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Ideation in a Virtual Reality Learning Environment: A pilot project from Iceland in Innovation Education

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Abstract

Innovation Education (IE) is a new subject area in Icelandic schools. The aim is to train students to identify needs and problems in their environment and to find solutions: a process of ideation. This activity has been classroom based but now a specific Virtual Reality Learning Environment technology (VRLE) has been created to support ideation. This technology supports online communications between students and teacher and enables them to develop drawings and descriptions of the solutions. The VRLE is Internet connected and the students work online with their ideas in real time. As this learning environment is new it is important to evaluate and explore its use and value in supporting ideation in the context of IE.

The primary author has run a series of pilot studies to identify the pedagogical issues of using the new VRLE to support ideation within IE. In this paper, he discusses the background of Innovation Education in Icelandic Education and reports the pilot studies.

The main aim of the pilot studies was to explore the ways in which ideation was developed in students when using IE materials within the VRLE. The researcher used the following research questions:

a. What are the pedagogical issues of using the VRLE for ideation in Innovation Education?

b. Which issues influence the ideation process in the VRLE in Innovation Education?

c. How can the teacher effectively manage such issues?

These questions were explored using a range of specific techniques in an action research model. Data was gathered from three, triangulated, pilot studies. This was analysed and used to prepare a new set of research questions and a more developed exploration using a subsequent series of case studies.

Key words

Innovation Education, Virtual Reality Learning Environment, ideation, ideation process, pedagogical model

Introduction

The context of this research project is the development of the new Icelandic Innovation Education (IE) subject, its pedagogical model and a supporting Virtual Reality Learning Environment (VRLE) (Denton and Thorsteinsson, 2003). The aim is to gain a greater understanding of the pedagogy of using this VRLE in support of ideation in Innovation Education in Icelandic schools. Pilot studies were built on the curriculum development in the InnoEd project (Thorsteinsson, Lehtonen, Page, and Ruokamo, 2005).

This pilot study was concerned with the exploration and development of the ideation process when students used the IE learning resources within the VRLE. The researcher undertook a series of action research based case studies built on an interpretive research paradigm to understand the complex and dynamic sociological/educational context.

The following research questions were used:

a. What are the pedagogical issues of using the VRLE for ideation in Innovation Education?

b. Which issues influence the ideation process in the VRLE in Innovation Education?

c. How can the teacher effectively manage such issues?

This paper will explain the background of this project, the ideation process in Icelandic Innovation Education and the VRLE environment. It will explain the research methodology and the outcomes. Finally, the authors discuss the results of the research and indicate the next phase of work.

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Innovation Education in the Icelandic context

This project took place in secondary schools in Iceland. It concerns the ways in which school students develop their ideation skills using the VRLE. The project is based on existing curriculum development undertaken in Iceland, since 1992 (Thorsteinsson, 1998). Work has already been done on the VRLE though the European InnoEd project (Page and Thorsteinsson 2004) where it was adjusted to the IE pedagogical model. Innovation Education is already established as a subject in the Icelandic National Curriculum (1999). Schools are running classes based on the pedagogy described by Gunnarsdottir (2001). Many schools in Iceland and seven other countries (Norway, Finland, England, Estonia, Denmark, Saudi Arabia, Romania) have been using the VRLE for several years and are still using it as a support to class based activities and for the young inventors' competitions (Thorsteinsson, 2002).

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 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.

Hoyle (1972:176) described innovation as a concept that refers to an idea or practice which is perceived by a group of people to be a significant departure from existing practice. Innovation is described as embedded in social processes, which take place over time and are a part of the social reality of a community of people.

Innovation, as defined in this research project, is a creative school activity. So what is the difference between a creative activity and ideation? It has pedagogical values that lie in the context of general education. "Students can best utilize their creativity when given the opportunity to mature and develop in a conscious and targeted manner. Innovation work emphasises that the individual uses their power of creation to mould their environment. Innovation work is intended to encourage this aspect of a child's

character and thereby strengthen the stability of future societies. The heart of the theory might be stated, 'Man is the creator of his human world'. (Thorsteinsson 1996:6).

Innovation Education (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 (Thorsteinsson 2003). Innovation Education, in Iceland, is now an optional cross-curricular subject within the National Curriculum (The Icelandic National Curriculum 1999).

Ideation is a concept derived from Guilford (1950) and used in this research 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 Webster 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". Imagination is, in general, the power or process of producing mental images and ideas (Webster Dictionary 2005).

Santanen (et. al 2004:23) stated that ideation activities are fundamental to the process of creativity. During an ideation session, one or more people work to generate as many solutions to the problem at hand as they can in the hope of finding solutions that might otherwise go undiscovered. A solution is deemed to be innovative to the extent that it is feasible to be implemented and that it falls outside the set of known solutions. What might be genuinely creative in one student may be something that has already been done, nevertheless there is value in this activity.

In the context of design, ideation has also been defined as a structured approach to thinking for the purpose of solving a problem, often employing graphic representation. One tool that is often used in this area is 'brainstorming'. This was originally coined by Osborn (1953) and developed by others including Buzan (1982). Brainstorming (sometimes referred to as Word Storming or Thought Showering) is a method for generating ideas by thinking without interruption or imposed constraints. When individuals brainstorm, they use their imagination to come up with as many ideas as possible. In Innovation Education, this is done by searching for solutions in order

to fulfil a certain need or problem the students have found in their environment. Brainstorming is recorded for subsequent use using words, notes or images rather than linear lists. Usually the Brainstorming takes place in a cognitive network (people working in groups) in response to stimuli. There is a strong case for group collaboration when brainstorming complex problems (Osborn 1963). Brainstorming is a specific skill within ideation.

Ideation is used primarily in the conceptual phase of a design process. Feasibility studies are often performed to define the problem, identify important factors that limit the scope of the design, evaluate anticipated difficulties, and consider the consequences of the design (McGraw-Hill, 2002). Analogous to this, the Innovation Education student focuses on the 'front-end' of the design process, i.e. the identification of needs/problems, initial concept generation and the development of basic solutions using simple models (Thorsteinsson and Denton 2003).

The ideation process in the Icelandic Innovation Education (IE) context

In this project, the term ideation is the method by which students work through the Innovation Education course. 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 facilitating creativity for ideation (Gunnarsdottir 2001).
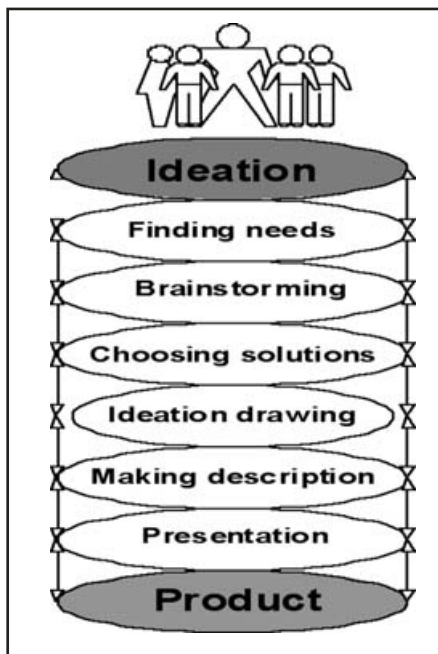

Figure 1: The ideation working process as used in the research project

a. Finding the needs
Students explore their environment beyond the school and identify needs or problems. Most often, they use a notebook. Students speak to people, read newspapers, watch the TV, look inside school, go to shops, or use the internet in search of these needs/problems. In most cases, students will actually bring back initial solutions in their notebooks. This provides the opportunity for teachers to explore the need or problem rather than developing concepts without understanding their origin (Thorsteinsson 1996).

b. Brainstorming
The teacher writes the needs on the blackboard and students brainstorm possible solutions together. In this way, co-operative brainstorming techniques are used to expand knowledge and understanding (Buzan 1985).

c. Finding the initial concept
The students choose the concept they want to adopt after discussion with the teacher and colleagues.

d. Ideation drawings or modelling to develop the technical solution
Sketching, modelling and discussion facilitate understanding and development of the concept towards the solution. These involve self-communication and advice from the teacher (Gardner 1993). Freehand sketching can be used to explore ideas quickly. These sketches are usually rough and incomplete, typically not following the conventions of more finished drawings (McGraw-Hill Higher Education, 2002).

e. Making a description of the solution as addition to the drawing
Students provide a description of their innovation work both for display and as a basis for a presentation. Making a poster can be a good way to understand a solution. The poster will include illustrations, 2D and 3D drawings showing how the solution works, who will use it, where it could be used and the materials it could be made of.

f. Presentation
Developing a spoken presentation based on the poster is a good way of deepening the student's understanding of their concept, solution, its relationship with the environment and the original need/problem identified.

This process also develops communication skills. Discussion of the presentation offers valuable feedback to students.

The 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 this project is a managed learning environment and includes the InnoEd Virtual Reality, the primary author has named it a Virtual Reality Learning Environment (VRLE). 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 manage learning environment (Thorsteinsson, Denton, Page and Yokoyama, 2005). The VRLE is accessed from the InnoEd site (www.innoed.is). It includes an email 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 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 2).

Figure 2: A student using the interface of 3D InnoEd Virtual Reality Learning Environment featuring Avatars from the student's perspective

The student's autonomy is fundamental within the IE model 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 3). 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.
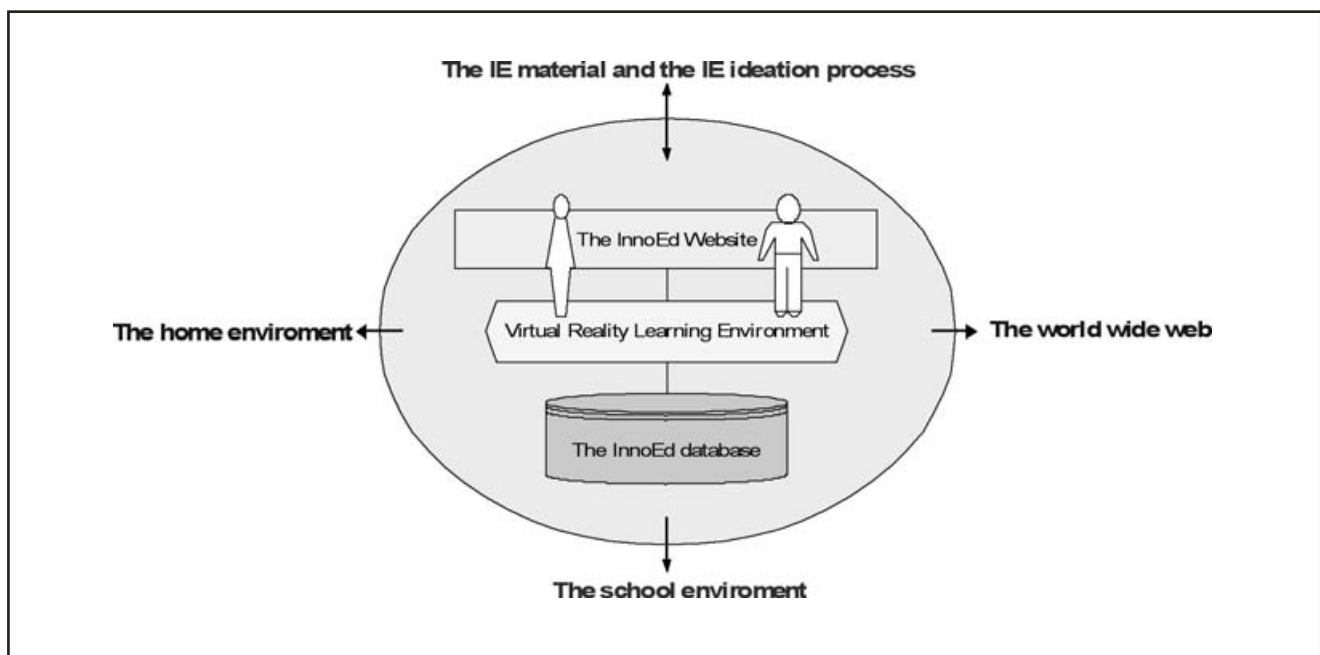
Figure 3: The Database Support of the Virtual Reality Learning Environment

Research Project Objectives

The research project is an attempt to understand the nature of specific aspects of the work conducted in this curriculum development. No research has been done so far in this new field of IE. It is important to explore the use of the VRLE as it is new; the curriculum development work needs to be critically examined, and the nature of practice evaluated.

Specific **objectives**:

1. Identify the significant contributing aspects that affect the ideation process in the VRLE in this Icelandic context.
2. Develop understanding of the **pedagogy** relating to the use of this VRLE for supporting ideation in IE.
3. Establish an **appropriate research methodology** to explore the value of the VRLE in this context.

Research Methodology

The research is interpretive as it seeks to understand and interpret the VRLE, the learning experiences of the students and the developing pedagogy used by the teachers. Neuman (1997:68) defines this as exploring "…socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understandings and interpretations of how people create and maintain their social worlds".

To retain the integrity of the phenomena being investigated, efforts are made to 'get inside' the person and to understand them (Cohen et al., 2001). The interpretive researcher begins with individuals or groups and sets out to understand their interpretations of the world. Theory is emergent from particular situations; it should be grounded on data generated by research acts (Glaser and Strauss, 1967).

Action research was chosen as a way of observing the complex social/educational activity in the VRLE. One of the key principles is that action research is participatory: it is research through which practitioners work towards the understanding and improvement of their own practices (Kemmis and McTaggart 1992:22-5). However, in this work, the researcher's role was as planner and external observer; the teacher took the lessons.

The research was built on three case studies. After analysing data from each study, the researcher revised the plan before starting the next (see Figure 4).
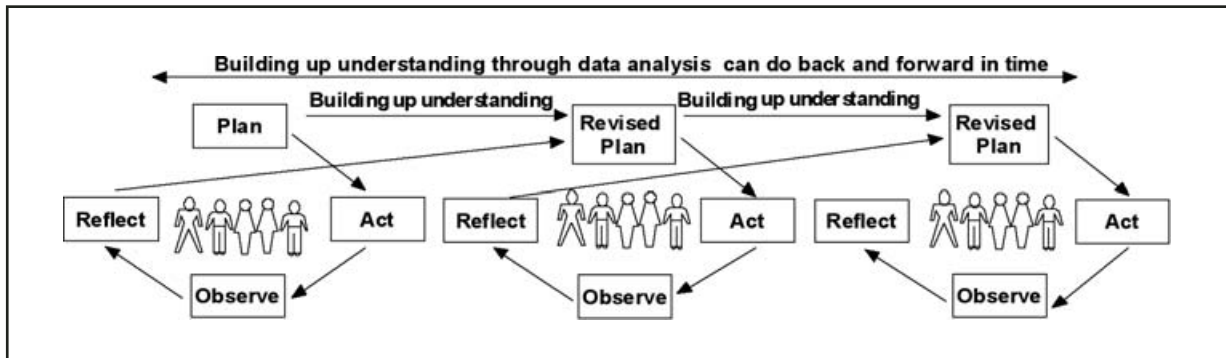
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Figure 4: The action research cycle supported the research

1. The first case study explored the use of the VRLE in relation to ideation, identifying factors and enabling a sharper focus.
2. The second was built on educational material made to support students in using the VRLE. This material was based on the first case studies.
3. The third was to identify possibilities of using mainly the VR part of the VRLE for the IE ideation process.

The measuring instruments

The observer needed a comprehensive set of data collection in order to get as much of information as possible relating to the research questions. Different data were intended to triangulate the research and build validity. To analyze the qualitative data, the researcher employed the qualitative and inductive methodology developed by Glaser and Strauss (1967). The specific instruments used are listed against research questions in Table 1, below.

The course plan and the data collection methods

A course plan was established to support the teacher, based on four lessons;

1. Introduction and training in using the VRLE.
2. Individual students work out solutions using the VRLE.
3. Students develop solutions as a group inside the VRLE.
4. Individual students develop solutions for an exhibition in the VRLE.

The various data collection methods applied in the case study series enabled triangulation. Table one shows the connection between the data sources and the research questions. The data was treated as follows:

a. Data collected.
b. Summaries written.
c. Results identified in data.
d. Data analysed and classified.
e. Interpretations written
f. Interpretations used to form new research questions.

	Data Sources	Q1 answer	Q2 answer	Q3 answer
1.	Screen captures in the VRLE	x	x	
2.	Interviews with the teachers	x	x	x
3.	Interviews with students group about the course and their work	x	x	x
4.	The researchers logbook	x	x	x
5.	Drawings and descriptions from students	x	x	
6.	Video recordings in the classroom	x	x	x
7.	Data from the VRLE		x	
8.	The Inventor's Notebook	x	x	

Table 1: Data collection methods and how they answer research questions

Main pedagogical issues emerging from data

The main issues established by the pilot research were:

Computer literacy

Interviews with students and teacher plus observations indicated that the students easily learned to use the VRLE and CAD software. Little teacher assistance was needed. However, further training helped them to draw better and faster using the hardware and software involved. The new VRLE technology can be used as children have enough computer literacy to use it.

Managing the VRLE in the school context

The interviews with the teacher, his logbook, and observations showed the importance of the teacher managing the VRLE hard and software. Appropriate facilities are needed to run the system such as graphic cards, headsets, and digital pens. Introducing such new approaches and technology does, however, require a great deal of effort for the teacher. Training would be necessary to enable teachers to manage.

The role of the teacher

In the interviews and logbook the teacher talked about the importance of being trained to use the VRLE. In addition, it is necessary to understand the IE ideation process. In his observation, the researcher could sometimes see a lack of the teacher's understanding for the IE innovation process. He frequently tried to give the students a brief it they had not found a problem or a need they could solve. He also tried to get them started with his own ideas when the children were meant to find solutions to needs they had identified in their environment and recorded in their Inventor's Notebook.

The pilot case studies showed the teacher felt more an assistant/facilitator than a teacher. The VRLE was found to be user friendly and enabled the students to be self-reliant. Nevertheless, the teacher still had to use familiar pedagogical principles such as giving clear instructions. It was important to link the students' homework with their activities inside the VRLE through brainstorming sessions in the classroom. After that, the students could work independently. When they had to undertake their work in the VRLE, they sometimes got tired after 20-30 minutes. By using short brainstorming sessions the teacher found it was possible to refresh them.

The teacher role in IE is one of the issues and relates to:

- The teacher's knowledge and skill in using the new technology.
- The teacher's preparation for the course.
- How the teacher organises the lessons.
- How the teacher understands the IE ideation process.
- How aware the teacher is of the students' staying power when they are using the IE/VLE/VRLE to be able to refresh them when they get tired.
- How effectively the teacher uses brainstorming sessions in the lessons.

Ideation within the IE process

The Inventors notebooks showed that students originate their ideas at home by identifying needs and problems. When the students started to use the VRLE in the second pilot case study, they talked about getting more ideas, not just at home but also while using the VRLE.

The pilot showed some confusion amongst the students in relation to what are needs, problems, and solutions. They were able to collaborate inside the VRLE and develop solutions based on a common need. This had, however, to be done through brainstorming.

Several observations on students' drawing skill showed they had difficulties using their computers to draw. They used simple CAD software and used the specific whiteboard inside the VRLE. First, they used the mouse and later two different drawing pens. The earlier pen required the students to look at the screen as they drew. Students found it easier to use the mouse than these pens. The second pen was dual function in that it made a mark directly on paper while working with the computer. These pens were easy to handle and draw with as the student gained direct feedback on the paper in addition to the screen.

Discussions

Some issues of ideation when using a VRLE have been explored though the pilot case studies. They will be used as guidance for the next phase.

The role of the teacher is one of the main issues when adopting a new technology or pedagogy in schools. Bjork (1995) observes:

> "New course structures, new roles for teachers, and new patterns for organizing classrooms in schools with the technology, often with very exciting possibilities, cannot be done unless we build whole courses from the beginning using the technology".

The teacher's role was different from the classroom-based teaching; he was more an assistant and facilitator than a tutor. In the interview, he speaks about lack of training for using the software and about the need for having a good training course before starting the research. An effective manual would also be helpful.

The student's computer and VRLE literacy is important. In the research, the student needed very little training to use the equipment. Many of them use computer games built on similar technology. To use such kind of technology in school was interesting, as they frequently told the observer in the interviews. The students' skill was different but in the video recordings and observations, the researcher could see them help each other in the classroom if they had technical problems. Using the VRLE outside the classroom as a tool for open and long distance education might change this, as the students would have to communicate with each other through the computer only.

Sketching is a valuable part of the IE ideation process. It allows the students quickly to represent their design ideas in a physical medium. The students were able to cooperate using the VRLE but their work was dependant on their ability to use the computer technology for sketching. They had difficulties in using the computer to draw and their sketches were very inaccurate.
They found it easier to use a simple pen and a paper. A wireless ink pen used late in the research was more user-friendly but not compatible with the whiteboard in the VRLE. Plimmer and M. Apperly (2002:6) came to similar conclusions in their research work, "Although

most designs are rendered on a computer, most designers choose not to use a computer for the first stage of design because the currently available interfaces do not support the informality of sketching". In their article, they point out that using computers for drawing depends largely on the quality of the equipment and the software.

The student's understanding on the ideation process is important. Different ways of communication when using the VRLE seem to facilitate their ideation as they state they find more solutions when using the VRLE. It is important to train them in how to work together through brainstorming sessions and to use this technique frequently during the work. The students reported they got more ideas when they worked together inside the VRLE and when the teacher refreshed them with brainstorming sessions. This will be explored further in the next case study series.

Using the VRLE gives the students and teacher various ways of communicating their ideas and this seems to support the ideation process and motivates the students to come up with more ideas. The video recordings in the classroom show the students discuss their ideas with each other and explain them for each other. The concept of VRLE is linked to the feeling of being in a location other than where you actually are. This means that you can control an avatar or another device at a distance. It is possible that the fact that students can 'play a role' via the use of avatars when using the VRLE may be an issue which merits further research (EDS, 1991; McLellan, 1995; Ulman, 1993, 1997; Shimoga & Khosla, 1994; Wong, 1996).

Conclusions

Our pedagogical understanding of using this VRLE for Ideation has to be developed further. Many possibilities lie in the application of the VRLE software. The basis of the technology is already part of the daily lives of young people, but to date, is less advanced in general education. Using the VRLE depends largely on the teacher's ability to manage it. Work has to be done to develop course material for training teachers so they can manage to use it and fully adopt it in schools. It is also necessary to explore the possibilities that lie in the

usefulness of such technology for open and distance education in the context of ideation in IE.

As seen from this project the VRLE can be useful to reinforce the process of ideation. However, the indications from the pilot research are that we need to explore and understand the application of the VRLE to support brainstorming and ideations further. A new research question for a new series of case studies will therefore be:

> "How can one analyse the use of brainstorming sessions in this VRLE to support ideation (in the context of IE in Iceland)?"

A brainstorming session will be undertaken in the VRLE and in a classroom and compared. Criteria will be established and developed for evaluating the effectiveness of such brainstorming sessions in the VRLE.

This new series will hopefully give a clearer picture of the pedagogical values of using VRLE for Innovation Education in Icelandic schools.

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