COMPUTER SUPPORTED COLLABORATIVE LEARNING IN TECHNOLOGY EDUCATION THROUGH VIRTUAL REALITY LEARNING ENVIRONMENTS

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Abstract
Innovation Education (IE) is a new subject area in Icelandic schools. The aim of the subject is to train students to identify needs and problems in their environment and to develop solutions: a process of ideation. This activity has been classroom based but now a Virtual Reality Learning Environment technology (VRLE) has been designed to support ideation. This technology supports online communications between students and teacher and enables them to develop drawings and descriptions of their solutions. The VRLE is network based and the students work online in the school with their ideas in real time.

As this learning environment is new it is important to explore and evaluate its use and value. This paper describes the basic IE pedagogical model and the subsequent development of the VRLE. These are discussed in relation to constructivist learning theories.

Keywords: Innovation Education, ideation, pedagogy, Virtual Reality Learning Environment, constructivism, Computer Supportive Collaborative Learning.

Introduction

This paper describes the Innovation Education model developed within the Icelandic education system and, particularly the development of a Virtual Reality Learning Environment (VRLE) designed to support it. These developments are discussed in relation to learning theories, particularly the constructivist perspectives.

Firstly the background to these developments are described. The pedagogy underpinning IE is described and a model of this form of teaching and learning is presented. Secondly constructivist theory relating to generic VRLEs is discussed, including the concept of Computer Supported Collaborative Learning (CSCL). Finally this theory is related to the specific Icelandic IE VRLE and a second model of teaching and learning is presented as a contribution to discussion.

Background to Innovation Education in Iceland

Innovation Education (IE) was a curriculum development project which originated in Iceland in 1991. This project focussed on conceptual work; searching for needs and problems in the student's environment and finding appropriate solutions or applying and developing known solutions (Thorsteinsson 2003, Gunnarsdottir 2001). IE was aimed at general education, rather than design type subjects. In 1996 Iceland University of Education coordinated a three year European Union funded project *Practical use of Information Technology and Open and Distance Learning in Innovation Education* (InnoEd), which took place between 2002 and 2005. This took the original IE work and introduced computer-based technologies in order to develop new ways of supporting students work in IE classes. A major output of the InnoEd project was the development of a virtual reality learning environment (VRLE) in which children could interact, communicate, and host their innovation education work.

The pedagogy of Innovation Education

Innovation Education (IE) is defined as an innovative school activity. It has pedagogical values, in

the context of general education and is part of the Icelandic National Curriculum (1999). IE is based on conceptual work which involves searching for needs and problems in the student's environment and finding appropriate solutions or applying and developing known solutions (Denton and Thorsteinsson 2003). Innovation can be defined as inventing something new or designing something and improving old 'things' (Gunnarsdottir 2001). Zhuang *et al.* (1999) described innovation as either:

- an invention which may be considered completely new;
- an improvement of an existing product or system; or
- a diffusion of an existing innovation into a new application

Developing students' ideation skills is the main empasis of the pedagogy of IE (Gunnarsdottir, R. 2001). By strengthen individuals' ideation in a general educational context they are meant to be better able to deal with their world and take active part in society.

The IE process is a simple way to teach ideation skills. The flowcart shows the fundamental steps in the innovation process as it has been promoted. Ideation skills are used at all stages of the IE innovation process

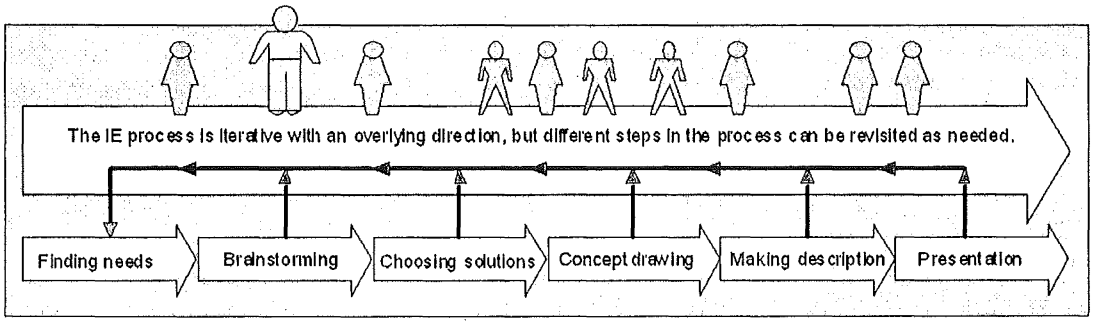

Figure 1: Ideation within the IE working process.

Students learn through innovation process within the overall IE pedagogical framework which is managed by the teacher;

1. Finding the needs.
2. Brainstorming.
3. Finding the initial concept.
4. Ideation drawings or modelling to develop the technical solution.
5. Making a description of the solution as addition to the drawing.
6. Presentation.

Ideation is at the core of the IE pedagogical framework. The IE process is iterative with an overlying direction leading from 'finding needs' to 'presentation of solutions'. Innovation has to do with the usefulness of ideas and/or how they can be implemented as solutions to problems encountered in daily life. IE is a cross-curricular approach to teaching and learning with its own ideology, pedagogy, and methodology (Thorsteinsson 2002).

In Innovation Education, students use knowledge and information from different sources, as appropriate, to find solutions. This comprises the search for solutions to needs and problems encountered in their own environment. This mirrors Vygotsky (1978) on the zone of proximal development (see below). Students work with their own concepts, but must learn to use the ideation processes needed to bring their idea into being; gaining what is now known as Creative Relevant Skills (Gunnarsdottir 2001).

Gunnarsdottir's (2001) research has shown two main pedagogical processes when students take part in Innovation Education. These are acquiring Creative Relevant Skills and the Ideation process. The Creative Relevant Skills are defined in the teaching material of IE as knowledge and skills that are important for the students to learn in relation to the development of ideas. This includes learning relevant concepts, how to register needs and problems identified at home, brainstorming techniques and to make drawings and descriptions of developed solutions.

Ideation is a concept derived from Guilford (1950) and used as a name for a pattern of interactions that forms when a person works on and produces an idea or invention. Ideation is defined in the Oxford Dictionary (2005) as "The faculty or capacity of the mind for forming ideas; the exercise of this capacity; the act of the mind by which objects of sense are apprehended and retained as objects of thought". Within IE ideation is interpreted further to become a learner skill in relation to innovation.

Gunnarsdottir's research shows that these two processes need to be in balance during IE lessons (2001:25). She suggests that if the teacher's role is overwhelming then the students tend to stop using their experience and little creative work will happen. In addition, it appeared an important factor that the students interacted with each other to stimulate the evolution of skills and knowledge within the lessons. This balance and the central processes are explained in figure 2. (Gunnarsdottir 2001).

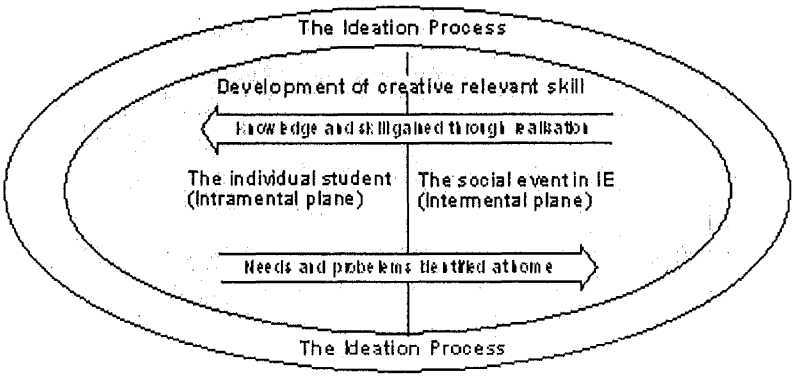

Figure 2: Pedagogical model for IE developed from Gunnarsdottir 2001

There is a disagreement between this work and those of Gunnardottir. When she define ideation as a process base on creative relevant skills this work define ideation as the skill the students need when undertaking the Innovation process. Innovation, in a general sense, can be seen as a process with different stages stretching from "idea generation" to "implementation". Innovation includes the generation of ideas, alternatives, and possibilities (Smith 1998). Innovation is a form of problem solving that begins with the feeling that change is needed and ends with a successful implementation of an idea (Smith 2003). Creativity is considered (Gurteen 1998) the part of the process which leads to and includes, the idea generation. As seen from the above, Innovation Education is defined as a creative school activity, based on the innovation process. Idea generation takes place in the innovation process, as ideation is the skill the students need, when they go through the IE process. This is the basis of the pedagogical model established for Innovation Education in Iceland (see fig 2.).

A VRLE to support ideation

A specific VRLE was designed to enhance ideation via collaborative learning support in IE classes and thus offer individual and social educational opportunities. This development was based on work by Thorsteinsson 1998, Thorsteinsson 2002, Gunnarsdottir 2001, ,Osberg 1994 and Brichen 1994,

Jonassen 2000. Collaborative learning is an term for approaches in education that include joint intellectual effort by students or students and teachers (O'Donnell, el.al. 2006). Groups of students work together looking for understanding, meaning or solutions or in creating a product. Collaborative learning activities can include collaborative writing, group projects, and other activities. Collaborative learning has taken on many forms for example Computer Supported Collaborative Learning (CSCL). CSCL has emerged as a new educational paradigm among researchers and practitioners in several fields, including cognitive sciences, sociology, computer engineering (Crook, 1994).

The VRLE aimed to offer multimodal communications to strengthen ideation within the innovation process. Of specific interest was the method of ideation used. The IE process is not seen as a rigid model but as a useful basis for ideation work and therefore could be regarded as a tool to facilitate ideation (Gunnarsdottir 2001).

Constructivist theory relating to generic VRLEs

Meredith Bricken (1990) theorizes that immersive applications of VRLE's are a 'very powerful' (sic) educational tool for constructivist learning. The hidden curriculum of VRLE's could be: "make your world and take care of it. Try experiments, safely. Experience consequences, then choose from knowledge" (p. 2). William Bricken (1990) has also theorized about VRLE as a tool for experiential learning, based on John Dewey's, Vytgosky's and Jean Piaget ideas. According to Briken, a VRLE can teach active construction of the learner's environment. As the VRLE is a computer created reality it is physically safe for the studens and can be used for establishing basis for different education expiriences that would both be impossible and not save in the physical world. The specific VRLE version is also closed for visitors from outside of the system, with access code and password and the users can not be disturbed in their work.

Jean Piaget and Vytgosky (Bricken, 1991; Bricken & Byrne, 1993) introduced the constructivism theory in educational sciences. Central to the vision of constructivism is the view of the learner as "active" and their mental structures are formed, elaborated, and tested, until a satisfactory structure emerges. The Piagetian perspective implies that interactions in groups can create the cognitive conflict and disequilibrium that leads an individual to question his or her understanding and try out new ideas. Vytgosky (1978) illuminated the role of opposition and equilibration in learning. He was interested in the role of inner speech, the learning concepts, the role of the adult and as well as learners' peers as they conversed, questioned, explained, and negotiated meaning. Constructivists who favour Vygotsky's theory suggest that social interaction is important for learning because higher mental functions such as reasoning, comprehension, and critical thinking originate in social interactions and are then internalised by individuals. Children can accomplish mental tasks with social support before they can do them alone. Thus, cooperative learning provides the social support and scaffolding that students need to move learning forward (Woolfolk, 2001, p. 44).

According to Slavin (2000) Vygotsky's theories have been utilised as support to instructional classroom based methods that underline cooperative learning, project-based learning, and idea finding. Two key principles are important for cooperative learning. Firstly, children learn through cooperative interactions with adults and peers. In cooperative projects children are exposed to their peers thinking process, knowledge and skills. This cooperation can strengthen the learning outcome. Vygotsky (1978) noted that successful problem solvers talk themselves through difficult problems. In cooperative groups, children can 'hear' this inner speech loudly and this helps them to solve their problems through their approaches. The second key concept is the idea that children learn best

concepts that are in their zone of proximal development. The zone is formally defined as: "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers." (Vygotsky, 1978, p. 86). When children are working together, each child is likely to have a peer performing on a given task at a slightly higher, cognitive level, exactly within the child's zone of proximal development". The "zone of proximal development" (ZPD) is the site where learning occurs. This concept has been the focus of several educational research groups (Edwards 2001) that underline the importance of learning as a collaborative process. It is also suggested that computers can be used as media to provide new contexts in which this collaborative learning might take place (e.g. Newman, Griffin & Cole, 1989).

According to Vygotsky (1978), the zone of proximal development is the difference between what a student can do alone and what he/she can do through supportive collaboration. There are implications for cooperative-learning situations in an IE class in relation to this theory (Gunnarsdottir 2001) and according to Bricken (Bricken, 1991; Bricken & Byrne, 1993) the use of a VRLE in conventional classroom may support such situations (Thorsteinsson and Denton 2005). The initial stage of the IE innovation process starts in the student's own environment, when they identify needs and problems at home. In the school classroom, they communicate with the co-students and the teacher and expose to each other thinking process during the innovation process. This part of the IE school activity brings the students closer to their zone of proximal development and is one of the characteristics of the IE pedagogical model. According to this, the use of the IE VRLE technologies could be seen as a constructivist-learning tool based on CSCL processes (Lehtonen, Page, & Thorsteinsson, 2005).

For constructivists, learning is not the result of development; learning *is* development (Fosnot, 1996). Teaching strategies using social constructivism include teaching in contexts that might be personally meaningful to students, negotiating taken-as-shared meanings with students, class discussion, and small-group collaboration. Emphasis is growing on teachers using different ways to maintain dialectic tension between teacher guidance and student-initiated exploration, as well as between social learning and individual learning. According to the Piagetian perspective, interactions in groups can create a cognitive conflict and disequilibrium that can lead an individual to question his or her understanding and try out new ideas.

Bricken (1991) describes VRLEs as experiential and intuitive as they can offer a shared context that provides interactivity. They can also be set up for individual learning styles (Winn 1993). VRLEs can also support group projects and discussions, field trips, simulations, and concept visualization. Bricken argue that within the limits of system functionality, it is possible to create anything imaginable and then become part of it.

Bricken speculates that in VRLEs, students can actively inhabit a spatial multi-sensory environment. Students are both physically and perceptually involved in the experience; they get a sense of being within a virtual world. Bricken suggests that VRLEs allow natural interaction with information. Learners are allowed to move, talk, gesture, and manipulate objects and systems intuitively, within the limitations of the system being used.

According to Bricken, VRLEs can be highly motivational: they can have a magical quality. "You can fly, you can make objects appear, disappear, and change. You can have these experiences without learning an operating system or programming language, without any reading or calculation at all.

But the magic trick of creating new experiences requires basic academic skills, thinking skills, and a clear mental model of what computers do" (Bricken, 1991, p. 3).

VRLEs, therefore, can be powerful contexts, in which learners can control time, scale, and physics. Participants can have entirely new capabilities, such as the ability to fly through the virtual world, to occupy any object as a virtual body and to observe the environment from many perspectives. Understanding multiple perspectives is both a conceptual and a social skill; virtual reality enables learners to practice this skill in ways that cannot be attained in the physical world.

VRLEs offer a shared experience for many participants. Meredith Bricken theorizes that VRLE's provide a developmentally flexible, interdisciplinary learning environment. A single interface provides teachers and trainers with a variety and supply of virtual unbreakable learning materials.

There are lot of critical issues and considerations concerning the use of a VRLE technology in education. A VRLE technology contribution to conventional school education means extra cost for the school, as the school has to buy the software used and all the equipments needed. However, most schools have modern computers they can manage with for such technology. A desktop VRLE is also a cheaper solution than VRLE technology that needs expensive head-mounted 3D glasses or haptic equipment.
Durkin (2003:p2) raises questions about man's existence and his relationship with the machine: "We cannot understand our world by intellect alone. We comprehend it as much by our feeling. Therefore, our judgment of the intellect to understand is at best only half of the truth. Consciousness requires feeling. Our search for the intelligent machine is therefore an equal mix of technology and emotion". Sometimes new technologies bring us to this questions again. Aristotle opened his Metaphysics with: What are we? What will we become? Perhaps no better opportunity exists for us to answer these questions, and continue our evolution, than in the quest for the intelligent machine (Durkin 2003). One of the limitations of the VRLE technologies is that computers can only show us the surface of things. However, our own natural senses do it as well. They bring us images of the external world our brains interpret as composed of distant objects surrounding us. In the case of both sight and hearing, no contact with external objects is necessary. Just reflected or emitted light rays pass through our corneas, and only aerial compression waves batter our eardrums. Our other senses however require material contact with external objects. For example, the difference between a touch and a skin-piercing wound is only a few pounds of extra pressure. Tasting and smelling gives us for example information of the qualities of things around us.
VRLEs do not lack in powerful emotional stimulation but these limitations might be one of the reasons it is necessary to use them in the context of conventional school environment instead of being totally used in the context of open and distance education, on an individual bases. In the classroom, the students have the closeness to each other and the teacher. Our brain does much more than just process pictures and noises. It integrates all our sensory inputs to make us believe in a persistent, solid world that contains other people besides ourselves who may have intentions toward us. We might even have special brain circuits for interpreting other people's facial expressions. Nothing we see is emotionally neutral; it is either good or bad for us, and tagged as such in memory. Not everything we see necessarily exists: the brain continually calls on memory to fill in those parts of the world as it lacks the bandwidth to monitor in real-time. Just like a VRLE technology, the brain can visit its database to change the world from inside, in addition to perceiving the one outside.
Computers are essentially generators of realities and channels for communications. A VRLE generates a direct experience of the computational environment (Winn W. (1993). The characteristics of VRLEs could be described as those of good teaching. The teacher wants to create an environment

that he can manage (curricula) and in which the students participate. But virtual experiences are not just the one we experience in VRLE environment. All we do to educate with words and pictures can be seen as virtual experience. We can vary location, scale, density of information, interactivity and responsiveness, time, and degree of participation.
Using the VRLE inside the conventional classroom in the context of constuctivist learning through CSCL is meant to minimize the cognitive load students often expirience in an traditional teaching and learning context (Daniel K. Schneider 1996). The students' autonomy and freedom to make their own choices about their projects is higly respected by the teacher (Thorsteinsson 2002). The VRLE offers students access to the Internet and makes them able to communicate with the world outside of the school. At same time, they are communicating with themselves, each other, and the teacher. Using the VRLE in the classroom brings a multi-channel learning (MSL) support to the IE classroom. The students can access different source of information. They have to choose and use the information channels that support the development of their ideas and close the ones that are not supportive. They can also be taken away from their work and be bombarded with too much amount of information or they can get interrupt by entertainment material. Probably this is a way to support constructivist learning through Computer Supportive Collaborative Learning but requires self-discipline and a strict supervision from the teacher.

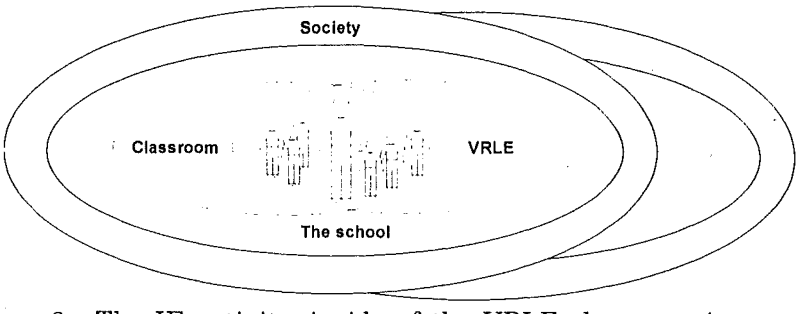

Figure 3. The IE activity, inside of the VRLE classroom is connected to the environment through multi-channel learning opportunities.

Interaction and interactivity between students and computer environments has been the foundation of constructionism developed by Seymour Papert and others (Papert 1993). Papert saw constructionism as a combination of two strands: first, "it asserts that learning is an active process, in which people actively construct knowledge from their experiences in the world. Constructionism deals with the idea that people construct new knowledge, when they are engaged in constructing personally-meaningful products" (Bruckman and Resnick 1995: 9).

VRLE technology can be defined by the interactions among the users within it, more than by the technology with which it is implemented" (Hamit 1993: 26). Multiple-user interaction is one of the major factors in creating VRLE. Interaction is also of central concern in the concept of learner autonomy. The concept of learner autonomy contains the idea that learning arises essentially from supported performance, which is central to the works of Vygotsky.

These principles could be realised quite effectively in the IE/VLE/VRLE this project deals with. The student's work has personal meaning as its origins come in the form of identified needs and problems from their home environments. In their work using the VRLE exist both human-computer interactivity and human-human interaction. This could support them to create more meaningful solutions than in a formal institutionalised classroom.

Collaboration around and through desktop computers in group settings.

Desktop based VRLEs commonly use basic computer equipment such as monitors, mouse and headset. They attempt to immerse the learners in an experience as close to actual as possible within the limitations of the equipment. The goal is for the learner to interact with both the VRLE and the actual environments at the same time in order to facilitate and improve on the collaboration that takes place in the classroom.

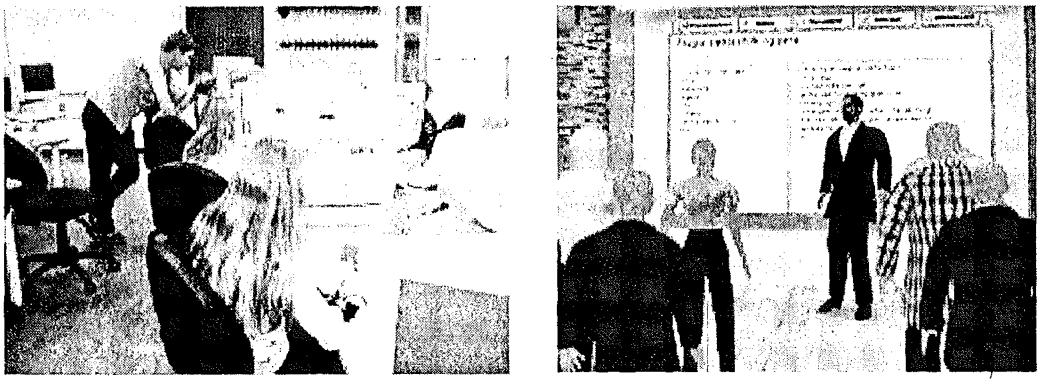

Figure 4: The teacher and students in the conventional and the VRLE classroom.

Computer Supported Collaborative Learning is not necessarily designed to replace face-to-face communication (Lehtonen, 2005). It can support and facilitate group processes in conventional face-to-face classroom based communication or be totally online for distance interaction and learning. CSCL is designed for multiple learners working at the same workstation or across networked machines. The purpose of CSCL is to support students in learning together effectively. CSCL can support communicating ideas and information, sharing information and documents, and providing feedback on problem-solving activities (Crook 1994).

Educators using VRLEs often aim for higher-order thinking skills, problem solving abilities, epistemic fluency, and collaborative development of knowledge within a field of practice. Often they include an emphasis on collaborative aspects of learning as well as individual ones, an identification of social interactions as an important element of knowledge construction, a focus on the learner(s) and their activities (Bricken, 1991; Bricken & Byrne, 1993).

VRLEs can also be considered as tools (Jonassen, 2000; Vygotski,1978) to support ideation (Thorsteinsson and Denton 2005). When such tools are used in social settings for socially important learning processes, providing objects for shared attention and activity, we could consider them as sociomental tools (Jonassen, 2000).

VRLEs can be more sophisticated than previous approaches of computer support in education. As an often social learning context there are an infinite number of variables. It is therefore more difficult to evaluate the effectiveness of VRLE activities (Bricken, 1990). Nevertheless, all actors involved in VRLE based CSCL processes, need to have evidence of whether, how, and when expected improvements in learning take place.

The Icelandic Innoed VRLE

Virtual Reality (VR) can be defined as "the idea of human presence in a computer-generated space" (Hamit 1993: 9), or more specifically, "a highly interactive, computer-based, multimedia environment

in which the user becomes a participant with the computer in a 'virtually real' world." (Pantelidis, 1993: 23). Virtual Reality systems have been used for many different purposes. Probably the most common are games and occupational simulators. However, Virtual Reality has also been used for educational training and online meetings.

Because the software used in the IE project is a managed learning environment and includes the InnoEd Virtual Reality, it has been named a Virtual Reality Learning Environment (Thorsteinsson and Denton 2006). Hall (2001) defines the managed learning environment or e-learning environment as all-in-one solution software designed to facilitate online learning for an organization. It includes the functions of a learning management system for those courses within the learning environment in addition to teaching and learning materials. A learning environment is characterised by an interface that allows students to register and partake in courses. The program will usually include self-instructional portions, along with an academic structure. This model is often facilitated by an instructor, where a group can proceed on a week-to-week basis with seminar assignments (Paulsen 2003).

The original idea behind the InnoEd VRLE was to find a new way of supporting ideation using virtual tools inside the managed learning environment (Thorsteinsson, Denton, Page and Yokoyama, 2005). The VRLE is accessed from the InnoEd site (http://www.innoed.is). It includes an e-mail system, discussion forum, and all features associated with content delivery and evaluations. Students can record needs found and solutions and share them with others as text and drawings. The immersive VRLE 3D interface comprises numerous functionalities. Eight predefined avatars, which represent the user as a human figure in the 3D environment, are available, both as children and as adults. Five movements can be performed with these key board-controlled avatars: nodding or shaking the head for yes or no, gesturing, "*come here*", waving hello, and shaking hands with the right hand. As for communication functionalities, the 3D environment offers chat, audio, PowerPoint slide projection screens, websites, file sharing screen, smart board, and video board. The 3D environment features different physical places where avatars can meet: main entrance, classrooms, group workroom, conference room, and corridors (Lehtonen, Page, and Thorsteinsson 2004), (see Figure 5).

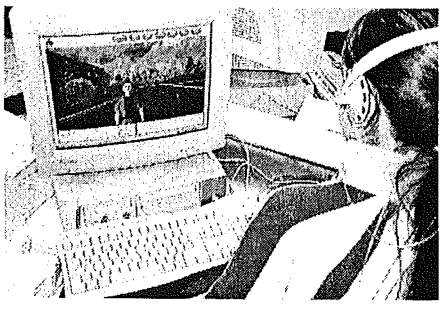

Figure 5: A student using the Interface of 3D Virtual Reality Learning Environment Featuring Avatars from the student's perspective.

The student's autonomy in a collaborative model is fundamental within IE as the student brings his/her ideas into the school and works with them (Denton and Thorsteinsson 2003). This can promote a wider socio-economic view of inventive thinking and wealth creation. This makes Innovation Education different from most other school activities. Being in a VRLE might give the student, more freedom to think and act independently and communicate in an environment without borders (Vezina el al 2004), (see figure 6). However, the students can communicate with the outer world through the Internet and access knowledge from it to bring their ideas to realisation, but their

work is based on the IE ideation process.

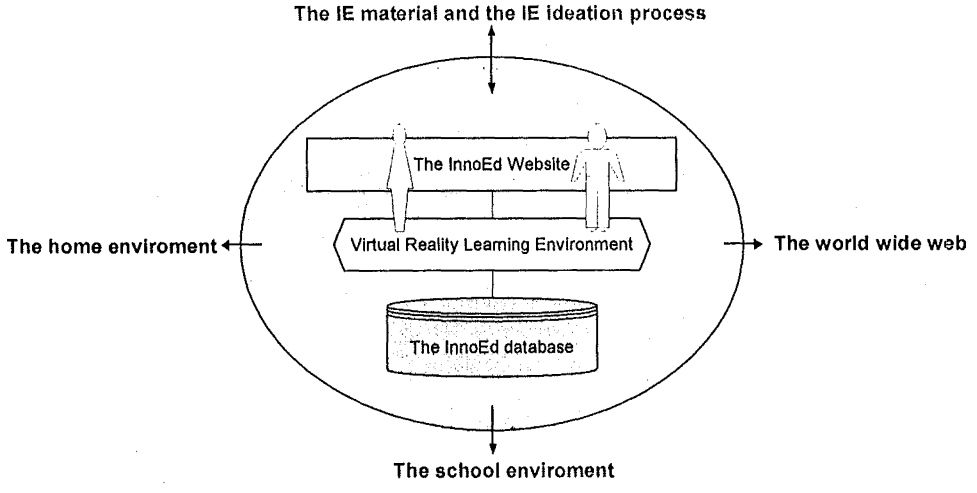

Figure 6: The Database Support of the Virtual Reality Learning Environment.

Conclusion

The Constructivist theory has been a useful basis for developing the IE VRLE. Earlier research implies that the IE pedagogical model can be used as a sociomental tool for bringing students closer to their zone of proximal development (Vygotsky 1978, Jonassen 2000). One of characteristics of the IE pedagogical model is the connotation to the students environment when needs and problems are identified at home. This part if the pedagogy gives the IE a personal meaning for the students (Gunnarsdottir 2001) and is a support to cognition in the IE classes. It has been defined as a constructivist learning process. Using the VRLE in the classroom supports multimode communication and offers Computer Supportive Collaborative Learning opportunities to support Ideation inside of the on-going IE innovation process, in the conventional classroom. Throughout the VRLE the students can access the environment in different ways that increases their possibilities for a meaningful education.

VRLE theory states that students can explore and make mistakes safely in a VRLE as it is computer created and physically safe for the students. It can be used for establishing a basis for different educational experiments and experiences that would not be impossible in the physical world. However there are health and safety issues also concern the use of computers and displays in schools and have too be taken in to account. Over-long use of computers can cause stiffness in the neck, shoulders and eyestrain. The use of the VRLE is also seen as multi-channel learning technology that requires a big attention from the students and can include overwhelm of tropism that can easily take their attention away from their work. The VRLE can not be disturbed from irrelevant people. The class privacy is secured in the specific VRLE version as it is closed for visitors from outside of the system. An access code is needed, before the users can enter the VRLE and other than the users can not disturb the work.

How do we evaluate student learning supported with the VRLE affects their ideation skills and

cognition and how can we understand how it affect the already established pedagogical model focusing on ideation? The primary author has already undertaken an action research based case studies to develop the application of the VRLE to support ideation in IE conventional classes (Thorsteinsson and Denton 2006). The next step is to observe the VRLE's impact on the already defined IE pedagogical model out from conventional classes context. This approach has to be based on earlier research and the pedagogical model already established for IE. According to the above it would look closely at the teacher role and the students social interaction in the light of constructivism and VRLE Computer Supportive Cooperative Learning. Using the VRLE aims to promote social interaction and collaboration computer support among students to support their ideation skill in the process of innovation. In relation to earlier research (Gunnarsdottir 2001) the teachers role was important as if it is were overwhelming the students tended to stop using their experience and little innovative work will happen. The students interaction with each other, also appeared to be an important factor to stimulate the evolution of ideation skills and knowledge within the IE lessons (see figure 2).

What would be the appropriate research methodology for such research? Conventional scientific paradigm models of research and evaluation cannot be used as the IE is a complex and dynamic sociological/educational context. It is therefore necessary to use a different paradigm to inform subsequent research design. Grounded Theory approach (Glaser and Strauss 1967) based on iterative paradigm though an observational analysis work would be a good option for such research. This would be supported by the above disused issues, the IE pedagogical model, constructivist theories and CSCL.

To find out the educational efficacy of using the VRLE in the classroom requires development of appropriate and meaningful forms of assessing this new mode of learning support. This could be done by looking at the differences between a traditional classroom based pedagogical IE model and the same model supported by the VRLE. The outcome might look as seen by figure 7.

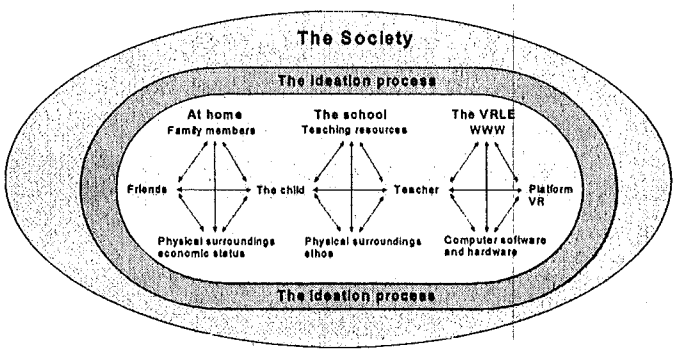

Fig 7: The figure shows the VRLE as a contribution to the former pedagogical model.

The literature indicates the importance of observing the VRLE as constructivist learning tool based on CSCL processes. To see the pedagogical value of collaborative VRLE for ideation and how it affects the earlier pedagogical model it is important to look at the activity in the classroom when the students are using the VRLE and observe the following:

- How long it takes them to learn to use the interface, become immersed and comfortable with the environment.
- How much the students and the teacher use the VRLE in the classroom.

- The social interaction with and without the VRLE. How the teacher and the students communicate within and outside of the collaborative VRLE environment and the meaning of the collaboration when the ideation take place.
- The difference between the students' collaboration in a classroom with and without the VRLE and its role during the ideation.
- To talk to the teachers about how they have adapted pedagogical models to accommodate the VRLE.
- How the teachers role differs from conventional based classes and how it affect the students ideation skill when using the VRLE.

The VRLE might be useful to reinforce the process of ideation. The pedagogical understanding of using the VRLE for Ideation has to be developed further, though research. The basis of the technology is already part of the daily lives of young people, but to date less advanced in general education. The indications from the literature show that we need to explore and understand the application of the VRLE to support ideation and its impact on IE pedagogy further. This has to be based on constructivist learning and computer supportive collaboration. It is intended that this will give a clearer picture of the pedagogical values of using VRLE for Innovation Education in Icelandic schools.

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