects is of special interest. Despite the big effort of research in this area, barely a single project exceeds experimental stage. Hence, another goal of this study is to identify weaknesses as a rational for the low number of real-life applications and to derive future potentials.

1 Introduction

Optimized learning processes are the aim of people, who look for improved teaching methods. To achieve this goal relatively new approaches are so-called virtual learning environments (VLE). As they are based on a combination of common pedagogic theories and the use of modern information technology, like virtual reality (VR), to extend or even provide heretofore unknown learning experiences, they are very promising. "Besides being able to show anything we want in VR, a VLE can be used to create the oldest form of learning: experience"(Boot, 2005).

Right from the start, interactivity was considered an important factor for learning in virtual learning environments. Interactivity allows the user to become active in shaping his own learning experience instead of being a passive spectator. It enhances learning in everyday life and therefore is therefore supposed to have the same effect in virtual learning environments. Taking into account that compared to a rich visualization of a virtual environment, the degree in which it can be manipulated and interacted with, has a bigger influence on the user's involvement, there are reasons for implementation of virtual learning environments that rather focus on interactivity than perfect graphical presentation.

Due to technical restrictions a large number of virtual learning environments was designed for single users in the past. However, current projects investigate pedagogic approaches, which were not realizable so far. Rising processing power provides new opportunities for the development of more ambitioned applications. Collaborative, multi-user environments and the way they enhance virtual learning experiences get the focus of scientific research. "As it becomes possible to easily place more than one student within a VLE simultaneously, questions arise regarding the potential impact of the collaborative aspects of the experience on learning processes"(Jackson and Fagan, 2000).

This paper describes trends, potentials and challenges of recent work with virtual learning environments, especially designed for educative work at school. It is organized as follows: the next section provides a theoretical background of basic concepts concerning virtual learning environments and constructive learning. Chapters three to six present selected examples of VLE applications at school. It analyzes in detail their features along the two dimensions: technical implementation and pedagogic approach. As collaboration and interaction are central aspects of all projects, special attention is also turned towards their different characteristics. Finally, the outcomes for each virtual learning environment will be concluded. In chapter seven similarities and differences, as well as common challenges of the projects are discussed. At last a summarizing conclusion is drawn.

2 Theoretical background

2.1 Classification of virtuality

The reality-virtuality continuum, as proposed by Milgram (Milgram et al., 1994), describes a scheme to classify systems by the relationship of reality and virtuality (see figure 1). Real environment on the left hand side and complete virtual environment on the right hand side, it offers a consistent scale for mixed reality (MR) in between, including augmented reality (AR) as well as augmented virtuality (AV).

Virtual reality "is the use of computer graphics systems in combination with various display and interface devices to provide the effect of immersion in the interactive 3D computer-generated environment"(Pan et al., 2006). For example head-mounted displays (HMD) that provide a stereoscopic view of the virtual world offer complete immersion of the user.

Mixed reality (MR) is settled between the real environment and virtual reality. As mentioned above, MR can be subdivided into two more specialized categories: on the one hand augmented virtuality describes some kind of virtuality which is enriched by real world objects. Whereas on the other hand augmented reality describes an environment, which allows the user to see the

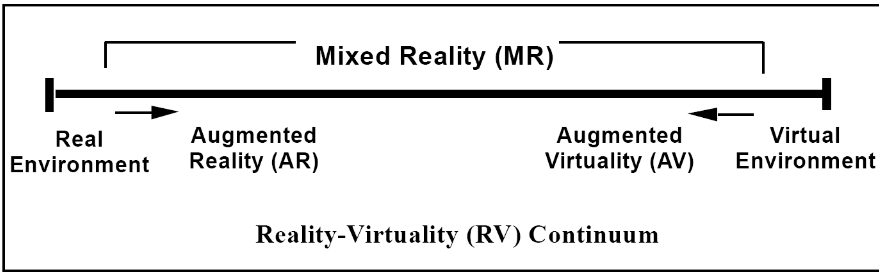


Fig. 1. Reality-virtuality continuum, Milgram et al. (1994)

real world, with virtual objects superimposed upon or composited with the real world (Azuma, 1997). As strict delimitation of AR from AV is hard to accomplish in some cases Milgram proposes additional dimensions for distinction.

Milgram has "posited some of the essential factors which distinguish different Mixed Reality display systems from each other: Extent of World Knowledge (EWK), Reproduction Fidelity (RF) and Extent of Presence Metaphor (EPM)"(Milgram et al., 1994). Typical hardware setups for MR are see-through displays, which overlay virtual objects and direct seen reality, and monitor-based displays, where computer generated graphics are combined with video images.

2.2 Virtual learning environment

Virtual learning environments are software systems, intended to support e-learning. Teachers and learners should be supported by tools for communication, content sharing, collaboration, administration etcetera.

According to Dillenbourg (Dillenbourg et al., 2002) VLE can be identified by several features:

– Designed information space: The Structure of the information depends on the functional requirements of the environment.
– Social space: Interaction with other users is a central concept of VLE and can occur in different ways (synchronous/asynchronous, one-to-one/many-to-many, text-based/audio/video and so forth).
– Explicit representation of the virtual space: As representation influences students' behavior and attitude towards the environment, the main design issue is less technology oriented but more about the structural relationship between the spatial representation and the information space.
– Active students as actors: VLE potentially provide not only active consumption of content but also possibilities to contribute additional information to the social information space.
– No restriction to distance education: VLE can be used in distance education as well as in presential education.
– Integration of heterogeneous technologies: Different technologies can be use and should be integrated into a single application, to reach learning objectives in an optimal way.

– Overlap of virtual and physical environment: The border between virtuality and reality becomes indistinct as computers get connected with physical artifacts.

VLE "not only provides rich teaching patterns and teaching content, but also helps to improve learners' ability of analyzing problems and exploring new concepts"(Pan et al., 2006). As shown above, VR/MR is not substantially connected to VLE but potentially holds many of its features.

2.3 Constructive learning

Based on the fact that VLE builds on concepts like interaction with other users or active contribution of information, many touching points with the theory of constructive learning can be found. "Constructive learning theory addresses learning as a process of actively constructing knowledge from experiences in the world"(Kritzenberger et al., 2002). Moreover, effectiveness of knowledge building increases, if students can operate in an authentic environment and produce meaningful results for themselves or others. Mantovani (Mantovani, 2001) points out three central principles which can be found in VLE.

– **Constructivism:** The idea of constructivism characterizes knowledge, which grows out of direct interaction with objects from the real world. Dealing with objects in a physical way is one of the most important factors in the learning process. "Students reach an understanding of the material under study through object manipulation and building of physical artifacts"(Mantovani, 2001). They gain best results if they do not only perceive information from texts or by teachers, which was prepared beforehand, but if they construct knowledge, engaging themselves with the content. Virtual learning environments can foster the process of knowledge construction, if they provide possibilities for interaction in virtuality similar to those in reality. Moreover, the possibility to experience different perspectives allows sharing results and process flows, which are hard to communicate in conventional ways.
– **Exploratory learning:** If students are allowed to decide autonomously about their interaction with the learning matter, they assimilate knowledge in a more effective way. The mental effort invested in research and classification of content leads to conceptual models, which conjoin new and existing knowledge. The continuous process of generating meaning from new information allows students to gain an insight in the subject and to construct their own version of reality, instead of perceiving pre-build points of view. VLE hold the advantage that students are directly located in the context they have to learn about. In this way the process of applying new knowledge is much more effective than in non-context-related situations.
– **Collaboration:** A central function of virtual learning environments is the assistance in social interaction, since it plays a central role in cognitive growth and is an important element next to the actual learning product.

> Working in groups provides the opportunity for students to interact and engage in learning at the same time and also come to an understanding about the meaning. VLE provide a common environment for students, irrespective of geographical distance, to interact in various ways, such as verbal communication, collective decision making, conflict resolution etcetera. Because technical circumstances and spatial separation may impede visual contact, avatars are a well-established way to represent users and their activities.

In the following sections four selected applications of virtual learning environments will be examined and evaluated in terms of technical and pedagogic aspects.

3 ArtDeCom

3.1 Project description

ArtDeCom is a project about "Theory and Practice of Integrating Education and Training in Arts and Computer Science" and a result of cooperation between Muthesius Academy of Arts, Design and Architecture and the Institute of Art History of the Christian-Albrechts-University in Kiel. As part of the program "Culture in the Media Age", its aim was the development of "curricular elements for an integrated education of arts and computer science"(Kritzenberger et al., 2002). The setup of ArtDeCom includes a Mixed Reality environment, consisting of a projection wall and an image recognition system, in which pupils are actors in a stage play and influence the narrative process by their actions and body expressions.

ArtDeCom addresses eight to nine year old pupils in third class of elementary school. Its concept intends to integrate lessons of Art and Computer Science. The creative process of developing content, which is used in the virtual environment later on, plays a central role in the project. At the end of this process pupils perform a musical revue in a self-designed mixed reality environment. The design process begins with a project development plan. The children are divided into several design teams and think about a story, materials they want to use to build the scenery and the possibilities for computer use to extend the real world. In a second step they build the scenery, from various materials, such as papier-mâché, produce animations for the Virtual Environment and program the computer for scenarios of interaction and image recognition (see figure 2). Considering suitability for children, LEGO Cam and LEGO MindStorms Vision Command occurred as adequate tools for this task.

The final mixed reality environment consists of a stage, where the children perform their revue, the self-made props, a projection wall, where an animated landscape is shown and a camera, for image recognition (see figure 3). The story developed by the children in the described example was named "World of Dragons". Children act and dance, disguised in different colored dragon costumes. During their performance, they have two different possibilities to interact with the computer. On the one hand there is spatial information, which includes movements and dancing of the children and on the other hand there is perceptual information, consisting of the color of the costumes. Both are interpreted by the computer and lead to effects like playing the sound of wind or dragon roars.

(a) (b)

Fig. 2. Children tinker scenery (a) and create animation (b), Winkler et al. (2002)

3.2 Evaluation

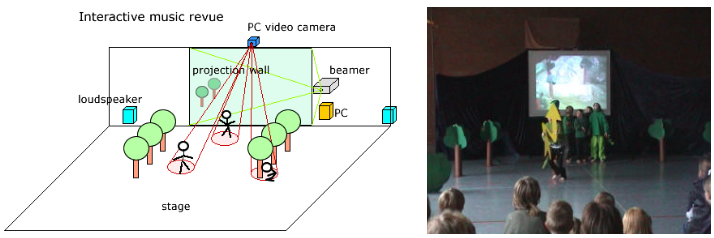
Winkler (Winkler et al., 2002) describes the goals of the project as follows: "Education in the media age means to develop media competence and deeper understanding of media characteristics starting from kindergarten age to high school education. The learning goal is to understand the design as well as the use of the media and also to understand the essence and nature of specific media"

ArtDeCom addresses many aspects of VLE. Even though its technical level is inferior compared to available possibilities and solutions of other projects, its approach shows a simple but nevertheless effective way of creating a virtual environment. Attention is not directed to high quality 3D graphics, perfectly overlaid with reality, but to an adequate way to provide a system, which works with a whole class and can easily be handled and understood.

Aspects of constructive learning are implemented in a more direct way. It is necessary for the pupils to collaborate throughout the whole project as none of the tasks can be accomplished without communication and social interaction. The practical approach of the project contains constructivistic as well as exploratory aspects. "In designing and in working with a mixed reality environment, the children construct a configuration of the world instead of a describing knowledge"(Winkler et al., 2002). Children work with real material to create physical artifacts but also with the virtual equivalents to create content for animations.

The results of the project appraise that "mixed reality environments are a very promising learning space for a constructive and collaborative learning"(Kritzenberger et al., 2002). However, ArtDeCom represents an educational situation which diverges from everyday life at school. Children may need intense assistance to produce adequate content for animations and programs, if they use the provided tools for the first time. Considering that a project like ArtDeCom is a singular event for pupils, the effort may exceed the quality of the results. Moreover, the playful approach can prevent pupils from learning, if they lose sight of the learning target and lose themselves in playing - a risk which should not be underestimated at abstract goals like media competence.

Overall the authors do not give a clear statement if they reached their goal to improve children's media competence, but ArtDeCom is surely a welcome change for lessons in Art and Computer Science and even Physical Education for pupils in elementary school.



(a) (b)

Fig. 3. Schematic view of the MR environment(a)and children performing their music revue (b), Kritzenberger et al. (2002)

4 Global Change World

4.1 Project description

Global Change World is a project of the Learning Center at the Human Interface Technology Laboratory (HITL) at the University of Seattle. It simulates climate changes in a virtual model of Seattle over long periods of time. Therefore head-mounted displays are used to create an immersive virtual environment (see figure 4). To support communication between participants, the system offers the possibility of voice communication. A wand is used as input device, allowing to navigate through the virtual world and to interact with dedicated items.

Global Change World consists of a bounded model of a geographic area, which is loosely based on Seattle. The System allows attendance of two Students at the same time, represented as comic-like avatars in the virtual world. The avatars consist of eyes, ears, mouth and hands to provide the information necessary for communication and orientation.

The environment in this local region is represented by three different elements in the VLE:

– Trees symbolize the amount of green plant biomass

– Factories symbolize the amount of heavy industry
– Cars symbolize the population

Fig. 4. Students using Global Change World Jackson and Fagan (2000)

To manipulate one of the element values a corresponding wheel has to be turned. After setting the values of the specific scenario, a time portal allows students to jump to future points of time. There they can see the effects of their settings on the climate and how it changed. Students can use a virtual toolkit to prove their observation and to fulfill given tasks. For example they can measure the temperature of air and water, the amount of greenhouse gases and rain. In addition to precise measurements, there are also more or less obvious environmental changes visible in the model, such as a variation of water level of the Puget Sound.

4.2 Evaluation

Global Change World uses state of the art components for its VLE and was designed "to investigate the dynamics of collaboration in the domain of science education"(Jackson and Fagan, 2000). Jackson conducted a study on Global Change World, "to simply document middle school science students studying global warming demonstrating the propensity to collaboratively expand upon classroom -based subject matter knowledge while immersed in a VLE"(Jackson and Fagan, 2000). This study gives valuable information about the technical performance of Global Change World. Even though students were trained to use the system in the forefront of the study, many of them had problems to use the input device in an effective way. These difficulties were accompanied by orientation problems inside virtual reality. The audio communication system however, proved its functionality, since problems were solved by communication between students or by instructions of the tutor. Overall most students enjoyed the experience, felt high presence and were willing to reuse the system.

The impact of interactivity, which is supposed to be important for learning outcomes, could not be proved definitely. Depending to the extent of guidance students received, they constructed false conceptual models and tended to regard them as true. Moreover they varied in confining themselves on concepts presented in the virtual reality. Jackson comments: "We must be very careful about unwillingly embedding misconceptions in our VLE designs"(Jackson and Fagan, 2000).

Lennart Boot of the University of Twente conducted a study, critically considering the effect of interaction associated with virtual learning environments. As Global Change World was one of his topics, he concluded: "Global Change World showed some remarkable results that hinted in the direction of positive effects of interactive VLE's"(Boot, 2005). Nevertheless he states that students might belief rather their own conclusion drawn from interactive experience, even if these were wrong, than opposite facts they were taught before.

Regarding collaboration, the audio communication system played a central role, allowing students to communicate in a nearly natural way. This helped solving the requested tasks, because students were able to discuss and plan their movements, activities and proceeding. Even though students were very willing to work collaboratively, the study "was not successful in identifying the kinds of specific collaborative strategies that would be most suitable for VLEs"(Jackson and Fagan, 2000).

5 Construct3D

5.1 Project description

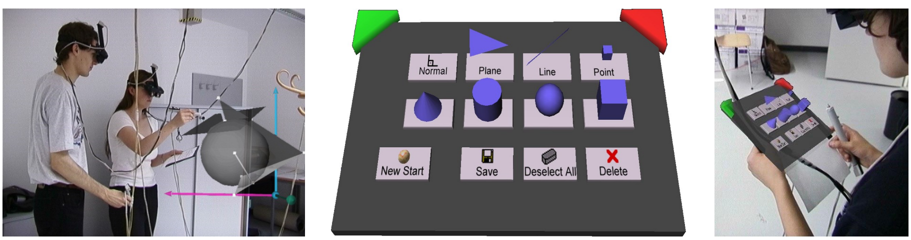
Construct3D is a three dimensional geometric construction application for multiple users based on the augmented reality system "Studierstube". It was developed at the Institute of Software Technology and Interactive Systems at Vienna University of Technology and addresses students in high school and university. Construct3D allows students to construct dynamic geometric entities, by use of simple primitives, as points, lines and planes, and basic three-dimensional bodies like spheres and cones (see figure 5 (a)).

As a result of an ongoing development of Construct3D and the underlying platform, there are several different setups for teacher-student interaction today (Kaufmann and Schmalstieg, 2002).

– **Augmented Classroom:** One part of the augmented classroom are two augmented reality kits, consisting of a computer with wireless network connection, a stereoscopic see-through head mounted display and pinch gloves as input devices. A table is used as common workspace, to allow collaboration. Due to the lack of wearable AR kits, the other part of the system consists of computer, projector and camera, so that other students can also have a look at the actual construction.
– **Projection screen classroom:** In this setup all users look at stereoscopic projections on a single screen. This kind of semi-immersive technique implies the use of stereo glasses, and leads to some disadvantages. As all users share the same screen, projection can be distorted, depending to the point of view. Furthermore it is not possible to directly manipulate objects.

– **Distributed hybrid classroom:** This solution provides a personal semi-immersive environment for a group of students. A camera in combination with monitor and shutter-glasses allows choosing between an individual viewpoint and a shared viewpoint.
– **Remote collaboration:** This approach tries to make collaboration between distanced users possible. Regardless of the individually used hardware, it is possible to share constructions and work together remotely.

As shown above, Construct3D supports a large diversity of input and output channels. The Personal Input Panel, which shows three-dimensional icons and allows performing predefined actions, like "save", "delete" and the selection of standard primitives, and the stylus, which allows direct manipulation of objects with six degrees of freedom, are central input devices (see figure 5 (b) and (c)).



(a) (b) (c)

Fig. 5. Students using Construct3D (a), virtual menu of the PIP (b) and Students using Stylus and PIP (c), Kaufmann (2003)

Next to two and three dimensional primitives, additional functions like intersection, normal lines and planes, symmetry operations and measure taking can be performed during construction. In order to facilitate collaboration, a 3D-layer system was developed. According to similar concepts, known from image processing applications, it allows controlling visibility of different parts of a construction by overlapping. So each student is able to see either the parts constructed by himself, everything or preselected parts by the teacher.

The versatile character of Construct3D continues within its pedagogic approach. Considering that exploratory leaning is very challenging, when the learning context is too unstructured, it offers adjusted modes for learning.

– **Teacher mode:** According to usual practice, the construction is performed in front of one or more students. The teacher has the possibility to show prepared steps and to jump between different states of the construction.
– **Normal tutorial:** Whole construction processes or parts of them are shown and explained to students automatically by the system. Later on they have to reproduce the problem, guided by a teacher.
– **Auto-tutorial:** Students have to understand the tutorial autonomously and are only supported by the system. Moreover they should be motivated to repeat the construction.

– **Exam mode:** The whole construction is performed by students and compared to the pre-structured solution afterwards.

5.2 Evaluation

Construct3D was designed as "a simple and intuitive 3D construction tool in an immersive environment for educational purposes", as Kaufmann (Hannes Kaufmann, 2000) describes. Their "goal was to keep the user interface as simple as possible to facilitate learning and effective use." Construct3D is in ongoing progress of development and therefore several improvements recommended by a user study on the system have been implemented by now. This illustrates that the system is in focus of research and not its influence on learning. Further work is necessary for "the development of substantial educational content that is put to real use in classroom"(Kaufmann, 2003). Shortcomings could be found in the imprecise tracking of input devices. So students criticized the setting of points at given coordinates, which was linked to a deviation up to two centimeters. Moreover, hand-eye coordination formed an obstacle, as it is challenging to spot a point spatially correct without haptic feedback or restriction in movement. Visual disturbance was caused by a small field of view of the head-mounted displays, slow rendering of constructed objects and partly confusing transparency shading of solid objects. Despite those issues, students were able to solve their tasks and provided mainly positive feedback.

Construct3D enables students to build geometric constructions, which had to be projected to different 2D views on paper otherwise. Hence interactivity in virtuality is inherent to the system. In the field of Mathematics the factor of exploratory learning is not as distinct as in other subjects. New insights always ground on existing knowledge and results can either be right or wrong. Thus it is hard to develop wrong conceptual models. Moreover, the concept of Construct3D is oriented on traditional teaching methods. Students get to know new content and are encouraged to apply their knowledge afterwards. Raising the limits of projection and giving bodies three dimensional shapes facilitates the process of understanding. Construction of knowledge in the way of rediscovering new mathematical concepts independently is not considered useful and by no means goal of the authors.

In its early stages Construct3D was designed as a single-user application. As the goal of the authors was to develop a system which can be used in everyday school life, it was extended for the hybrid hardware setups, described above. Advancements like 3D-layers, audio communication and networking allow collaboration in manifold styles.

6 Teatrix and NIMIS

6.1 Project description

NIMIS is part of the European ESPRIT program. It stands for "Networked Interactive Media In Schools" and is a software environment, especially designed for children, which consists of three applications and is applied in an

"Computer-Integrated-Classroom" (CIC). "The project is targeted at supporting literacy-oriented activities in the age group of 5-8 year old children"(Tewissen et al., 2000). Besides "T'rrific Tales" and "Today's Talking Typewriter", there is "Teatrix" which will be regarded more intently.

Having today's use of classrooms in mind, the equipment for NIMIS was designed to meet the needs of children and teachers. The traditional blackboard is replaced by an interactive height-adjustable screen and school desks containing integrated LCDs, which allow information input by pen. By this means virtual content can be perceived in a natural way, as technology is seamlessly integrated into its surroundings and nearly invisible (see figure 6 (a)).

Teatrix provides a playful approach for children to create stories in a collaborative way. "Merging acting, reading and writing into one single environment, and supporting it, was one of the main goals of the research"(Prada et al., 2000). Using Teatrix is composed of three phases: story set-up, story creation and story writing. During the **story set-up** the basic components are appointed. Several scenes building the location of the story, can be selected and connected, to allow the characters to move between them. Virtual characters act according to their role, for example, as hero or beloved one. They can interact with surrounding items and have one of three emotional states - happy, sad and neutral. During the **story creation**, children can develop their story in collaborative work. Characters can be controlled by children or automatically. In order to receive a meaningful storyline it is necessary to act in compliance with the characters' role. In the phase of **story writing**, children can watch a movie of the story they created (see figure 6 (b)). They are encouraged to think and write about what they have seen and share their results with classmates.

In an attempt to improve Teatrix, an additional mode for character control was implemented. So called Hot Seating causes a pause of character's action. "Stepping out of the character's motor control, the user is able to inspect the character's role, goals and previous actions, reflect upon them, and perform some changes if necessary"(Machado et al., 2001). The goal was to give a better understanding of characters' roles and to help children creating consistent stories, sticking to these roles.

6.2 Evaluation

The NIMIS system is implemented in three European elementary schools, where it is "used in normal curricular activities for one hour each day"(Tewissen et al., 2000), for example in Duisburg. The system is well-engineered in a way that allows teachers and students to use it without support. This is essential for regular use and furthermore fostered by the use of proved technology, which is robust and easy to handle.

Teatrix was first installed in the NIMIS environment in a Portuguese school, where the authors conducted informal studies on system use. In general, children enjoyed using Teatrix, however there were limited possibilities for them to develop characters' behavior and creative expression was restricted by limited resources.

(a) (b)

Fig. 6. IMIS classroom (a) and Teatrix screenshot (b), Prada et al. (2000)

Since the children should create stories, they were provided several ways of interaction. First of all they have to control their own character throughout the story. Secondly, they have the ability to look at the state of mind of other characters in order to understand their mood and intentions.

Based on this information they should act in a meaningful way, whereby they develop well-formed stories, collaborating with the other children and their characters. Also the possibility to review former stories, to comment on them and to discuss characters' actions allows children to work in "an environment where both drama and story creation are merged into one medium providing a form of collaborative make-believe for children"(Prada et al., 2000).

7 Discussion

The enormous range of application types of virtual learning environments used in schools has been illustrated by the presented case studies. Thereby technical implementation covers the whole scale of the mixed reality spectrum. Common information technology is represented for example in ArtDeCom as well as in setups like Global Change World, which are highly specialized and tailored to their application. The level of technization seems to be correlated to students' age ranges: projects addressing elementary school pupils offer simple surroundings clinging closer to reality, whereas immersive virtual reality systems were designed for students of higher age-group levels. This fact could be ascribed to higher complexity and challenging system handling. A general assertion, confirming this assumption would require a more detailed analysis of current virtual learning environments concerning this matter.

Regarding their pedagogic approach the presented virtual learning environments refer to the theory of constructive learning to consolidate their capability of knowledge building. However, this is also related to certain risks as the study on Global Change World (Jackson and Fagan, 2000) clarifies. It is important to assure, that the content of virtual learning environments neither limits the students angle nor leads to wrong implications. This is a difficult task, as not all students are influenced in the same way by the information that the virtual learning environment provides. On the one hand too much information is hard to structure but on the other hand too little information impairs the system's attractiveness. Additionally the approach of playful learning, which is basically asserted positive, can be found within all examples. However, a moderate usage level is an important condition as otherwise playing hinders students from learning.

Proving their impact on learning outcomes is a central issue for almost all presented case studies. Therefore, future research requires empirical analysis which is based on a profoundly operationalized model that yields unambiguous results. In line with Boot's findings (Boot, 2005) most of the systems are stuck for an answer in question of efficacy, as they are more concerned with technical aspects rather than their effects on learning. Yet, such objective evidence is essential to legitimate the use of virtual learning environments. Moreover, there is a lack of edited pedagogic learning material, which is not remarkable as most responsible persons work in technology-oriented areas of studies.

Another challenge is the universal applicability of systems. A larger part of them represents a specialized solution for a specific problem. Comparison shows that such approaches are not practicable: usefulness of a personal computer derives among other things from the amount of applications being capable of running on a standardized system. If different applications like text processing, gaming and internet browsing needed different devices, which are incompatible to each other, nobody would use them. Virtual learning environments are in this situation at the actual state of affairs. Next to financial and administrative issues, virtual learning environments will be hardly integrable into everyday school live if teachers were forced to use varying systems in different subjects and age-group levels.

A good attempt to attain this aim would emphasize the system's tool-character as it is described by Tewissen. The environment has to be "ready to use, easy to use, and adaptable to the concrete context of usage. The design of software, hardware, and furniture must be subordinate to curricular goals, and not vice versa"(Tewissen et al., 2000). Moreover cooperation between domains of computer science, educational science and psychology of learning can be considered necessary in order to design appropriate systems, which meet the requirements of students and teachers.

8 Conclusion

This paper presented selected case studies for virtual learning environments addressing teaching and education at school. Technological aspects, like different hardware setups, use of virtual or mixed reality as well as input and graphical output devices were described and their strength and weaknesses were analyzed. Moreover this study focused also on the realization of pedagogic approaches. Possibilities for interaction and collaboration were analyzed, as they directly influence the creative process of knowledge construction. Finally, findings about common potentials and challenges were summarized. The case studies pointed out that a lack of adaptable learning material and absence of universal applicability are central obstacles for current virtual learning environments, which can be particularly redressed by advancing systems' tool-character and cooperation between affected domains of science.

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Privacy in E-Learning

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Abstract. While more and more schools and universities use e-learning tools to supplement their educational systems, little effort has been put in the development of secure and privacy-obtaining applications so far. This paper focuses on privacy threats and requirements in e-learning, and outlines several attempts that are currently used or could be used to meet these requirements. In addition, different organizations such as the Institute of Electrical and Electronics Engineers (IEEE) try to establish privacy standards which are adopted for e-learning tools. A comparison of selected applications for electronic supported learning shows that there is still a backlog concerning privacy issues in e-learning, but that the attention for these issues is bigger than ever and keeps growing.

1 Introduction

Although e-learning already has a pretty long history there are few attempts to promote privacy issues for e-learning applications so far. When the first tools for electronic supported learning were developed, there was no need for privacy as these tools were created for off-line usage only. With the rapid and continuing revolution in network and especially Internet technologies, today most of the e-learning applications are used on-line. Nevertheless, the effort made to develop secure tools to fit the privacy needs of a diverse user group is still very small. This might also be due to the users themselves, who are not yet aware of the critical data the applied e-learning system deals with.

While few, there actually are some attempts in research and economy to enhance the knowledge of privacy requirements and possible privacy technologies for e-learning applications. There are even attempts to standardize privacy technologies that are successfully adopted in e-learning, like for example the Platform for Privacy Preferences Project (P3P) that was developed by the World Wide Web Consortium (W3C, 2007).

To discuss possible solutions for privacy enhancement in e-learning, in the first place one needs to figure out where the problems are. To do this, this paper first focuses on network security as a fundamental requirement for privacy in e-learning and then points out further privacy threats and requirements for distance learning applications. For instance, there needs to be distinguished between several kinds of data and communication channels which are not necessarily relevant for security and privacy concerns (El-Khatib et al., 2003).

After two privacy standards, the Platform for Privacy Preferences and the IMS Learner Information Package are introduced, a current (Moodle) and a possible future (Second Life) e-learning platform are discussed to get an overview how well the concepts presented before are already practically applied.

2 Network Security as Fundamental Privacy Requirement

In a time, where more and more e-learning applications are Web-based, security is one fundamental part of privacy for those applications. There are several communication channels between different entities of an e-learning system, and not all of these channels need to be secure, as not the whole data flow needs to be protected due to privacy issues.

The Learning Technology Systems Architecture (LTSA), as standardized in (IEEE LTSC, 2001),

> "(...) specifies a high level architecture for information technology-supported learning, education, and training systems that describes the high-level system design and the components of these systems."

El-Khatib et al. (El-Khatib et al., 2003) specify several channels described in the LTSA which require security measures to support privacy. Figure 1 shows the LTSA system components with these channels highlighted bold.

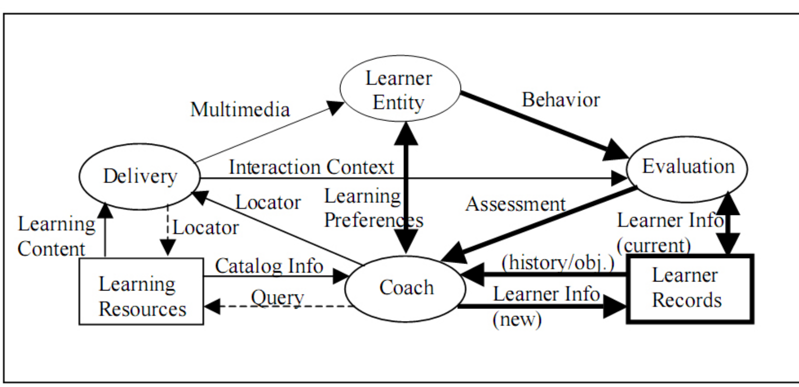

Fig. 1. LTSA system components (El-Khatib et al., 2003)

The components consist of four processes - coach, delivery, learner entity and evaluation - as well as two stores - learner records and learning resources.

There are seven crucial data channels and stores. *Learning preferences* is a channel between *learner entity* and *coach* and contains critical data, like the learner's strategies. The user behaves in a certain way to all tasks and courseware. This *behavior* is evaluated afterwards. It depends on the applied system, whether this channel needs to be protected or not, as the *evaluation entity* might be implemented as a tool on the user's local machine. Also depending on where the *evaluation entity* is located, channels between this entity and the *coach* and the *learner records* module possibly need to be secured. These channels include *assessment*, where the user's evaluated data is transferred to the *coach* process, as well as *learner information*, that need to be transmitted to and stored in the *learner records*. The *coach* is also able to store and retrieve information about the learner, so the transmission channel between *coach* module and *learner records* might also be in need of security.

As most of the above-mentioned entities and stores communicate using a network, network security plays a big role preserving a user's privacy. It can be categorized in user authentication, data integrity and network privacy.

2.1 Authentication

Authentication means the inevitable act of ensuring that users can access a system only after proving their identity. Without authentication, every user would be able to access private data and perhaps even change system configurations.

There are several ways to verify the identity of a user. One that is very common in the World Wide Web is authentication through user name and password. In a registration process, new users can manually choose their account names and often also arbitrary passwords. The choice of an arbitrary password might be a security risk as a possible attacker could easily decrypt weak passwords, for example by dictionary attacks, where dictionaries of possible passwords are compared to the sniffed encrypted password string. Even though there is no complete security, at least the security level can be increased by the pretended use of numbers, alphabetic characters and punctuation marks altogether in one password.

Another possibility to verify the identity of a user is the usage of electronic signatures. This practice is based on the use of a private and a public key. Every communication entity knows the public key, while the private key is only known to the sender of a message. It is used by a signature algorithm to produce a string out of it in combination with the given message. The public key is used by a verification algorithm to prove the authenticity of the message (Fischlin et al., 2005). Figure 2 illustrates the verification process with electronic signatures.

Anyway, without the users being physically present, there seems to be no way to really verify their identity as other persons might know their account data or use their computers to communicate with the e-learning application.

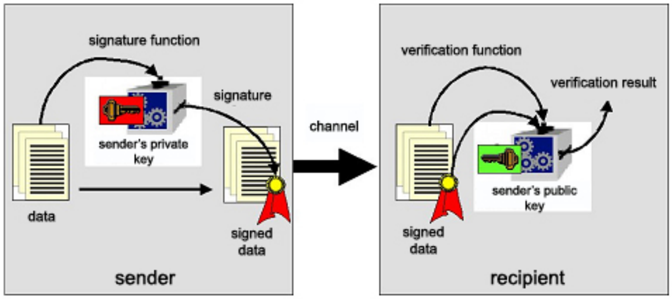

Fig. 2. Verification process using electronic signatures (Fischlin et al., 2005)

2.2 Data Integrity

Data integrity aims to prove that data is sent by a denoted sender and transmitted without data loss, damage or manual changes. The application of digital signatures cannot only verify a sender's identity, but also ensure that the data sent was not changed on its way to the recipient.

As already mentioned above, these methods cannot ensure that there are really the denoted persons sitting on their PCs and using the e-learning application. This might not be a big problem, if the current users are working on a learning unit, but if the system requires the users to participate in a long-distance test it is essential to verify their physical presence on the used machine.

In this particular case, network security cannot be used to solve this problem. A possible, but also insecure solution is to monitor the users' activities by a video camera. Lin et al. (Lin et al., 2004) hold that the only secure concept is to adopt methods from conventional education, for example to observe students during their on-line tests by a human supervisor. Then, of course, some advantages of distance learning are discarded to ensure the right students taking the right exams.

2.3 Network Privacy

Network privacy tries to ensure that data communicated in a network cannot be wiretapped by possible attackers. Whether wireless or wired data flow, both is usually protected using ciphering algorithms. As already known from digital signatures, keys are also used for data encryption and decryption. An encryption algorithm uses several operations to generate so-called ciphertext out of the plain text of a message and a key. If the same key is used for both encryption and decryption, the applied method is called symmetric. If there are two different keys as seen with digital signatures one uses an asymmetric coding method.

Symmetric ciphering concepts require a secret key to be exchanged between both communication entities. This key exchange needs to happen on a secure way. Even if the used encryption algorithm is publicly known, there is supposed to be no way to decrypt wiretapped data without any knowledge of the secret key. This is known as Kerckhoffs' principle (Fischlin et al., 2005).

Using a public and a private key, one usually talks about asymmetric ciphering methods. Similar to asymmetric concepts for digital signatures, the sender encrypts a message using the recipient's public key and the recipient is able to encrypt the received ciphertext using his own private key. Although there is no need to exchange a secret key, it must be ensured that the public key belongs to the denoted recipient of the message. To do this, certificates are used. A certification authority (CA), for example a governmental organization, controls the applicants' identity and issues a certificate that can be used by the applicants to prove their identity. As there are different CAs, every certificate is only as secure as the issuing CA is reliable.

3 Privacy Threats and Further Requirements

In addition to network security to protect private data against possible attackers, there are several other privacy requirements for e-learning systems.

3.1 Copyright Protection

The above mentioned security technologies were mainly outlined to protect a user's critical data. One aspect that has not been mentioned yet is that there is not only the student who uses an e-learning tool but also supervising tutors or teachers. In most cases, there will not be too much data about a teacher that needs to be secured, there is especially no data about learning preferences, grades and credentials. The one thing that needs to be secured though is probably teaching material, called courseware.

This material is digital in e-learning, hence it is normally easy to reproduce what is a threat to copyright issues. To protect courseware against illegal reproduction, one possibility is also to use encryption algorithms. But there are always students or other coaches who are able to easily copy courseware, for example by capturing the screen during an on-line presentation.

As with all kinds of digital media, it is currently still very hard to protect it against copyright violation. There are attempts to use digital rights management (DRM) to secure digital media, but at the moment, there is no solution that is 100 percent save.

3.2 Stored Data (Content and Logfiles)

Although there might be possibilities to secure data flow between several communication entities, Weippl (Weippl, 2005) mentions that there is still the threat that possible crackers get in control of or at least gain access to the application's servers to modify, delete or steal critical user data.

Critical data stored on the application's server includes content like for instance courseware, private data of students and teachers, and logfiles. Data like discussions in course-related forums is sometimes stored for several years and needs to be protected against possible attackers.

In e-learning, logfiles are often used to retrieve information about one student's learning preferences or to monitor the student's learning behavior. Weippl found out that indeed about 70% of a polled student group accepts user tracking, because some of the user's data is indeed necessary to find out key functions and often used parts of an e-learning application. These insights can then be used to improve the program's work flow and functionality with regard to what the users need.

3.3 Credentials

There are two different kinds of credentials that are worth being mentioned in relation to privacy in e-learning. On the one hand, credentials are closely related to network security and used to authenticate several communicating parties. Certificate Authorities (CA) are third-party organizations to prove that one party's identity fits its public key. On the other hand, there are needs in e-learning to prove both the users' identity and also their ability to enroll into a certain course or program (Aïmeur et al., 2008). Therefore, there has to be a sophisticated system using network technologies to ensure the users' identity and credentials to represent their qualifications, like graduation or courses already visited.

3.4 Customizable Privacy Levels

Not only in e-learning, dealing with privacy issues is a trade-off between maximum privacy and security on the one and maximum usability and performance on the other side. That is why Aïmeur et al. (Aïmeur et al., 2008) suggest a system based on different privacy levels which are customizable by the users, the Framework for Privacy Preserving E-Learning.

A division in four privacy levels (No Privacy, Soft Privacy, Hard Privacy and Full Privacy) is therefore predicated on the users' data components, which are the users' identity, demographic profiles, learning profiles, course histories, and their current courses. Depending on the selected level of privacy, more or less of these components are visible to tutors or teachers, as illustrated in Table 1.

	No Privacy	Soft Privacy	Hard Privacy	Full Privacy
Identity	visible	—	—	—
Demographic Profile	visible	—	—	—
Learning Profile	visible	visible	—	—
Course History	visible	visible	—	—
Current Courses	visible	visible	visible	—

Table 1. Privacy levels of the Framework for Privacy Preserving E-Learning

As these settings do not affect user monitoring and tracking, Aïmeur et al. suggest that the learner should also be able to customize the tracking features of the system in four different levels.

3.5 Privacy Principles of the EU

The European Union specifies the right for privacy and the protection of personal data in the Charter of Fundamental Rights of the European Union (European Union, 2000):

- Article7
  Respect for private and family life
  Everyone has the right to respect for his or her private and family life, home and communications.
- Article8
  Protection of personal data
  1. Everyone has the right to the protection of personal data concerning him or her.
  2. Such data must be processed fairly for specified purposes and on the basis of the consent of the person concerned or some other legitimate basis laid down by law. Everyone has the right of access to data which has been collected concerning him or her, and the right to have it rectified.
  3. Compliance with these rules shall be subject to control by an independent authority.

These rights were drafted being absolutely independent from technical aspects and affect a human's basic right for privacy. To go into privacy issues related to technical aspects, the European Parliament published the Directive 2002/58/EC of the European Parliament and of the Council on July 12, 2002 (EU2002).

4 Standardized Privacy and Security Concepts

As seen above, there are constantly a lot of threats to a user's privacy, not only in e-learning, but in many other on-line services, too. Nevertheless, privacy and security have long been neglected issues in e-learning. There have been some attempts though to standardize privacy and security concepts. Some of these concepts can be adapted to e-learning systems and are outlined in the following sections. Several organizations are currently engaged in the enhancement of standards related to distributed learning systems. Important working groups are IEEE Learning Technology Standards Committee (IEEE LTSC, 2007), IMS Global Learning Consortium (IMS Global Learning Consortium, 2008), Authoring and Distribution Networks for Europe (ARIADNE, 2006) and Advanced Distributed Learning - Sharable Content Object Reference Model (ADL-SCORM, 2007). However, not all of these standards do necessarily contain concepts to preserve the learner's privacy.

4.1 Platform for Privacy Preferences

The Platform for Privacy Preferences (P3P) was developed by the World Wide Web Consortium and officially recommended on April 16, 2002 (W3C, 2007). As a protocol to exchange privacy information, it is not directly aimed at e-learning, but can be used for distance learning applications, too. P3P is supposed to offer an easy opportunity for Web sites to declare what happens to the users' private data. The users themselves can specify their privacy preferences in the first place, which are later verified against the Web site's privacy policies. On November 16, 2006 the latest version P3P1.1 was published as a W3C Working Group Note.

Most of today's Web browsers contain intern P3P agents and allow the users to edit their privacy preferences, for instance how to deal with cookies, directly using the browsers' graphical user interfaces. Thus, the users' privacy settings can be observed without them having to read every Web site's privacy policies.

The site's policies are described in an XML-based file that can be referenced either by an HTTP header or by an (X)HTML link tag that has the advantage that no changes in the server behavior are required.

The following code, taken from the W3C's P3P1.1 specification (Cranor et al., 2006), shows a sample P3P file, where all given statements are valid for two days. Different P3P policies apply to different locations. Policy */P3P/Policies.xml#first* for example applies to the entire site, except resources whose paths begin with */catalog*, */cgi-bin* or */servlet*.

```
<META xmlns="http://www.w3.org/2002/01/P3Pv1">
 <POLICY-REFERENCES>
  <EXPIRY max-age="172800"/>

    <POLICY-REF about="/P3P/Policies.xml#first">
      <INCLUDE>/*</INCLUDE>
      <EXCLUDE>/catalog/*</EXCLUDE>
      <EXCLUDE>/cgi-bin/*</EXCLUDE>
      <EXCLUDE>/servlet/*</EXCLUDE>
    </POLICY-REF>

    <POLICY-REF about="/P3P/Policies.xml#second">
      <INCLUDE>/catalog/*</INCLUDE>
    </POLICY-REF>

    <POLICY-REF about="/P3P/Policies.xml#third">
      <INCLUDE>/cgi-bin/*</INCLUDE>
      <INCLUDE>/servlet/*</INCLUDE>
      <EXCLUDE>/servlet/unknown</EXCLUDE>
    </POLICY-REF>

 </POLICY-REFERENCES>
</META>
```

Although P3P provides a good method to specify both machine- and human-readable privacy policies, there are at least two disadvantages that are worth mentioning.

P3P is self-regulatory, that means Web administrators specify the privacy policies for their Web sites or their servers. As El-Khatib (El-Khatib et al., 2003) states, those policies do not necessarily need to match the actual site settings, because there is no P3P specification to ensure that a Web-site's implementation matches its privacy policies.

As P3P was not developed for a certain Web application, it can easily be used for distance learning applications, too. Assuming the just-mentioned problem being resolved, P3P would be a good step to inform the users about what happens with their data, always giving the opportunity to leave the site if they want to. But if users need to use a certain e-learning application, perhaps as an addition to their classical off-line studies, there is no way for them to adjust the level of privacy. The only two opportunities are whether to use or to leave the application. If they have to use it, they will be aware of the privacy risks, but will also have to take them.

4.2 IMS Learner Information Package

The IMS Global Learning Consortium (IMS GLC) is a non-profit organization developing open standards for e-learning systems, especially in matters of interoperability and reuseability of courseware. IMS Content Packaging, for instance, specifies an XML-based data format for e-learning, that is supposed to unify exchangeable on-line courseware (IMS Global Learning Consortium, 2003).

As there is a specification for content interoperability, with the IMS Learner Information Package (IMS LIP) there is also a specification that deals with the literal exchange of learner information among distributed systems. Thereby, learner information also includes information about a producer of learning content and consists of education record, training log, professional development record, relevant work experience, qualifications, education history, life-long learning record and community service record. As shown in Figure 3, a server stores the learner's data and is responsible for exchanging it with other servers or systems.

The IMS LIP specification (IMS Global Learning Consortium, 2001) explicitly refers to the importance of privacy and data protection, dealing with two mechanisms (quoted directly from the specification):

- Privacy and Data Protection Meta-structure
  Within the learner information tree structure each node and leaf has an associated set of privacy information (the usage of these fields is optional). The granularity of information that can be exchanged is defined by the smallest set of data at which there is no further independent privacy data. The nature of the privacy data is beyond the scope of the specification as all that is defined within the LIP is the place at which such information is associated with the learner information data structure.

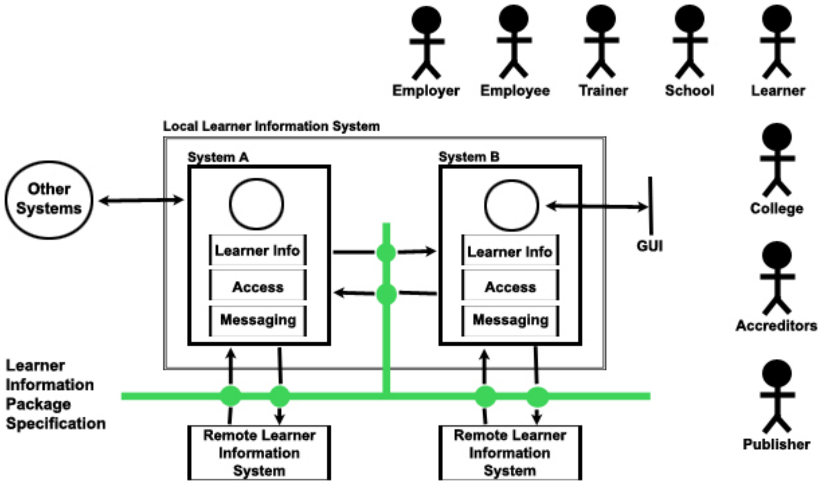

Fig. 3. Learner information system component representation (IMS Global Learning Consortium, 2001)

– Learner Security Keys
  The security keys for the learner include their public keys for public key encryption, passwords for access to the information (electronic and verbal) and digital signatures to be used to ensure data authenticity. The detailed structure for the keys will not be defined but this data will be supported in the 'securitykey' core data structure.

Although the importance of privacy is emphasized, implementation details are not specified in the IMS LIP standard.

5 Examination of Sample E-Learning Platforms

The past sections gave an overview on how important data security and privacy, especially in e-learning actually is. There are attempts to protect the users' privacy by the implementation of standards and technological concepts. Whether these concepts are already used practically in existing e-learning systems or not is shown in the following sections, where Moodle and Second Life are outlined as to privacy issues.

5.1 Moodle

Moodle, the name was originally an acronym for "Modular Object-Oriented Dynamic Learning Environment", is a free, open source and platform independent Learning Management System. It is highly customizable and extensible and widely used as there are currently 44,828 registered sites with a total of 20,747,533 users as of June 16, 2008 (Moodle Statistics, 2008). The platforms extensibility is due to a modular construction that allows the development of several plug-ins. It was developed to allow teachers to create on-line courses with a highly interactive character. Figure 4 shows a screenshot of the e-learning system of the Institut für Kommunikationswissenschaft und Medienforschung of the Ludwig Maximilians University Munich, based on Moodle.

Fig. 4. Sample Moodle Web-site (Institut für Kommunikationswissenschaft und Medienforschung, Ludwig Maximilians University Munich, 2008)

Moodle's authentication mechanisms allow the educator to adjust the security level to his own needs. So, if a new course was created, the creator can decide whether to allow anybody to register for the course, if the access should be restricted to students with an enrollment key or if students can only be enrolled in the program after they were manually added by the administrator himself.

On the first look, using an enrollment key seems to be a safe way to grant access to a whole group of students. The weakness of this mechanism is the distribution of the key, though. Especially if there is one key per course circulating, one cannot be sure that no unauthorized person gets to know and to use it to enroll for the course. A concept that would provide higher security would be not one key per course, but one key per course participant. However, the problem of how to distribute the key still persists and the concept would not make a big difference to the manual enrollment of students by the teacher. This, in turn, requires the teacher to know the authorized students and there will always be the problem that there is no proof that only the right students use their own accounts.

Moodle provides the ability for course administrators to retrace almost all steps of logged in students. Critical information like visiting times, file access, IP address and probable location of the user's computer can be tracked by the supervisor and is stored in the system's database. There is no way for the student to limit this tracking abilities or to change the privacy level. In most cases, the users probably do not even recognize that they are monitored by the e-learning platform. However, Moodle's modular design could probably be used to extend its functionality by a plug-in that enables customizable privacy levels.

Weippl (Weippl, 2005) demonstrates the advantages of open source code by implementing the opportunities to send anonymous emails to course members and to post anonymous messages to forums and newsgroups. Therefore, it must be assured that no information of the user is stored and anonymous browsing must be implemented.

On the first look, the open source character of a distributed learning platform like Moodle seems to be a security risk, too. On the one hand, attackers can easily identify security leaks as the source code can be analyzed by anybody. On the other hand, given this fact the security of a product can be increased as such leaks are recognized much faster and can be closed. As Anderson describes in (Anderson, 2002), there is a continuing discussion among proponents of the open source community on the one and the proprietary vendor community on the other side. However, Hoepman and Jacobs (Hoepman and Jacobs, 2007) are taking sides with the open source community, stating that open source code increases the security of software over a long period. The quality of open code can constantly be increased by the community on the one side, while the knowledge of possible attackers of closed systems increases on the other side in the long run.

5.2 Second Life

After a common e-learning tool was discussed above, this section takes a brief look at privacy issues of an application with possible e-learning potential. Second Life (SL) is an on-line virtual 3D environment that was launched on June 23, 2003. With currently 13,941,501 user accounts (as of June 9, 2008), SL is one of the leading Massively Multiplayer Online Worlds (MMOs) and can be seen as a possible 3D e-learning environment (Linden Research, Inc., 2008). It is developed by Linden Research, Inc. (commonly referred to as Linden Lab) and implemented as a client-server architecture. SL users, so-called residents, have to install a client application on their computers. These clients are only used to interact with the user, to communicate with the SL server and to render the user's view of the 3D world. With the client being pretty light-weight, the whole environment is mainly server-based.

Although SL is used for different tasks, research and pastime, one possible application is to give interactive on-line presentations and lectures and also to share courseware in a virtual environment. As the mechanisms on how this can be done are out of the scope of this work, the following part concentrates mainly on the privacy and security techniques of SL.

There are no guest log-ins in SL, every user needs to have a registered account. However, as long as the users do not upgrade their accounts or enter credit card information, there is no information like the real name or the address stored. The users have the opportunity to choose their residents' last names out of a given list of names and are only free to choose any first names they want for their accounts. Since June 2006, the only real-world information a user has to provide to register is an email address. Therefore, the user's privacy is protected pretty well and nobody needs to publish a real name in the virtual world. Of course, this makes it almost impossible to authenticate another resident in-world and it is even possible for users to own several SL accounts. For this reason, Second Life can currently not be used to write exams or to hand in solutions, because data integrity cannot be assured.

If educators want to give presentations in SL they can either upload the presentation slides as images to the SL servers or they can stream the presentation. Images as well as video streams can be used as (multimedia) textures in-world. In SL, users can create content on certain sandbox islands or on land they own using a build-in 3D modeling tool and a scripting language called Linden Scripting Language (LSL). A comprehensive rights management allows the residents to decide whether they want to enable others to copy or even to transfer their objects or if they cannot be copied at all. The opportunity to form special interest groups makes it also possible to only hand on objects to other members of the same group. This concept is a good step to preserve the creators copyright, but there is still the problem that every SL resident could just capture the screen during a presentation.

Another problem is that SL is proprietary and owned by Linden Lab. Due to their decision to publish the source code of the client, there are countless possibilities for developers to modify the existing or to write their own client application, but the server software stays closed though. Although one can spend a money-free Second Life, if you want to own land, buy objects or upload media like for example courseware, you have to pay a certain amount of money. Linden Lab respects copyright by keeping an explicit copyright notice with every object stored on the SL servers. The problem using such a big proprietary system that is not solely designed for e-learning is the unpredictability due to server maintenance and downtime. No teacher wants the servers to be maintained or rebooted while giving a presentation in-world.

Summing up the above mentioned, Second Life might be a good application to give on-line virtual presentations as it preserves copyright for courseware and offers multimedia support. There are current research studies looking into Second Life as an educational platform. Kemp and Livingstone (Kemp and Livingstone, 2006) try to link classical Learning Management Systems, more precisely the above discussed Moodle with SL, while Mason and Moutahir (Mason and Moutahir, 2006) deal with SL as a collaborative workspace for experiential education projects. However, these papers primarily highlight the potentials of SL as an e-learning tool without considering privacy aspects as there might be no necessity for it if one is for instance working on a collaborative project. Second

Life is still very complex to use and does not provide obligatory authentication methods, so it can not be considered as a serious e-learning platform yet. Nevertheless, there are some organizations, like the German Volkshochschule that are offering in-world learning courses. Figure 5 shows the Second Life interface with the building of the Volkshochschule and the organization's course offer.

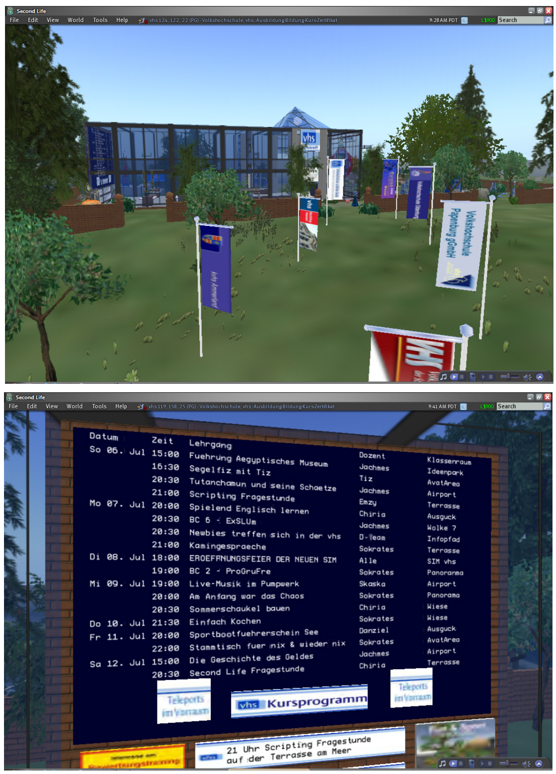

Fig. 5. Volkshochschule in Second Life (a) and the course offer (b) (Second Life, 2008)

6 Conclusion and Outlook

E-learning became more and more popular within the last years, not only in distance education programs like virtual universities, but also as a support for classical university and school education.

In this work, the importance of security as a protection mechanism for the users' privacy was outlined in the first place. As the focus was on distance e-learning applications, the mentioned security mechanisms authentication, data integrity and network privacy are all related to network security that is a fundamental privacy requirement for those applications. Further requirements were due to copyright protection, credentials, which are closely related to authentication mechanisms and the quantity of tracked user data and content stored in the e-learning system. A viable approach for privacy in e-learning and for Web applications in general would be a solution for customizable privacy levels. The Framework for Privacy Preserving E-Learning (Aïmeur et al., 2008) as well as partly the W3C's Platform for Privacy Preferences (W3C, 2007) are such possible solutions. Disadvantages of the later are that P3P is self-regulatory and that the visitors of a Web site are able to store their privacy preferences though, but only have the choice to stay or to leave the site if its policies do not match their settings.

With the IMS Learner Information Package another standard was presented before Moodle and Second Life were examined as to privacy issues. Among these, Moodle represented a classical and common distance learning platform, whereas Second Life could only be considered as a possible future application to be used for e-learning purposes.

Privacy principles were not given much attention when the first e-learning applications started to come up several decades ago. But with the emergence of the Internet and especially the World Wide Web, e-learning got a new face and privacy and security issues are a solid part of it that may not be underestimated. Although it probably was underestimated in the last years, there are currently several non-profit or industrial organizations to be engaged with this topic. The number of technologies and standards ensuring the users' and learners' privacy is constantly increasing and privacy-related issues experience growing attention both in e-learning and other Web applications.

Even national and international law recognized the importance of privacy protection and enforces the use of Privacy Enhancing Technologies (PETs). Using PETs, the collection of critical private user data is supposed to be reduced to a minimum. Of course there is a need to store specific data for several purposes, but - although a common usability problem - many sites still collect more user data than actually necessary to perform a certain task. As can be seen in (European Commission, 2007), the European Union currently deals with privacy related issues and also enforces the use of PETs what can be classified as another indicator for the increasing importance of privacy and security in on-line applications.

So, the tightrope walk between maximum privacy and maximum functionality will be supported by enhanced technologies further on.

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Motivation and Persuasion in E-Learning

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Abstract. This paper deals with motivation and persuasion in E-Learning, especially with techniques that help to increase the motivation of the learners in these settings. It shows the various types of motivation which are explained in three different theories: Attribution Theory, Expectancy-Value theory and Goal Theory. Furthermore varied techniques how to increase motivation are listed: Classical theories in general, like the Time Continuum model and the ARCS model, and Persuasive Technologies in particular. Then three E-Learning applications are analyzed in reference to these techniques. It will be shown that techniques of both the classical models and tools of Persuasive Technology are used in these applications. Finally, it will be discussed, which techniques are the most appropriate ones for E-Learning applications. Results and former research show that the older motivational models are at least as relevant for increasing motivation in E-Learning environments as the newer Persuasive Technologiy tools.

1 Introduction

E-Learning can be defined as a learning process where digitally delivered content is combined with learning support and services (Pires et al., 2003). As E-Learning can be understood as an extended or modified form of classical learning, motivational aspects are at least as important here. Regarding learning as a whole, motivation is a very important factor. Without motivation, learning processes and making progress are hard to manage. According to Dick and Carey, motivation can be considered as *"the most important factor in successful instruction"* (Dick and Carey, 2001). Not only is motivation a causative element of learning, but it can also procure learning and can be a drive for further learning (Wlodowski, 1985).

Building a concrete standard definition of motivation is quite difficult, there does not seem to exist a universally valid definition. Formerly, motivation was said to be associated with primitive drives and needs (Weiner, 1990). But newer research disproved this view. Mangel states that motivation is *"a measure of* *physiological state directly related to the behavior of interest. Changes in motivation, via experience, can lead to changes in behavior"* (Mangel, 1993). Another definition, declared by Moshinskie, says that motivation can be explained by *"the attention and effort required to complete a learning task and then apply the new material to the work site"* (Moshinskie, 2001). Bandura however delivers a more detailed analysis of motivation, as he identifies three various forms of motivation (Bandura, 1997).

In the followings, these forms of motivation will be listed. It will be shown that motivation can depend on different aspects, explained in three theories called "Attribution Theory", "Expectancy Value Theory" and "Goal Theory". After that, two classical motivation models, the Time Continuum Model and the ARCS Model, will be presented as well as further techniques for an extension of these models. Then, the paper will deal with Persuasive Technology, an area where computing technology is used to effect persuasion. As persuasion can be used to increase the motivation of learners, this paper will show different Persuasive Technology tools which can be used in terms of motivational aspects. As a next issue, three different E-Learning applications will be analyzed regarding these various motivation methods. Finally, the paper will conclude with a discussion about the adequacy of the different motivation techniques.

2 Forms of Motivation

Although a concrete, standard definition of motivation is not possible, a quite detailed analysis of the different aspects of motivation made by Bandura exists (Bandura, 1997). He ascertains three forms of motivation, explained in three theories which state on which factors motivation can depend. In the following, these theories are listed and in addition to that, intrinsic and extrinsic motivation, two further forms of motivation, will be explained.

2.1 Attribution Theory

The Attribution Theory describes that motivation depends on whom or what learners attribute their success or failure to, that means, how they explain the outcomes of an event or a task. These explanations of success or failure can be categorized in the following way:

The cause of success or failure can either be internal, if the learner attributes his success to himself, or external, if he sees other factors that have influenced the outcome.

Then, the reason for success or failure can be stable or not. It is stable, if it is probable that the outcome will be the same if one person shows the same behaviour on another incidence again. A factor is not stable, if the outcome of another incidence will supposedly differ. If a student thinks, he will not be able to earn good grades, because he thinks of himself as a bad student, this would be an attitude which is stable over time.

Finally, the reason of success or failure can be either controllable or uncontrollable over a specific period of time. An account is controllable, if the learner thinks he himself can make changes in the future. It is uncontrollable, however, if the learner does not believe he can change it easily, just as the example named before, when a student does not think he is a good student, this is an uncontrollable element (Hodges, 2004).

The Attribution Theory assumes that people attribute their success or failure mostly in a way to feel as good as possible about themselves. That means if a person is successful with one task, he is likely to attribute this success to himself, whereas if a person fails with a task, he probably accuses external factors to be the cause, which he did not have control of. For example, if a student gets a good mark in a test, he probably says "I learned a lot for this test, so I deserved this good mark". But if he earns a bad mark, he rather says "The teacher does not like me so he consciously gave me a bad mark. I couldn't do anything about it."

So regarding motivation, it has to be considered that motivational designs should help the learner to attribute the success of their achievements to their own effort and that these attributions should be controllable and not stable over time. (Hodges, 2004)

2.2 Expectancy-Value Theory

The Expectancy-Value Theory states that people have certain expectations regarding the outcomes of a special behavior. They make more effort in fulfilling a task if the outcome is highly valued. So motivation can also depend on how valued the results are. For example, one student wants to get a good mark in his next test. So he learns what he thinks to be an intense amount of learning work and then he also expects a good mark. If he earns that good mark, his expectations were fulfilled; he is satisfied and likely to perform the same amount of effort on a test that is valued as high as the first one again (Hodges, 2004; Bandura, 1997).

2.3 Goal Theory

According to the Goal Theory, it motivates learners to set up goals that they have to try to achieve. There are two sorts of goals; learning goals and performance goals. If a learner wants to adopt new abilities or knowledge, for example learn English in order to be able to communicate in a foreign country, he sets up a learning goal. A performance goal is an aim where a learner wants to achieve a certain performance level, for example if he wants to get a certain grade in his next test. Also, close or distant goals have to be differed. A goal is close if the time period in which it approximately will be accomplished is only short or distant if the goal can only be attained in the far away future (Hodges, 2004).

There may not exist a general definition of motivation, but all three theories have one aspect in common: In each theory, motivation is involved with self-efficacy. Bandura states that *"perceived self-efficacy refers to the beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments"* (Bandura, 1997). In the Attribution Theory, students who attribute their success to their own effort and competence, gain self-efficacy, which again helps them to do well in future tasks. Also considering the Expectancy-Value Theory, students who successfully complete a task, obtain an increased self-efficacy and are therefore likely to perform similar in their next challenge. In the Goal Theory, self-efficacy determines what types of goals students set up for themselves. The success or failure they experience while trying to achieve these goals have then also an effect on their self-efficacy (Hodges, 2004).

2.4 Intrinsic and Extrinsic Motivation

Intrinsic motivation is described as a form of incentive that comes from within the learner, from his desire to fulfill a task for his own interests, for his delight or contentment. Intrinsic motivation *"is valued for its own sake and appears to be self sustained"* (Calder and Staw, 1975). If external elements cause a learner to perform a task, if he can only satisfy his needs indirectly, this is called extrinsic motivation. Intrinsic motivation can be far more effective than extrinsic motivation, and extrinsic rewards have to be given carefully: Husen and Postlethwaite state that learners, who are initially motivated intrinsically, but receive extrinsic rewards, can tend to disregard their own intrinsic motivation factors in favor of the extrinsic rewards (Husen and Postlethwaite, 1994).

As a general definition of motivation is hard to find, because it consists of many different aspects, a common strategy how to apply motivational techniques into a learning environment, cannot be given. There are, however, several motivation models and techniques that can be made use of in learning settings. Two motivational design models, the Time Continuum Model and the ARCS model, created long before the wide spread of the internet and E-Learning, will be introduced. Additionally, Persuasive Technology, tools designed especially for the use with computing technology, will be presented.

3 Motivation Techniques

The next section will deal with different motivational models and techniques which were designed independently from the use of computers and the internet. Explained are Wlodowski's Time Continuum Model and Keller's ARCS Model, both created in the 1980s. Newer research by Taran will then show even more detailed techniques for the very important attention aspect of Keller's model.

3.1 Classical Motivation Models

3.1.1 The Time Continuum Model

In Wlodowski's Time Continuum Model of Motivation (Wlodowski, 1985), three critical periods of a learning process are identified: The beginning, the middle and the end of a learning process. In each period different aspects are especially important:

In the beginning of a learning process, the attitudes and needs of the learner are most important. This means, the instructions of a learning session should appeal to the learner's needs and also develop a positive attitude. Therefore, it is helpful to use icebreakers. Then explicit goals have to be assessed, so the learner gets a clear understanding of the further course of action. It is also recommended to use a strategy which is already familiar to the learner.

For the middle of a learning process, the designer should focus on stimulation and affect. To keep alive a stimulating effect during the learning session, the designer should utilize humor and some variation regarding the style of the presentation, ask questions, and alter the instruction mode (lecture, group work, etcetera). The major aim of these strategies is to personalize the learning experience and make it more relevant so the learner can relate to it as much as possible.

At the end of a learning process, competence and reinforcement are very important. Confidence can be increased by frequent feedback and enough reinforcement so the learner becomes content with his progress.

3.1.2 The ARCS Model

Another classical technique is described by the ARCS model (Keller, 1987). The ARCS model consists of different features: The first is a description of four aspects (attention, relevance, confidence and satisfaction) which categorize motivation. As a second feature, the model proposes several strategies for offering instructions that are incentive for the users. The third feature recommends a systematic design process, "motivational design" (Keller, 1987). The model assumes that the chances of success and the value of their learning can motivate learners. This relates to the Expectancy-Value Theory explained above. For each of the four motivation categories, Keller proposes several strategies:

To maintain attention, it is helpful to vary the instruction format, use humor, participation, and facts that are in conflict to the learner's initial intuition. To increase the relevance, it has to be emphasized, how the lecture can help the learner to achieve present or future goals. Additionally, it is proposed that those who have already accomplished the task successfully give a guest lecture in which they state how helpful it has been for them, so the course gains relevance. To increase the confidence of a learner, it is important to establish goals that can be attained realistically. It is also crucial to let the learner attribute his success to his effort, and to make him independent in his learning process. For the last category, satisfaction, the learner should receive positive reinforcement, personal attention and feedback. According to Keller, negative influences like threats, external performance evaluations, and overt surveillance have to be avoided.

To create a motivational design, for steps are essential: Define, design, develop, and evaluate. During the define phase, the problem has to be classified. If it is a motivational problem, the learners' motivation has to be analyzed, and motivational goals have to be prepared. In the second step, design, potential strategies have to be created and then selected. Then, in the development phase, motivational elements should be prepared and integrated into the instruction. Finally, during the evaluation phase, developmental try-out has to be performed, and the motivational outcomes have to be evaluated.

It is evident that both the Time Continuum model and the ARCS model are similar. They have several strategies in common, as they both are based on using developments in motivation. The ARCS model may have a stricter structure, but using either one of the models will have analog results. (Hodges, 2004)

Next, ten motivation techniques that concentrate on the user's attention are given by Taran and explained as follows:

3.1.3 Motivation Techniques regarding Attention

Taran (Taran, 2005) concentrated on the attention aspect of Keller's model and proposes ten techniques how to attract the learner's attention and maintain it during the learning sessions. These ten techniques are "manding stimuli", anticipation, incongruity, concreteness, variability, humor, inquiry, participation, breaks and energizers and storytelling.

To capture one's attention, "manding stimuli" is quite effective. Mands are such statements as "watch out!", "now listen closely", or "please keep in mind that..." that intend to attract someone's attention.

Then, Taran suggests anticipation as a tool how to increase attention. Words like "finally", "now", or phrases like "can't wait to", "looking forward to", etcetera, should create curiosity and excitement. These are useful as attention of a person increases when he is excitingly waiting for a task (Jones and Gerard, 1982). Learners also seem to recollect tasks that are not finished, better than finished ones (Jones and Gerard, 1982). Therefore, it is recommended to use stimulating features also at the end of a lesson or before a break, so the learner is eager to continue.

Another technique is incongruity, which can be *"a conflict between what students expect to see/hear and what occurs, increases sensory stimulation, and therefore attention, by propelling curiosity"* (Apter, 1982). So building in some aspects that contradict what the learner's intuition would be, can arouse interest in him.

Concrete, non-complex information can also have the effect, that learners pay attention. Information, that have too many details and are hard to comprehend, can let the learner zone out and make him lose attention, so it is important to give precise data, for example anecdotes, biographies, or statistics (Taran, 2005).

A very important technique is using variety. Changing elements can keep the student's attention alive. There are various aspects that can be altered: You can change the tone from formal to informal, the movement (use animations instead of text and graphics), the format of instructions (for example, from presentation mode to a game), the interaction patterns, the channel of instruction (from visual to auditory) and the information validity (from factual to fantasy) (Taran, 2005).

As a next method, humor is very effective in maintaining someone's attention, because it can advance the emotional state (Jones and Gerard, 1982). The format can either be textual like jokes, graphical (for example little cartoons) or situational. Humor elements have to be tested before they are actually used, because misinterpretations have to be avoided.

Attention can also be increased by using inquiries: Asking questions where the learner's knowledge or comprehension is tested, where he has to solve problems or answer provocative queries can raise his attention.

According to Rose, participation can increase attention, too (Rose, 1987). Practicing exercises, games or simulations make learners feel that they have the possibility to participate actively which motivates them to continue practicing. It has been arisen out of research, that attention of learners can only be kept alive for 30 minutes (Rose, 1987). Therefore, it is advisable to propose several breaks during one session. As an alternative, the designer can also choose to offer energizers, such as little games, to refresh the learner's enjoyment and attention. Finally, storytelling has to be mentioned as a method that can be used to increase motivation of learners. Introducing a new chapter with the words "Have you heard the one about...", for example, can capture the learner's attention. Personal experiences, as well as known anecdotes or other stories, that support the content, reinforce or inspire the learner, can be applicable. In the best case, these stories are as realistic and content-relevant as possible (Taran, 2005).

In the section, Persuasive Technology as another area that can also be used to increase the motivation of learners will be explained and the seven types of persuasive tools will be listed.

3.2 Persuasive Technology

3.2.1 Definition of Persuasion and Persuasive Technology

The definition of persuasion is controversial, but Fogg tries to explain it as *"an attempt to change attitudes or behaviors or both (without using coercion or deception)"* (Fogg, 2003b). He emphasizes that persuasion must not be confused with coercion, which implies involuntary change. He also states that persuasion has to be outlined from deception, where people are tried to be convinced of something by giving false information.

Fogg then defines two levels of persuasion, macro and micro. Macrosuasion should describe the *"overall persuasive intent of a product"*, whereas microsuasion is explained to *"incorporate smaller persuasive elements to achieve a different overall goal"* (Fogg, 2003b).

Accordingly, Persuasive Technology can be described as the use of computers in terms of persuasion. As persuasion can be adopted to change attitudes and behaviors of people, it can also be used to change the motivation of learners. Fogg defines a Persuasive Technology tool as *"an interactive product designed to change attitudes or behaviours or both by making a desired outcome easier to achieve"* (Fogg, 2003a) and then gives a list of different Persuasive Technology tools. It will be shown that they can also be used to increase motivation in E-Learning settings. Below, the different types of tools that have persuasive effects are described.

3.2.2 Types of Persuasive Tools

Fogg ascertains seven types of persuasive tools, which are based upon different directives. They are described as the following:

Reduction

Reduction Technology is a strategy used to simplify instructions, to decrease their complexity. If only few steps have to be absolved in an instruction and if the directives are kept short and easy to understand, this helps to make sure, the user wants to use the product. As it is said that people try to increase the benefit/cost ratio, which means minimizing costs and maximizing gains wherever possible (Johnstone, 2004), they are therefore motivated if reduction technology is used, as it tries to increase this benefit/cost ratio. Another effect of this technique can also be that users gain self-efficacy when they see they can manage the program. This all can be conductive to make the user perform the behavior more frequently.

Tunneling

Using the tunneling strategy, the interaction course is predetermined. This means, the user is guided through every step of an action. For example, on an online shopping homepage, the buying transaction is predetermined step by step: Search for an item, add it to the shopping card, fill out personal data, confirm and send it to buy the object. Another example would be an online tutorial, where the user learns certain facts about one topic in several chapters. At the end of each chapter he then has to solve tests about these topics in order to control the learned knowledge. The solutions are shown to him so he can make improvements and repeat the chapter or go on to the next one. Offering users this clear way through a process can make it very easy and comfortable for them. Users also value the consistency they get by these systems: They already know what they engage in and do not have to fear they have to deal with a complete new system they are not sure of how to use it. Once the user has entered the "tunnel", he has to stay in it until the end in order to accomplish the task properly.

Tailoring
According to Fogg, a tailoring technology is *"a computing product that provides information relevant to individuals to change their attitudes or behaviours or both"* (Fogg, 2003a). By offering users only information they really use and need, users are not overstrained by the flood of information and are likely to use the product willingly, because it satisfies their needs exactly. For example, a computer software for learning a foreign language specifies on vocabulary that is especially helpful during vacation, the user gets personalized data. He is motivated to use the program because he expects a special relevance for him.

Suggestion
Another persuasion technology is suggestion: Making suggestions to users at moments that are convenient, persuasion will have greater power on them. Fogg defines suggestion technology as *"an interactive computing product that suggests a behavior at the most opportune moment"* (Fogg, 2003a). This technology tool is based on an old persuasion principle named "kairos". According to Greek mythology, Kairos was the "god of the favorable moment". So, it is important to have the right timing to make a proposal. But as an opportune moment is dependent on numerous factors, such as environmental aspects (for example, the actual position of the person, environmental or cultural circumstances, and etcetera) or personal aspects (the mood of a person, his attitudes, and more), this technique is quite difficult to realize.

Self-Monitoring
The self-monitoring technology is a tool that *"allows people to monitor themselves to modify their attitudes or behaviors to achieve a predetermined goal or outcome"* (Fogg, 2003a). Self-monitoring systems should work in real time and give the user constantly feedback about their physical or mental state, their location or give information about their improvement in a task (Fogg, 2003a), so the user always knows his actual status of progress. Getting this information, it is likely that the user continues to perform the requested behavior (Bandura, 1997). A tool that uses self-monitoring can also have the effect of actuating one's self-understanding (Festinger, 1954): People get to know themselves better when they observe themselves frequently. By knowing their actual status, people can change their behavior in order to improve on a special task.

Surveillance
As a next type of Persuasive Technology tool, surveillance has to be mentioned. Unlike the self-monitoring technique, people are getting observed by others here. Fogg defines surveillance as a technology that *"allows one party to monitor the behavior of another to modify behavior in a specific way"* (Fogg, 2003a). In comparison to the other tools mentioned before, surveillance is the most frequently used tool that can be found in an actual application, besides from E-Learning settings. There are several applications that use surveillance, for example hygiene

observing applications in employee restrooms that monitor clerks and senses if one does not use the sink. But in order to have a persuasive effect, surveillance has to be overt, which means, people have to know that they are being observed, otherwise they will not change their behavior willingly. Knowing, that others can monitor them, can motivate people to show the required behavior. Surveillance technology does not have to come along with punishment, if the task is not fulfilled properly, but can also promise rewards if it is. This is probably more motivating than using fear as a pressurizing method.

Conditioning

As the last persuasive tool, Fogg defines conditioning as a *"computerized system that uses principles of operant conditioning to change behaviors"* (Fogg, 2003a). Operant conditioning or "instrumental learning" works with positive reinforcement in order to increase motivation. (Powell et al., 2004). Getting a reward for an accomplishment can cheer people on. Examples can be found in computer games: A score shows the user his actual status. As he wants to make more points (get more positive reinforcement) he keeps on playing. Achieving the next level, or next chapter, for example, serves as the reward the user wants to earn, which can motivate him.

In the followings, the paper will show the results of the analysis of motivational methods in three different E-Learning applications. For motivation techniques, both methods of the classical motivation models and methods of Persuasive Technology were investigated.

4 Motivation Techniques in E-Learning Applications

To analyze different E-Learning applications regarding motivation techniques, the English learning CD-ROM software "ENGLISCH - Die Sofort-Grammatik auf CD-ROM" from PONS was used, also the Nintendo DS game named "Dr. Kawashima's Brain Training: How Old Is Your Brain?" and an online learning platform for children, called "funschool.com".

The three different applications were chosen, because they represent three different fields of E-Learning settings: A software, which is independent of an internet access, a portable learning environment and a learning platform especially designed for the internet. They have also differences regarding the target audience: The english software is more suitable for students or for adults, whereas the online platform is only for children. Despite the fact that it says that "Dr. Kawashima's Brain Training" is appropriate for users from age three on the package, it requires numeracy skills amongst others. Since the brain activity slowly decreases at the age of about 20, which is also the minimum brain age one can achieve during playing the game, the game is probably more suitable for users of at least this age.

The results of the investigations are listed in the following:

4.1 English Learning Software

The software "ENGLISCH - Die Sofort-Grammatik auf CD-ROM" of PONS provides grammar and vocabulary training for vacation and everyday life. It is separated into several chapters. Each chapter has different fields that are trained, for example plural forms, upper and lower case, and so on. Every chapter is divided into several steps that are recommended to execute in the proper order. At the end of each section, a short test has to be solved. The software also offers audible and graphical elements during a section or a test. It has some special features, for example the possibility of organization in a self created folder structure or viewing status information which can be accessed for single chapters or the whole progress. Every user has to sign up with his own password at the beginning of a learning session. This makes sure the user has his individual information, if several people use this software on the same computer.

Examining the software, different motivation techniques are noticeable. Several techniques the Time Continuum model proposes are used here: At the beginning of each chapter, a short summary of the goals that will be achieved is given. It is abstracted, which grammar forms and what vocabulary will be learned. Also, a familiar strategy is used: Going through several steps of a lecture and then completing a test at the end of a chapter, is a common strategy. Both features, assessing explicit, clear goals and using a familiar strategy come along with aspects of the first phase of the model, the beginning phase, where attitudes and needs of the user are especially important. Like proposed for the middle of a learning process, where stimulation and affect are crucial, and the software shows variation in the presentation style: During one lecture or even during a test, the presentation mode switches from plain text to text with audio or visual elements. By going through one chapter, a lot of questions are asked, not only in the test, but also during the whole lecture. These facts are in accordance with what the Time Continuum model suggests.

As there is also the possibility of getting feedback, the methods used in the last phase, the end phase, is fulfilled too. Figure 1 shows an example of the variation in the presentation style and the feedback statistics, the user can view.

(a) **(b)** **(c)**

Fig. 1. A huge variation in the presentation style can be found in the English software: changing from grahical-auditory to textual-autitory: a) and b). The user gets feedback through a statistical view: c)(PONS, 2005).

Not only methods of the Time Continuum model are recognizable, there can also be found many aspects of the ARCS model: Attention is maintained by the variation of the instruction format, as explained above, and by the possibility of participation. The user has to interact during the whole lecture. He does not just listen or read passively, but is also invited to fill in forms, solve little challenges, etcetera. Then, the relevance aspect can be seen, because present and future goals are appointed: A present goal would be to become proficient in using irregular verbs and a future goal, to have a good knowledge of the English grammar and a vocabulary for everyday life and vacation. Furthermore, becoming an independent learner is also a goal of the software: The user can apply his own folder structure with several tasks, he can choose the order of the lectures he wants to hear, can repeat them as often as he wants, and his status with information about his progress can be viewed at any time. This can support the user's confidence, and also satisfaction, the third and forth aspects of the ARCS model.

As Taran splits up the attention aspect into 10 detailed methods, amongst others manding stimuli, concreteness, breaks and energizers and storytelling, these methods can also be found in the software: Manding stimuli is shown, for example in an information box where it says "Good to know! Keep in mind the rule of thumb..." This example also demonstrates concreteness, as there are only short instructions and concrete information. Breaks and energizers can be found permanently: There are a lot of interactive activities and even little games such as crossword puzzles or bingo. They freshen up the user's concentration and attention. As a last point, storytelling is a frequently used stylistic device: The everyday life of a couple named Paul and Kate is told, and appears several times during all lectures. There are introducing sentences like "Kate meets an old friend at the supermarket she has not seen long time. Listen to the dialogue and try to understand as much as possible." (See figure 2).

(a) **(b)**

Fig. 2. Two methods to increase the attention are used: Energizers through little games during the lecture (a) and the storytelling method: Stories of the everyday life of two characters are told (b) (PONS, 2005).

Analysing the software, also tools of Persuasive Technology appear. The reduction technique can be seen everywhere: Instructions are held as short as possible, and if more details are wanted, they can be viewed additionally. Therefore, the complexity is reduced a lot. Then, the tunneling tool can be found, too. Indeed, the sequence of steps in a chapter can be chosen by the user, but there is a guideline which is recommended to follow. Figure 3 shows the sequence of steps in a chapter. Also the tailoring technique is used, only information relevant to the user is given, for example vocabulary for the everyday life or vacation, but not for business. There is also a selfmonitoring aspect: The user can watch his progress by himself; he can view the statistics of his advance whenever he wants and therefore has a certain amount of control over it.

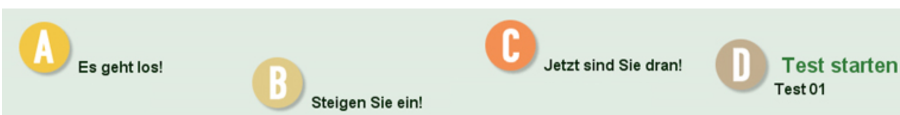


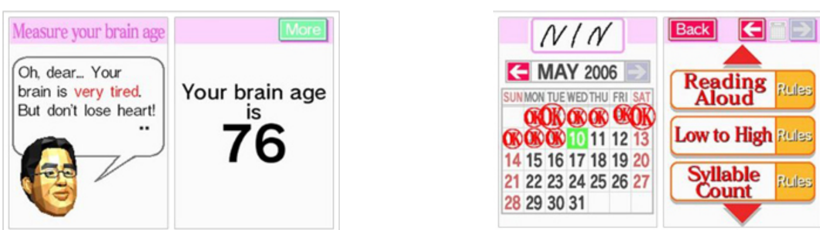
Fig. 3. Tunneling method: The English software uses a guided sequence of action through each chapter (PONS, 2005).

Comparing the results that where found according to the different models to the ones that refer Persuasive Technology, a lot of intersections can be detected. This surely has its origin in the fact, that the different techniques all base on similar motivation aspects.

4.2 "Dr. Kawashima's Brain Training"

Next, the game "Dr. Kawashima's Brain Training" was investigated: "Dr. Kawashima's Brain Training" is a game for the portable console Nintendo DS, which has two displays, including a touch screen, and works with a stylus pen. The game offers several mini games or training exercises that have to be fulfilled in order to improve the user's memory, to train his mental arithmetic ability, etcetera. It logs how fast these tests are answered and then calculates and saves the user's progress. An initial test after setting up a profile right at the beginning shows the current "brain age" of the user, which he is then trying to reduce during playing the game. He is advised to practice every day to be able to make as much improvement as possible. Solving the tests, the user has to give input with the stylus or also via voice. To keep track of his training, there is a calendar function that shows how often the user has done his training.

A lot of the methods mentioned in the time continuum model can be found in the training game: Starting it, Dr. Kawashima's face appears, greeting the user and welcoming him back. This has the effect of an icebreaker; the user's mood is loosened up. Right from the beginning, the major goal that has to be achieved is set up very clearly: The user has to practice hard in order to train his mental functions, to reduce his "brain age" (figure 4 (a)) These are all methods the Time Continuum model proposes for the beginning of a learning process. For the middle of this process, aspects like humor, variation in presentation style, asking questions are important, according to the model. Humor can also be found: The person of Dr. Kawashima is used to ease the user's mind, so he has fun during the practices. Then, the presentation style varies during the program. For some exercises, the user has to give input through the stylus pen, write, draw or select something, for others he has to speak into the microphone. So, the input methods are quite versatile. And there are a lot of questions; this is what makes up almost the whole game. The training is adapted to the user's needs and shortcomings. It is individual, depending on the skills of the user. So the relevance is maximized. Also competence and reinforcement are given, like the model suggests. The user can recalculate the actual age of his brain, which means he can get useful feedback (shown in figure 4 (b)). There is also a lot of reinforcement: "Dr. Kawashima" always looks pleased when the game is started again and he compliments the user after he has finished a task successfully.

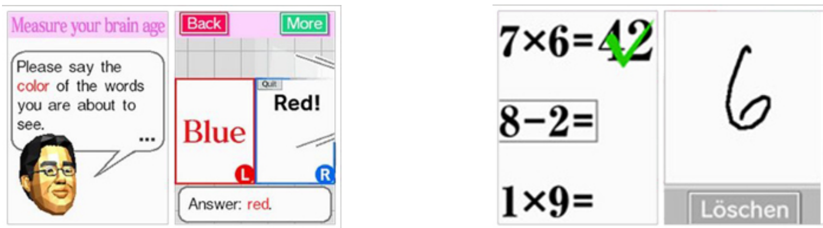


(a) **(b)**

Fig. 4. (a) After an initial test, the user's "brain age" is being calculated. This sets up the goal: Trying to reduce this age. (b) The calendar function gives the user feedback about his progress (Amazon.com, 2008).

There are also a lot of methods used in the game that are described in the ARCS model: As already mentioned above, the presentation format is varied and humor is used. Two screenshot of different tasks can be seen in figure 5. Amongst participation, which is also given by dozens of interactive tasks, these are important ways to attract attention and maintain it. Relevance is created by the goals that are set up right from the beginning and by the individualized tasks. The user can become confident, because he can observe his progress, and decide independently, how often he wants to learn. The satisfaction aspect can also be seen in "Dr. Kawashima's Brain Training": The user gets a lot of feedback and commendation. Especially for the attention aspect, several methods can be found: Anticipation is engaged by the joy Dr. Kawashima shows the user when initiating the game. There is also incongruity: If the "brain age" is older than the real age of the user, he is motivated to find out the reason and change it.

The method of putting breaks and energizers in is also there, the user is only able to practice a few exercises every day. This makes sure the user does not get bored or overstrained and also creates anticipation, to play again the next day.



(a) (b)

Fig. 5. A variation of presentation style can be found in the game: interaction possibility via voice (a) or (b) text input are possible (Amazon.com, 2008).

Regarding Persuasive Technology tools, the following are used in the game software: Reduction can be found, as the instruction is kept very simple and is easy to understand. In a way, tunneling is also used: The tasks are pre-chosen for the user. But he has also the possibility of selecting an exercise on his own. To some extent, the suggestion principle can be seen: The game proposes the user, to practice every day. As it has to be played on a portable console, the user can carry it with him and use it everywhere he wants. The exercises are quite short, so even if the user is very busy in general, he can choose to use it on his way to work, for example. This means, the chance of find an opportune moment to use the program is raised, although it does not motivate the user actively to continue practicing, but it leaves the decision in the hands of the user. Another persuasive tool, self-monitoring, is apparent. The user can observe his progress and can co-decide his advance by practicing as often as possible. Finally, the conditioning technique can be found. The game provides a lot of positive reinforcement through commendation of Dr. Kawashima.

4.3 Online Learning Platform "funschool.com"

As a last object of investigation, the online learn platform, funschool.com, was analyzed. It is a website especially designed for children that are in pre-school or elementary school. It offers several activities where children can learn maths, history, creativity, and more in a playfully way. These activities contain games, quiz, drawing and more (see figure 6).

Concerning the Time Continuum model, stimulation and affect, which are important in the middle of a learning process, are deployed: One can find humor elements, different forms of presentation and questions. Playing a quiz, the user can see a statistic at the end, which shows how many questions he answered correctly.

Fig. 6. The start page of funschool.com. Children have a great variety of interactive games.

More applied methods can be found regarding the ARCS model. The website uses humor as well as participation. A user can play a lot of interactive games: In a pre-school game for example, he has to catch a certain amount of fish in order to learn the numbers. As these games are not too hard to solve for children of the adequate age, their confidence in solving problems can increase. They also receive a lot of positive reinforcement. In the fish game example, it says "You're a star" or "Good one!" after catching the correct amount of fish (see figure 7). This is consistent with the satisfaction aspect of the model.

(a) **(b)**

Fig. 7. a) In the game "Fishin' Mission" the user has to catch a certain amount of fish. This game should help children to learn to count. b) Fulfilling a task, the user gets a lot of positive reinforcement (funschool.com, 2008).

The attention is captured and sustained by the following methods: The anticipation and curiosity of the users are increased by phrases like "Print a creepy crawlies puzzle!" Concreteness is also used: Making the history quiz, a short text to the subject appears after answering a question, for example "On April

30, 1789, George Washington took his oath as the first president of the United States. He was re-elected in 1792 and stayed in office until 1797". As a presentation format, text, tone, graphics, as well as animations are used. The user can participate through a lot of interaction possibilities. (See figure 8).

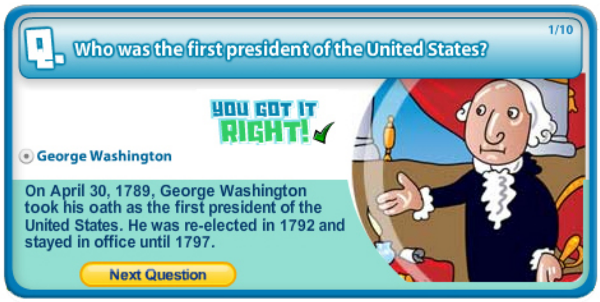


Fig. 8. In the history quiz, the Reduction method can be found: Only concrete, short information is given (funschool.com, 2008).

Looking for Persuasive Technology tools, the reduction technique can be found: Instructions are kept very simple, they are easy to understand. There is an extra section for pre-school children, besides the section for children of elementary school. This makes sure the users only get information about themes that are relevant for them. A child in pre-school would not want to play a quiz with history questions, and a child which visits elementary school has no interest in the fishing game, because he already knows how to count numbers. As last persuasive tool which is used on the website, conditioning has to be mentioned: The user gets frequent positive reinforcement, as already mentioned before.

4.4 Comparison

Comparing the three settings, it is apparent that in all of them similar techniques are used. This is based on the fact that the different techniques and models are similar in many aspects. But also differences are visible: Getting frequent and detailed feedback is not available on the online learn platform like it is in the English software or the brain training game. This is, because children could not do anything with this information. But they do get some kind of resonance through the score they can make during a game. This is, because children would mainly visit the website to have fun and not in order to learn something. Surprisingly, storytelling could not be found on the online platform or in the Nintendo game. It was only used in the English software. Positive reinforcement could not be seen in the English learning software as it is in the children's website or the brain training game. A reason could be that designers assume a high intrinsic motivation of the learners, to use the program frequently, whereas users of "Dr.

Kawashima's Brain Training" or funschool.com have to be motivated extrinsically by receiving a lot of rewards. This is especially important for children. They have to be motivated more intensely in order to stay attentive and not to lose concentration during a session. As only the game for brain training is portable, the suggestion method can just be found here. Incongruity, one of the methods to maintain attention, and surveillance, the Persuasive Technology tool that uses observation to motivate users, could not be found in any of the analyzed settings. Although using slightly different methods, some of the methods are especially important and used in all of them: Personalization, variation of presentation style, a lot of questions, participation possibility, breaks and energizers, relevant feedback where it is needed, and reduction.

5 Discussion

Discussing, which of the motivation models and techniques are more appropriate in E-Learning settings, could turn out to be quite difficult as they do not show a lot of differences. According to former research, relevance is the method which causes most motivation, closely followed by useful feedback that should preferably be personalized to the user. The variation of presentation formats and reduced, easily understood instructions can also have good motivational effects (Bonk, 2002; Hardre, 2001; Moshinskie, 2001; Song and Keller, 2001).

These results correspond with the ones made during examining the three E-Learning settings. As a consequence, it can be stated that although being relatively old methods, the Time Continuum model as well as the ARCS model are still relevant in E-Learning applications. It cannot be said that Persuasive Technology is more adequate while working with computer systems. This is not only, because a lot of the tools used in Persuasive Technology are similar to the techniques used in the motivational models: The persuasive tool reduction is a method that is analogical to the concreteness used to sustain attention, the first aspect of the ARCS model. Then, tailoring, the tool that provides only relevant information to the user is in accordance to the relevance method of the ARCS model or the middle phase described in the Time Continuum model, where stimulation and affect can be maintained by relevance and personalization. Finally, the persuasive tool named conditioning, which means giving positive reinforcement, is accordant to what the Time Continuum model proposes for the end of a learning process, namely competence and reinforcement, and also refers to the satisfaction aspect of the ARCS model, where it is suggested to use positive reinforcement in order to keep a user content.

To come to a conclusion, E-Learning environments should use the selection of techniques listed above to be able to maximize motivational effects. But they also have to be adapted to the target audience. If the user group consists of children, for example, less self-monitoring and independency increasing aspects and more positive reinforcement should be used. As technology is changing very fast, designers should always keep an eye on new motivation techniques that are especially adapted to electronical learning settings. But using the "old" models as foundation can surely always be a good base.

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