

Developing an understanding of the pedagogy of using a Virtual Reality Learning Environment (VRLE) to support Innovation Education (IE) in Iceland: a literature survey

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Abstract

Innovation Education (IE) is a new subject area in the Icelandic national curriculum. The aim is to develop students' abilities to innovate, with a particular focus on ideation skills. A Virtual Reality Learning Environment has been subsequently developed to provide a supplementary context for teaching and learning Innovation Education with certain advantages over conventional classroom activity. This paper reports on the literature search which was conducted to support an action research project aiming to develop an understanding of an appropriate pedagogy relating to this context.

The authors firstly describe the context for the research. The literature review strategy is based on the research questions:

1. How does the use of the VRLE affect the pedagogy of developing students' ideation skills in Innovation Education in the Icelandic context?
2. What are the key issues concerning the teacher's role in using the VRLE for supporting students' ideation in IE?

Terminology in the area of ideation, innovation, and virtual reality learning environments is defined and relationships established. The characteristics of VRLEs are illustrated. The pedagogy used with IE in a conventional classroom setting, prior to the introduction of the VRLE, is presented.

Pedagogical models on using virtual reality learning environments in school education are then explored. Many are related with Constructivism, Computer Supported Communication Learning, and Computer Mediated Communication. Principles are identified and contrasted with IE pedagogy as it stood before the introduction of the VRLE and subsequently with its use.

Conclusions are drawn enabling the authors to conduct an action research phase of the project in which the VRLE was used by teachers and pupils in Icelandic schools.

Key words

Innovation Education, Virtual Reality Learning Environment, Pedagogy, Constructivism, Computer Supported Communication Learning, Computer Mediated Communication, Ideation, Idea generation, Ideation techniques

Context

The context of this paper was the development of Innovation Education (IE) as a new subject in Icelandic schools. This subject was aimed at developing students' abilities to innovate and uses various conventional techniques to help students identify real needs in their environment and propose concept level solutions. This differs from UK Design and Technology, for example, which normally takes students through to realisation of prototypes. There are significant similarities between IE and the 'front-end' of design and technology activities (see figure 2 below or visit: www.innoed.is).

One of the authors saw opportunities in developing a parallel approach to IE teaching and learning employing a supporting Virtual Reality Learning Environment (VRLE). The specific VRLE is a combination of a Managed Learning Environment (MLE) and a Virtual Reality (VR) application. This offered several potential advantages: as a supplement to conventional classroom based IE activity it provided variety and novelty, the VRLE would enable pupils and teachers to interact in different ways, perhaps taking on other personalities in forms of role play. The VRLE could be populated with a variety of learning contexts which would enable students to explore ideas beyond the confines of the school safely (Cromby et al, 1995) yet in a manner which promotes motivation (Ainge, 1996, Bricken & Byrne, 1992, Johnson et al, 2002, Song et al, 2000).

New VRLE software was designed but the pedagogy of using it needed to be developed and understood. A research project developed which aims to explore specific issues within the development. This follows a broadly illuminative paradigm (Parlett and Hamilton 1983) which hopes to build understanding through 'grounded theory' (Glaser and Strauss, 1967). It uses a case study approach (Stenhouse, 1983) as a means of developing that understanding. In addition, part of the work involves action research (Cohen et al, 2003) in that it is a small-scale intervention in the functioning of an on-going curriculum development project and an examination of the effects of that intervention.

The project started with the proposition that 'A Virtual Reality Learning Environment can be used to support ideation in Innovation Education (in the Icelandic context)'. A literature review was designed to answer questions relating to the proposition:

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1. What do the central concepts mean? Innovation Education, ideation and Virtual Reality Learning Environments.
2. What prior research projects have been undertaken on the pedagogy of Innovation Education?
3. Can existing pedagogical theories be used to understand, and demonstrate an appropriate pedagogy of using a Virtual Reality Learning Environment in Innovation Education?

The review started by defining the topic and its fields. Key words were identified, explored and used for searching for appropriate literature in the field. This used online catalogues together with search engines such as Metalib, Ultraseek, Scholar and the Icelandic web portal hvar.is (English translation: where. is). Data has also been found in: books, reference materials, journals, conference papers, dissertations, indexes, printed abstracts, electronic databases, government publications, and theses. Key words included: ideation, idea generation, innovation, innovation education, inventions, design, information and computer technology, virtual learning environment, virtual reality, creativity and problem solving. In addition, keywords were generated by 'snowballing' while reviewing the literature.

Structure

The paper next defines terms and their relationships (2.0). The pedagogy used with IE in a conventional classroom setting, prior to the introduction of the VRLE, is presented (3.0). Prior research in IE is reported in 4.0, followed by pedagogical models relating to VRLEs in 5.0, specifically constructivist theory (5.1), computer-mediated communication (5.2) and computer supported collaborative learning (CSCL) (5.3). Finally conclusions are offered (6.0).

The central terms used in the enquiry

The most important terms relating to the project are ideation, innovation, and virtual reality learning environments. This section explores them, defines them and describes the VRLE technology used for this project.

Innovation

Innovation is the action of innovating; the introduction of novelties; the alteration of what is established by the introduction of new elements or forms (The Oxford English Dictionary, 2006). The terms creativity and innovation are strongly connected but much studied in isolation by researchers using different methodologies and pedagogical models. Innovation is generally defined as useful novelty. It is not novelty for its own sake, but novelty that can be applied and add value (Oldham and

Cummings, 1996). The word 'innovative' comes from the Latin word 'innovare'; 'to renew' or 'to make new' (Webster Dictionary, 2005). Innovation includes the generation of ideas, alternatives, and possibilities (Smith, 2001). Smith considered innovation to be a form of problem solving that begins with the feeling that change is needed and ends with a successful implementation of an idea. Nevertheless the authors also consider that innovation is not necessarily linked to 'problem solving', but can be opportunity based. An example may be finding uses for a new material; not a problem but an opportunity.

Rogers (1983:11) stated, "Innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption. It matters little whether the idea is "objectively" new as measured by the lapse of time since its first use or discovery. The perceived newness of the idea for the individual determines his or her reaction to it. If the idea seems new to the individual, it is an innovation." The novelty in a student's work has an individual meaning that has to do with the individual's ability to deal with their worlds by calling upon their creative talents on a daily basis (Denton and Thorsteinsson, 2003).

Innovation, therefore is different from creativity in that it is the application of creative new ideas (Smith, 2001). Creativity is the generating and articulating of new ideas. Gurteen (1998) similarly defines creativity as the generation of ideas whereas innovation is about putting these into action by sifting, refining and implementing. It follows that people can be creative without necessarily being innovative, for instance, if they have ideas, but do not implement them. Similarly, individuals can be innovative without being creative. If they apply or implement ideas from elsewhere then they are innovative, even though the ideas, were not their own. For example, the technology behind the Sony Walkman (a personal cassette player) existed; the innovation came in miniaturisation and the new context of use.

Ideation

Ideation is a concept derived from Guilford (1950) and used to describe a pattern of interactions that form when a person works on and produces an idea. Ideation is the formation of ideas or mental images of things not present to the senses (The Oxford Dictionary, 2006). In the Webster Dictionary (2005), ideation is defined 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".

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Santanen (et. al, 2004: 23) stated that ideation activities are fundamental to the process of creativity. However, reflection on the definitions in the previous paragraphs shows that the process of innovation clearly requires ideation skills. Ideation is important during innovation, including the development of ideas about problems to solve and solutions to those problems (Doolittle, 1995). Divergent thinking (Guilford, 1950), a cognitive process that focuses on developing multiple possibilities rather than finding a single solution, may result in greater ideation. A specific ideation tool often used in design and innovation contexts is mind-mapping (Buzan, 1983, other terms used include brainstorming).

Virtual Reality (VR) and related terms

The term VR is today used in a variety of ways and often in a confusing manner. Originally, the term referred to 'Immersive Virtual Reality' in that the user becomes immersed in an artificial world that is generated by a computer. The term 'Virtual Reality' (VR) was initially coined by Lanier (1989). Other related terms include 'Artificial Reality' (Krueger, 1991), 'Cyberspace' (Gibson, 1984), and, more recently, 'Virtual Worlds'. These have operated in educational, training and recreational contexts, a recent example of the latter being 'Second Life' www.secondlife.com

Cruz-Neira, Sandin, and DeFanti (1993) consider 'virtual environment' to be a better term. They note that VR implies a total substitution of something synthetic for something real, whereas a virtual environment is more suitable as a facsimile for a real or imagined environment. This is a reasonable observation as it also raises the issue of the need to differentiate the VR or 'environment' itself from the technology which is used to run it. Some platforms offer a 'reality' which uses conventional personal computer (pc) based inputs and outputs such as mouse and screen, a recreational example being 'Second Life'. At more sophisticated levels, for example advanced aircraft cockpit simulators, technologies are used to offer far closer simulations of reality. Nevertheless, at the root of all of these lies the individual's ability to use their imagination and to become part of the VR or environment, whatever the level of platform it is operated on. As Harnit (1993:9) put it "the idea of human presence in a computer-generated space" 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). In turn McLellan (1996) described VR as a communication technology that involves the human senses in new ways and allows the user to interact with data intuitively. In this work the authors have adopted the term VR as it appears to be that most generally in use today.

Zeltzer (1992) has proposed a framework for the characteristics of VR based on three dimensions; autonomy, presence, and interaction. There is also another characteristic; the concept of telepresence, that is useful for understanding applications of the VR (Bowman, 2000).

Some claim that VR is no more than a combination of multimedia systems (Dede, 1992). However, VR has unique characteristics that can be used to improve students' understanding and learning performance. Ignoring this premise has led to problems with a lot of earlier research in educational technology (Clark, 1983, 1985). It is therefore important to identify the unique characteristics of VR that might improve this understanding and performance in an educational context.

Loeffler and Anderson (1994) note four elements that make a VR. It is: three-dimensional, computer-generated, a simulated environment, and in real-time. We can extend these by noting that a VR can be used by a single operator, and also for multi-user communications.

In this paper the term Virtual Reality Learning Environment (VRLE) is used, as this underlines the educational context of the work. Another reason is the interaction with the managed learning environment embedded within the VRLE being studied. The VRLE is an educational technology used in IE classes that allows students and teachers to explore and manipulate a computer generated managed learning environment, which includes a 3-dimensional real time VR. The VRLE is hosted with an underlying database that meets the user's further expectation for it as an educational environment (Thorsteinsson and Denton 2006). The students' work can be hosted, revisited and used for discussion between pupil and teacher.

The Icelandic VRLE and Computer Supported Collaborative Learning

The Icelandic VRLE is desktop based and designed to enhance ideation via collaborative learning. This was based on work by Thorsteinsson (1998, 2002), Gunnarsdottir (2001), Osberg (1994), Bricken (1991), Jonassen (2000).

The goal is for the learner to interact with both the VRLE and the actual environment at the same time in order to facilitate and improve on the collaboration that takes place in the classroom. The teacher's role is to establish a framework within the VRLE in order to enable Computer Supported Collaborative Learning (CSCL). Subsequently, when running the VRLE, the teacher's role moves to one of facilitator.

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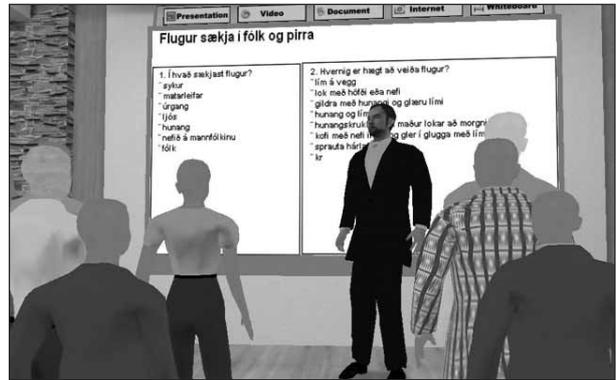


Figure 1: The teacher and students in the conventional and the VRLE classroom.

Collaborative learning is a term for approaches that include joint intellectual effort by students (O'Donnell, et al, 2006). This can include collaborative writing, group projects, and other activities. When collaborative learning uses computers it is then termed Computer Supported Collaborative Learning. CSCL has emerged as a new educational paradigm among researchers and practitioners in several fields, including cognitive sciences, sociology, and computer engineering (Crook, 1994). This area is explored further in section 5.2 below

The Icelandic VRLE aimed to offer multimodal communications, such as using email, real-time texting, voice over the IP, and using avatar body language, in order to strengthen ideation within the innovation process.

The pedagogy of Innovation Education

Innovation Education (IE) has pedagogical values, in the context of both general education and as 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 Thorsteinnsson, 2003). Zhuang et al, (1999) described the context of Innovation Education 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

The main emphasis of IE is developing students' ideation skills (Gunnarsdottir, 2001). By strengthening individuals' ideation in a general educational context they are meant to be better able to deal with their world and take an active part in society.

The IE process is a simple way to teach ideation skills. The flowchart 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.

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

1. Identifying needs in one's own environment
2. Brainstorming
3. Finding the initial concept
4. Ideation drawings or modelling to develop the technical solution
5. Making a description of the solution in addition to the drawing
6. Presentation.

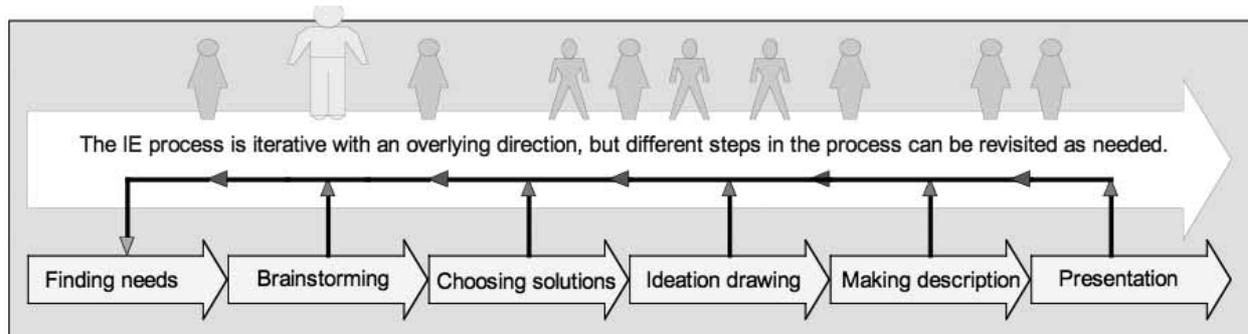


Figure 2: Ideation within the IE working process.

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Ideation, therefore, 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.

Research into IE

Two projects have been undertaken on Innovation Education, both prior to the development of the VRLE, when IE was taught in conventional classrooms. The earlier project, (Gunnarsdottir, 2001), was done to increase understanding of how students learn. The later, (Jonsdottir, 2005), looked for factors that influence the implementation of the Innovation Education curriculum in Iceland.

Gunnarsdottir (2001) tries to understand how students learn through their social/collaborative activities in IE. She put forward a model (see fig 3.) on interactions in IE (Gunnarsdottir, 2001).

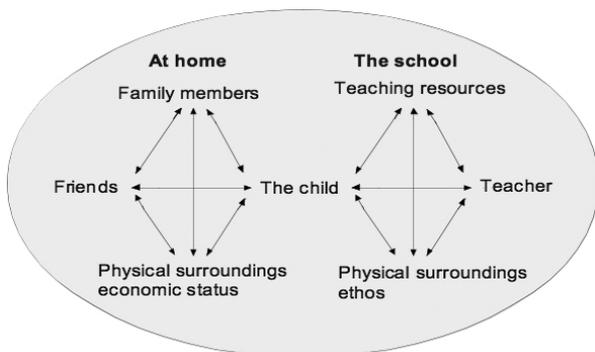


Figure 3: Model of interaction between the student, environment, the teacher and IE (Gunnarsdottir 2001)

The research concluded that the IE paradigm is related to social constructivism (Edwards, 2001). This is based on the work of Dewey, Piaget, and Vygotsky. It is based upon the theory that new knowledge is an active product of the learner integrating new information and perceptions with prior knowledge. Social constructivists study how people use social activities to change their conditions of existence and self-image (Shotter, 1993:111). Gunnarsdottir (2001) uses these theories to explain how individuals become active participants in the culture that surrounds them in and outside school (Edwards, 2001). Gunnarsdottir demonstrated that the extent to which a high degree of learning autonomy and limited direct instruction by the teacher can be indicative of Vygotsky's Zone of Proximal Development (Vygotsky, 1978). Gunnarsdottir (2001)

points out that in the IE process students use ideation skills and prior knowledge to suggest solutions and build their self-image as innovators. Students can work collaboratively and this significantly moulds the contents and working methods. They also use their teachers as one of several types of resource (Edwards, 2001). The role of the IE teacher is to create circumstances that support or scaffold students' learning and to be a source of information that facilitates the activity of the student (Gunnarsdottir, 2001).

Pedagogical models relating to VRLEs

The IE pedagogical model (figure 2, page 18) provides a basic framework for IE activities in the conventional classroom (that is, without the VRLE). Using the VRLE, however, opens new pedagogical opportunities and issues that have to be understood. Three areas of theory appear to be particularly relevant: Constructivism, Computer Supportive Collaborative Learning (CSCL) and Computer Mediated Communication (CMC).



Figure 4: Students using the VRLE to communicate ideas and develop solutions

Constructivist theory relating to VRLEs

Piaget and Vygotsky (Bricken, 1991; Bricken & Byrne, 1993) introduced the constructivism and social cultural 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 interaction in groups can create the cognitive conflict and disequilibrium that leads an individual to question his or her understanding and try out new ideas. Vygotsky (1978) illuminated the role of opposition and equilibration in learning. He was interested in the role of inner speech, the learning of concepts, the

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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: 44).

According to Slavin (2000) Vygotsky's theories have been utilised as support for classroom-based methods that utilise cooperative learning (see, also section 2.4 above), 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 processes, knowledge and skills. This cooperation can strengthen the learning outcome as well as help clear misunderstandings. 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 principle is that children best learn concepts that are in their zone of proximal development. The zone is 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: 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 location 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 and teacher generated frameworks in which this collaborative learning might take place (e.g. Newman, Griffin & Cole, 1989).

Bricken (1990) theorises that immersive applications of VRLEs are a 'very powerful' educational tool for constructivist learning. The hidden curriculum of VRLEs could be: "make your world and take care of it. Try experiments, safely. Experience consequences, then choose from knowledge" (p. 2). Bricken (1990) and Osberg (1994) have also theorised about VRLEs as a tool for experiential learning, based on Dewey's, Vygotsky's and

Piaget's ideas. According to Bricken, a VRLE can teach active construction of the learner's environment. As the VRLE is a computer-created reality it is safe for the students, in a physical sense, and can be used for establishing a basis for different education experiences that would both be impossible and unsafe in the physical world. There are issues relating to psychological dangers and web-based systems. The Icelandic VRLE is closed to visitors from outside of the system, by access code and password protection.

Constructivist learning models aim to support knowledge construction and to develop self-motivated, independent, intellectually stimulated learners (Wiske, 1994, Unger, 1994, Poplin, 1991, Duffy & Jonassen, 1992, Arnold, 1991). A VRLE can make a contribution to knowledge construction, as it is an environment in which students can imbed and extend their understanding, in both a visual and an interactive manner. When acting in a virtual world, students can ascribe meaning to objects, relationships and behaviours in a way that mirrors their personal understanding (Osberg, 1995).

VRLEs give students opportunities to interact directly with information embodied in a visual, virtual, form (Mones-Hattal & Mandes, 1995, Gigliotti, 1996, Rose, 1996). Interaction is an essential component to students' knowledge construction, both in a virtual or conventional educational environment (Byrne, 1996). Nevertheless, a VRLE can offer more than an opportunity for interaction; it can connect the whole body in a way that is valuable for developing body (somatic) memory (Kraft & Sakofs, 1989, Samuels & Samuels, 1985). It can supply the students with a possibility to communicate with the environment as if they were physically present in the computer-generated 'space' (Hoffman, Hullfish, & Houston, 1994). The possible value of this duality has been discussed by VRLE theorists (Hiem, 1994)

Computer-Mediated Communication

Computer-Mediated Communication (CMC) focuses on social effects of applying various computer-supported communication technologies. CMC is every form of communication, via computer-supported media between two or more persons who interact with each other (Wolz et al., 1997). CMC is a low-cost alternative for facilitating teacher dialogue with students and provides the teacher and the students with an electronic form of both individual and group learning support (Schrum & Berenfeld, 1997). An important element of CMC is the idea that the use of computers for communication can alter both the types of messages and the thinking of the individuals involved (Romiszowski & Mason, 1996).

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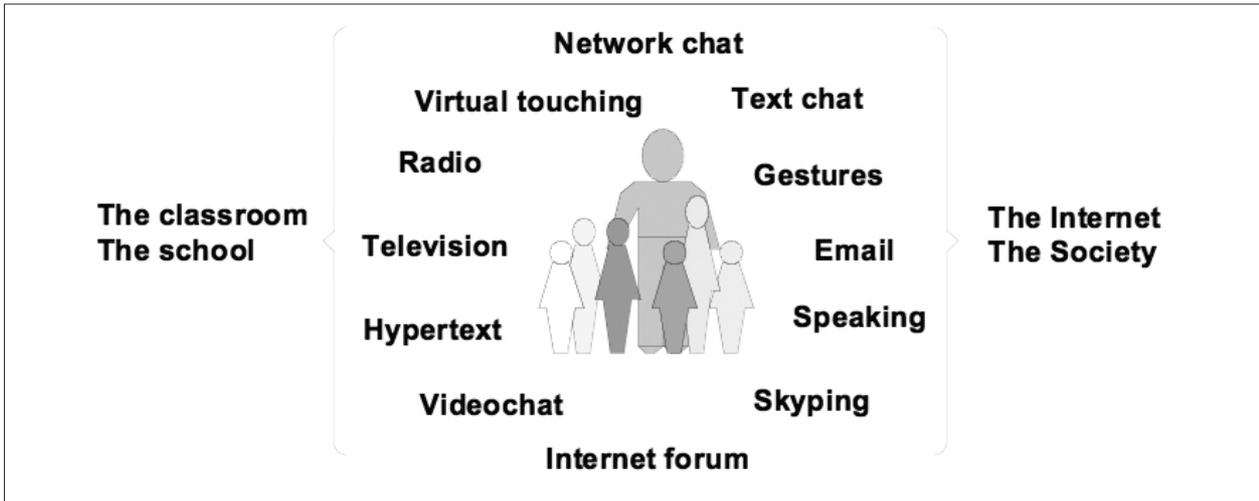


Figure 5: CMC offers various ways for communication in order to affect the group dynamic social interaction in the conventional classroom.

Many recent CMC studies involve internet-based social networking supported by social software such as VRLEs' (Schrum & Berenfeld, 1997) and specific software such as FaceBook (www.facebook.com), Skype (www.skype.com) and MSN (www.msn.com). CMC includes various forms of synchronous, asynchronous, or real-time interaction that humans have with each other using computers as equipment to exchange text, images, audio, and video. CMC includes, for example e-mail, network communication, instant messaging, text messaging, hypertext, Internet forums. CMC is very often used in a classroom setting to facilitate students' access to information in the convention classroom and to enable multi-mode communication between students and teachers. This also enables communication to the society inside of the classroom through the internet.

Computer Supported Collaborative Learning (CSCL) to support ideation

The VRLE opens possibilities for CSCL, though it is not 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 normally relates to multiple learners working at the same workstation or across networked machines. The purpose is to support students in learning together effectively, in a constructivist sense. CSCL can support communicating and storing/retrieving ideas and information, sharing information and documents, and providing feedback on problem-solving activities from both peers and teacher (Crook, 1994). It should be noted that CSCL can operate within a closed computer network, but also incorporate wider links via the internet to communications and data.

Teachers using VRLEs often aim for higher-order thinking skills, problem-solving abilities, epistemic fluency, and collaborative development of knowledge within a field of practice, in a constructivist paradigm. Often they include an emphasis on collaborative aspects of learning as well as the individual; 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).

The relevant VRLE studies found in the literature are few and none of them found, so far, concern ideation skills in the same context as this work. Nevertheless different VR applications have been used in research on creative education. For example Bricken and Byrne, (1993) undertook a study to evaluate the possibilities of using virtual reality (VR) as a learning environment (VRLE). The study examined whether children could design, build and then explore their own immersive VRLE's worlds. Results indicate that students demonstrated rapid comprehension of complex concepts and skills (Bricken & Byrne, 1993). They also reported their interest in the VRLE and a wish to use VR to establish the world they made based on their knowledge and imagination. The authors concluded that the VRLE is a powerful environment for teaching and learning (Bricken & Byrne, 1993).

Merickel (1991) designed a study in California to find out if training in 2-D and 3-D computer graphics would enhance certain cognitive abilities: imagery, spatial relations, displacement and transformation, creativity, and spatially related problem solving. He concluded that the associations between the ability to understand 2D computer graphic and solve 3D related problems were

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uncertain. Merickel pointed out that the ability to visualise and mentally manipulate two-dimensional objects depends on abilities to solve 3D related problems. He concluded that virtual reality is highly promising but needs extensive development as an instructional tool (Merickel, 1991).

VR technology has been used for ideation training and product development in the area of engineering and design. Because VR is computer based it can be used to capture ideas generated by users communicating during the innovation process (Watts, Swann and Pandit, 1998). By taking employees through a virtual model companies can avoid some potential mistakes and create a sense of employee ownership in the VR space. VR can provide suggestions that can be implemented immediately.

John Deere, the world's largest producer of agricultural machinery has been using VR software to create virtual prototypes of new earth-moving equipment. Ford Motor Company has used VR for designing vehicles. Both McDonnell Douglas and Boeing have used VR systems to enable their engineers to evaluate the maintainability of their aircraft designs before anything has actually been manufactured. Other companies in the market for construction vehicles, including Caterpillar inc. have also demonstrated an active interest in VR (Watts, Swann, & Pandit, 1998).

VRLEs can be more sophisticated than previous approaches of computer support in education, such as basic use of the Internet through web browsers and email communications. 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.

Conclusion

The literature indicates the importance of seeing VRLEs as tools that can support constructivist learning based on CSCL and CMC processes, both in schools and commercial contexts. 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 co-students and teacher and expose each other to thinking processes throughout their communication during the innovation process. This part of the IE school activity brings the students closer into their zone of proximal development (Vygotski, 1978) 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).

According to Bricken (1991) and Bricken & Byrne (1993) the use of a VRLE in conventional classrooms may support such situations (Thorsteinsson and Denton, 2006). With interactive technologies such as VRLEs, the process of constructing knowledge makes meaning from visual and aural contexts. Students can establish their work within their own environments, modify their ideas, make their own set of objects, and establish relationships. They can

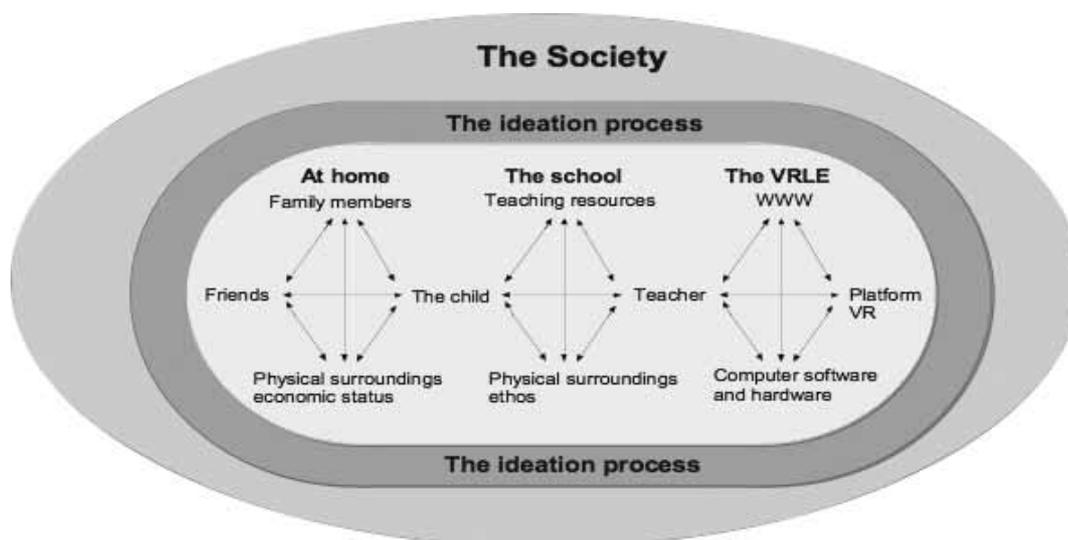


Figure 6: the VRLE as a contribution to the former pedagogical model.

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even behave in a way that is important and has meaning for them, for example play a role via the avatar. In VRLEs used in a classroom context, this can be shared and experienced through both real world and avatar interaction.

If students adjust the VRLEs they use, they get personal control over their learning process. At the same time, they develop their ability to facilitate their own learning (Winn, 1995, Osberg, 1995b). This strengthens their autonomy and control over their learning process and is a stronger experience than in a ready-made virtual world. However, there are critical issues concerning the use of VRLE technology in education, particularly the ethics of student security and cost.

To understand the pedagogical value of the Icelandic VRLE for collaborative supported ideation, it is important to look at activity both in the physical and virtual classrooms, when the students are using the VRLE. This requires the development of appropriate and meaningful forms of illuminating this new mode of learning support. This could be done by looking at the differences between a traditional classroom based pedagogical IE model (see figure 2) and the same model supported by the VRLE. The outcome might look as represented by figure 6.

An understanding of the pedagogy of using the VRLE for ideation has to be developed further by practitioner action research. This has to be based on constructivist learning and computer supportive collaboration. This will give a clearer picture of the pedagogical values of using VRLE for Innovation Education in Icelandic schools. The basis of the technology is already part of the daily lives of young people.

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