ENCOURAGING INNOVATIVENESS THROUGH COMPUTER-ASSISTED COLLABORATIVE LEARNING

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ABSTRACT

This article puts forward a three related case study series, using a Virtual Reality Learning Environment (VRLE) with a view to supporting the development of students' ideation skills in conventional primary and secondary education. This learning environment is fairly new and therefore it is necessary to examine its educational uses and determine if the new learning environment will meet teachers' expectations. Therefore, the overall goal for this research was twofold: (a) to explore the ways in which idea generation was developed during students' work and (b) to assess the way VRLE affects student idea generation work. The data collected was qualitative and the analysis was based on grounded theory principles and an interpretive paradigm.

Keywords: Idea Generation, Collaborative Learning, Computer-Assisted Learning, Virtual Reality Learning Environment, Pedagogy, Ideation Process.

INTRODUCTION

Computer-Assisted Collaborative Learning (CACL) is commonly described as a situation in which two or more people learn or work together, usually aiming for dissimilar goals (Dillenbourg, 1999; Chiu, 2000). Students involved in Computer-Assisted Collaborative Learning benefit from on one another's resources and skills. This can include assessing each other's ideas, asking one another for information and observing each other's work (Chiu, 2000). CACL can, furthermore, be described as computer-based network systems that upkeep group work for a joint purpose and provide a shared interface for a team to work with (Ellis et al., 1991; Stahl et al., 2006).

In CACL, computers are used within an educational setting to facilitate and support collaborative group learning processes. The main purpose is to support students in learning together effectively, for example, communicating ideas, accessing information and providing feedback on problem-solving activities (Stahl et al., 2006).

The paper reports three case study series took place in several elementary and secondary school classes (six to sixteen-year-old students; various groups of volunteers, from the seventh class onwards, took part in the research). The background of the VRLE is described and the overall aims, objectives and research questions stated. Idea generation is defined and a specific model for idea generation demonstrated. The research methods are explained and findings reported. Subsequently these findings are discussed and conclusion drawn.

1. Related Approaches to Idea Generation

The term Ideation originated from Guilford (1950) (Thompson, 2008) that used it to describe the pattern of interactions that arise when an individual produces an idea. As The Oxford Dictionaries Online (2011) states, ideation is the formation of ideas or mental images of things not present to the senses. Idea generation is the generation of possibilities, performed at various points in problem solving and innovation episodes (Smith, 2003). Lying at the heart of both invention and design, it is a widely acknowledged as a key part of the innovation process (Van de Ven et al., 2000).

Innovation is closely related to idea generation, as the innovation process invariably includes problem-need identification and problem solving (Smith, 2003). Osborn (1967) understood idea generation and idea evaluation as a two separate activities. Demerest (1997), similarly, recognised knowledge creation as a key separate activity supportive of idea generation. (Gunnarsdottir, 2007).

Rickards and Freedman (1978) suggest that an additional time separation or deferment of judgement should occur in the idea generation phase, as this time factor allows ideation to develop before idea evaluation takes place. Titus (2000) speaks of periods of idea generation rather than separated events, suggesting the need for reflection and further development. Similarly, Henry (1991) considers the need for a period of incubation in idea generation: this period is referred to as deferred judgement and is distinct from dormancy. Rather, it should be a period of knowledge creation through dialogue, debates, scanning, etc. Accordingly, ideas are generated and shaped, prior to idea evaluation.

Many research projects indicate that individuals or nominal groups using VRLE's for idea generation (in terms of number of ideas generated) perform better than verbally interactive groups (Paulus et al., 1995). Modern technology can be used to support collaborative ideation. Computer technologies and the Internet are now an everyday part of students' lives and are arguably becoming the preferred mode of both communication and the collection of information (Hennessey & Deaney, 2004; Passey et al., 2004). As the use of the VRLE was new and the learning and teaching context complex and dynamic, the focus became the exploration of the use of the VRLE to support student ideation work (Thorsteinsson, Page and Niculescu, 2010a). The intention was to identify the issues involved, to use literature and fieldwork to understand how these issues were related and, eventually, to be able to prepare a map of directions for further research.

2. The Virtual Reality Environment used for the study

The virtual reality environment was a part of an Icelandic Virtual Reality Learning System that included both a managed learning environment (MLE) and virtual reality environment (VLE) (Thorsteinsson et al., 2005). The VRE part was developed as a communication too to enable cooperative idea generation. It allowed the participants to utilize synchronous virtual communication with sound, pictures and movements. It also offered the possibility for using CAD for communicating ideas in the form of drawings and formation of 3D objects (Thorsteinsson & Denton 2006). The use of the VRE element was established with security requirements. It was possible to enter the VRE from inside a personal workshop after the user had passed all the security requirements (Thorsteinsson et al., 2005). When the user entered the VRE he or she could choose from a set of avatars (Figure 1). These avatars were both children and adults.

The VRE is designed as a house with many rooms and a garden. The students could walk about and communicate by using voice over IP or by sending text that appeared on the screen (Figure 2&3). They could also interact and communicate using the avatar's body language. Each room in the VRE had big screens for playing videos;

Figure 1. The avatar range available.

Figure 2. Students and their teacher at work inside the VLE in the classroom

Figure 3. Students and their teacher at work inside the VLE

browsing the internet, showing power point presentations and whiteboards that enabled the participants to draw together Thorsteinsson & Denton 2006).

3. Using a VRLE to Support Idea Generation

The original idea behind the VRLE was to find a new way of supporting students' ideation work, using information and computer technology (Thorsteinsson and Denton 2003; Thorsteinsson and Denton 2008). The specific VRLE was designed to enhance ideation via collaborative learning support and thus creating individual and social educational opportunities. The main output of the project was an online VRLE, linked to a database: this VRLE was developed as a combination of the managed learning environment (MLE) and the virtual reality environment (VRE). The MLE provided the framework for teachers to manage student learning, while the VRE provided a simple virtual environment that enabled students to meet and communicate through a number of means, such as voice, text, drawings, photographs and presentations. The database enabled these ideas to be shared and recorded and these, as a whole, represented the VRLE.

The VRLE is potentially a tool for experiential learning, as it provides various dynamic and rapid ways to see, experience and generate ideas and information. The VRLE can be used as a tool for problem solving and communicating ideas and includes the possibility of promoting a high degree of interactivity and immersion (Ogle, 2002; Bricken, 1991; Johnson et al., 2002; Jonassen, 2006; McLellan, 1996; Osberg, 1993). The VRLE is interactive in two ways: firstly, a user interacts with data in the database within the VRLE and also beyond; for example, via the World Wide Web (www). Secondly, it allows the interaction of a number of students and staff within the VRLE, using a range of modes including speech, drawing and writing. Students could be from the same class or in other schools or countries, accessing the VRLE via the www. Using the VRLE within the classroom context offers multi-modal communication and this would be expected to influence students' learning experiences.

The main reasons for students using the VRLE were the following:

- To offer another mode of working together, in terms of ideas, sharing problems, solving such problems and developing solutions;
- To enable students to meet each other and their teacher online;
- To facilitate easy communication inside virtual 3D spaces, where students and teachers could meet in real time, share information and work together with ideas;
- To provide the opportunity to develop certain skills within the ideation process (i.e., brainstorming, drawing and discussion) (Figure 4).

4. A Pedagogical Model for Idea Generation

The research activities were built on the following model for Idea generation (Thorsteinsson & Denton, 2003 (Figure 5). It is based on a series of steps, iterations and relationships, with the overlying direction leading from 'finding needs' to 'presentation of solutions'.

- Finding needs;
- Brainstorming;
- Creating and choosing initial solutions;
- Concept drawing or modelling, in order to develop the technical solution;
- Creating a description of the solution, in addition to the drawing;
- Presentation.

Ideation skills are employed at all stages of the innovation process and innovation relates to the usefulness of ideas and/or how they can be implemented as solutions to many problems encountered in everyday life. Students learn through the cycles of the innovation process, supported by the collaboration amongst individuals, as a group, and by the teacher. The overall framework is managed by the

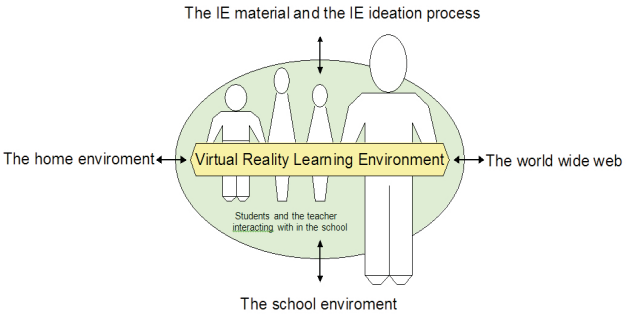

Figure 4. The VRLE offers different dimensions of communication.

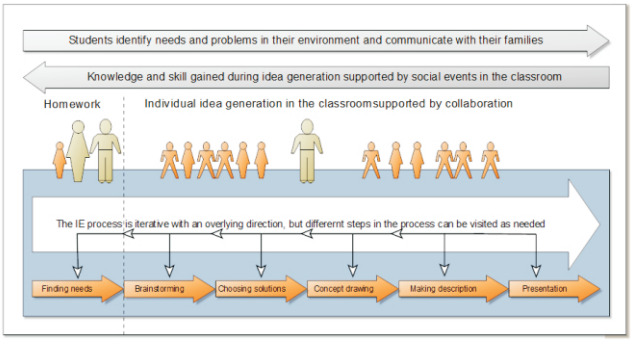

Figure 5. A basic pedagogical model for idea generation that illustrates innovation as a 'process', with appropriate feedback loops and options.

teacher (Figure 5).

A course plan and related research plan were established, on the aim and research question. The teacher set up email accounts and registered them to the VRLE; he also took digital photographs, in order to enable the students to personalise their VRLE workshops. The classroom used was an ordinary classroom, with12 network connected computers and digital drawing output devices. For computer-based VRLE activities, 8 students were adequate. While this was a small sample, it did enable a close focus on the group and was consistent with enabling pedagogical issues to emerge.

The various collaborative learning tasks designed for idea generation benefit from this virtual learning tool which enables students to connect to each other and the outside world, thus facilitating communication and knowledge transfer. While the VRLE has the potential to enable open and distance learning, in terms of co-operation between students and teachers across continents, it was decided that this would be too large a dimension for this research. Thus, the focus was limited to the use of the VRLE within the conventional classroom context.

The following research question was thus formed to guide the research: "How does VRLE enhance students' ability to generate new ideas and pass on knowledge in conventional classes?"

5. Research Methodology Development

As the research took place in a complex social/educational context, grounded theory (Glaser and Strauss, 1967) principles were used as a way of observing, describing and interpreting settings as sources of data (grounded theory is a principle based on the systematic building of theory, using qualitative or/and quantitative data). The key points in the data are marked with a series of codes, which are then grouped into emerging conceptual categories. These categories are related to each other as a theoretical explanation of the action(s) that continually resolve the main concerns of the participants within a substantive area (Denzin, 1984).

Grounded theory focuses on obtaining an abstract analytical schema of a phenomenon that relates to a particular situation (Creswell, 1998; Denzin & Lincoln, 1994). However, Strauss & Corbin (1998) explicitly pointed out that the value of grounded theory lies in its ability not only to generate the theory, but also to ground that theory in data. This inductive method is particularly helpful in identifying patterns of behaviour or thought in a particular group of people, as in this study.

Further reading on the principles of grounded theory and specific research methods appropriate to this educational context (Glaser & Strauss, 1967; Cohen et al., 2005) lead to the design of a programme of case studies intended to explore the research question. Three case studies were undertaken, each based on a programme of lessons, and these were used iteratively, in that a period of analysis and reflection followed each case study and led into the next. An action research phase was used to develop the pedagogical model further. Issues were identified and tested, in terms of the use of the VRLE within IE.

Specific techniques were used for data collection included interviewing, observations and document analysis. The use of different data sources helped the researcher to 'validate and crosscheck findings' (Patton, 1990:244). In the case study series, different types of qualitative data were collected in the form of interviews with the participating teacher and students; classroom observations; video recordings of students' activity when using the VRLE; screen video recordings; student work samples and the teacher's and researcher's logbooks. These multiple perspectives offered a good degree of triangulation (Denzin, 1984; Cohen et al., 2005).

6. General Findings

Throughout the research the VRLE worked well in general; it

was stable and easy to register the students. However, dealing with the VRLE technology might have been more difficult for a teacher without strong information technology skills. Probably due to good computer literacy, students learned to use the VRLE through direct experience. Using the VRLE network inside the classroom made it possible for students to learn from one another both face-to-face and online. They also got some instruction from the teacher. They quickly became self-reliant but the teacher considered they needed more concrete learning material and a traditional instructional phase.

The teacher's role was to help students to understand the innovation process. Training them via the VRLE was beneficial for their idea generation. Students normally quickly understood the innovation process and were able to identify needs and problems in their own environment. Identifying problems and need at home played a significant role in the first stages of the innovation process that took place at home. This was intended to trigger idea generation in lessons, helping students to generate the content of the course, make them self-directed and give their work a personal meaning.

Students usually defined their findings spontaneously and tended to record solutions in their notebook, instead of needs and problems. However, the teacher was able to help them to define needs rather than solutions by discussions while they worked inside the VRLE without imposing his own value judgements.

In interviews students stated working inside the VRLE were supportive for their ideation work and increased their ideation. Video recordings in lessons also showed students support each other and sharing problems needs during their work. The VRLE directed students' idea generation as it was structured upon the idea generation process. The VRLE facility for sharing needs, solutions and to brainstorm during classroom activities was identified as beneficial. Students frequently shared needs and problems with each other, both face-to-face, and online. There was a balance between needs identified at home and at school. However, the VRLE database indicated that most ideas were generated when students were working collaboratively inside the VRLE. Furthermore, the students reported in interviews they got more ideas working inside the VRLE then at home. Inside the VRLE they also could easily share problems, needs and solutions.

Table 1 gives overview over individual students' activities inside the VRLE. The abbreviates are explained below. The context of the table's content in relation to the students work and the course is also demonstrated.

Stb: Male student; Stg: Female student; S: Solutions; N: Needs; SN: Shared needs with others; SS: Shared solutions with others; C: Solutions sent to The Young Inventors Competition; GN: Needs the group shared; GS: Solutions the group shared; C-SN: Collaboration or shared needs with the following students; C-SS: Collaboration or shared solutions with the following students (Figure 6).

Students worked individually but supported each other by sharing their knowledge via the VRLE. The students generated similar amounts of needs and solutions and there was a balance between boys (20) and girls (20). Just one in the group shared their needs with one or more individuals and two shared their needs with the group. Four students shared nine solutions with individual students and with the whole group. Forty solutions were delivered in total

CSS2	S	N	SN	SS	C	GN	GS	C-SN	C-SS
Stb1	6	4	0	0	6	0	5	0	Stb2,Stb2,Stb2,Stb8,Stb8
Stb2	6	7	0	3	6	0	1	0	S8,S2,S2,S2
Stb3	5	2	0	1	2	0	2	0	S2,S2,S3
Stg4	5	7	0	0	5	0	1	0	S3
Stg5	3	4	1	0	0	1	1	S5	S6
Stg6	5	2	0	2	4	1	1	S5	S6
Stg7	7	7	0	0	7	0	0	0	0
Stb8	3	2	0	3	3	0	5	0	S2,S2,S8,S8,S8
Sum	40	35	1	9	33	2	16	2	20

Table 1. The table provides an overview of individual student's activities in the VRLE

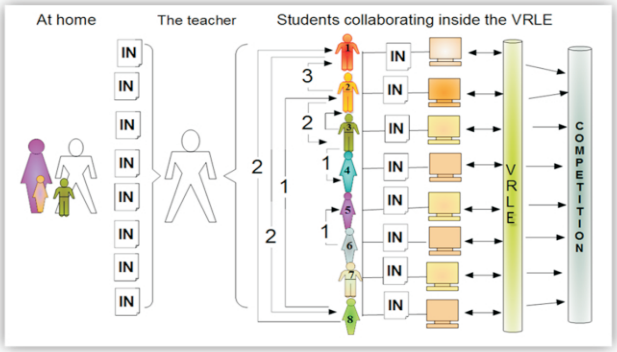

Figure 6. Shows how students shared ideas inside the VRLE

and 35 needs. The students established two group needs and sixteen group solutions. Most often, there was a congruency between the students' needs and solutions.

7. Discussion and Conclusion

The VRLE guided the students work, gave structure and reflected the role of the computer as a tutor, tutee and tool (see similarities in Blom and Monk, 2003 and Taylor, 1980) and enabled both CSCL and CSCW. The VRLE worked as a tool students used to enable their work. It included help pages and was structured on the innovation process. This structure and help pages guided and directed students during their work and was therefore a form of tutee. This structure and help pages guided and directed students during their work and was therefore a form of tutee (Thorsteinsson et al., 2010b).

During the research, students had no major problems in using the VRLE and quickly became self-reliant. Their confidence and IT ability enabled them to start using the VRLE easily. However, the case studies showed that additional training was needed for the hardware (specifically the graphical input devices) and the VRLE. The teacher also considered students needed training in using the VRLE for cooperative idea generation.

Social presence was an important aspect of using the VRLE and enabled a community of learners to grow as Hamburg et al. (2003) Hauber et al. (2005) have indicated. Playing informally in the VRLE was shown to promote the students' skills and confidence in using the VRLE, and familiarity with each other (see also in Prensky, 2005 and Hussain et al., 2003). The case studies indicated that being physically together and being able to speak to the teacher both inside the classroom and over the Internet at the same time appeared to assist students learning, probably via having multiple modes of communication (Loiselle et al., 1998 & Schrum & Berenfeld, 1997; Thurlow, Lengel, & Tomic, 2004 and Romiszowski & Mason, 1996). The capability of students personalising the interface of their virtual workshops appeared to be important in relation to increasing their perception of relevance and ownership of the VRLE, echoing Oulasvirta and Blom, (2008) and Blom and Monk, (2003).

It was the teacher's role to help students to understand the innovation process (see similarities in Gunnarsdottir, 2001) both with and without the VRLE (Thorsteinsson and Denton, 2008). They quickly became familiar with the innovation process in so far as bringing basic ideas to school to act as start points for effective collaborative idea development. However, it was evident that students in the case studies did not understand the fine differences between problems, opportunities, needs and initial ideas. This may be due to their relative immaturity (age 11 – 12) but is certainly an area that merits further specific research.

Collaboration played an important role, both at home, in the classroom and inside the VRLE to facilitate idea generation, supporting the position of Hamburg et al. (2003). Training students in idea generation via the VRLE and in the classroom appeared to be encouraging self-reliance and independence and appeared to be beneficial for idea generation. It furthermore gave the teacher a little more freedom to stand back and observer the group carefully. This supported him in adopting the role of a facilitator to a greater extent.

The VRLE was structured upon the innovation process and included a facility to share needs, solutions and brainstorm them. They can be seen as an interactive, collaborative, learning tool supporting idea generation. Students often shared needs and solutions inside the VRLE.

Students in the case studies were generally self-reliant and worked most often individually inside the MLE part of the VRLE, but also collaboratively inside the VRE at the same time. This collaboration was supportive for individually based idea generation (see similarities in Dennis & Valacich, 1993). However, students were still less productive and fewer ideas were generated as it was time consuming (as with Taylor et al., 1958 and Paulus et al., 1995). Being able to play inside the VRE, when working in the MLE, was a form of informal "edutainment" that supported collaboration and skill (see similarities in O'Quin and Derks, 1999). A light hearted spirit in lessons appeared to positively influence idea generation, supporting the position of O'Quin and Derks (1999).

The research indicates that this specific VRLE technology plays a positive role in enhancing learning in IE and, possibly, other related contexts. However, the pedagogical

understanding of using the VRLE for ideation has to be developed further and the educational efficacy of using the VRLE in schools is dependent on the development of meaningful forms of such learning support. The basis of the technology is already part of the daily lives of young people, but, to date, is less advanced within general education.

References

[1]. Blom, J.O. and Monk, A.F. (2003). A theory of personalisation of appearance: why users personalise their PCs and mobile phones. *Human-Computer Interaction,* Vol. 18, No. 3, pp. 193-228.

[2]. Bricken, M. (1991). Virtual reality learning environments: Potentials and challenges. *Computer Graphics,* Vol. 25, No. 3, pp. 178-184.

[3]. Chiu, M.M. (2000). Group problem solving processes: Social interactions and individual actions. *Journal for the Theory of Social Behaviour*, Vol. 30, No. 1, pp. 27-50.

[4]. Cohen, L., Manion, L. and Morrison, K. (2005). *Research methods in education* (5th ed.). London: Taylor & Francis e-Library.

[5]. Creswell, J.W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage

[6]. Demerest, M. (1997). Understanding knowledge management, *Journal of Long Range Planning*, Vol. 30, No. 3, pp. 374-84.

[7]. Denzin, N.K. (1984). *The research act. Englewood Cliffs*, NJ: Prentice Hall

[8]. Denzin, N.K. and Lincoln, Y.S. (Eds), (1994). *Handbook of Qualitative Research*. Thousand Oaks, CA: Sage Publications, Inc.

[9]. Dillenbourg, P. (1999). Collaborative Learning: Cognitive and Computational Approaches. *Advances in Learning and Instruction Series.* New York, NY: Elsevier Science, Inc.

[10]. Ellis, C.A., Gibbs, S.J. and Rein, G.L. (1991). Groupware: Some issues and experiences. *Communications of the ACM*, Vol. 34, No. 1, pp. 38-58.

[11]. Glaser, B.G. and Strauss, A.L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine Publishing Company.

[12]. Guilford, J.P. (1950). *Creativity*. American Psychologist, Vol. 5, No. 9, pp. 444-454.

[13]. Gunnarsdottir, R. (2001). *Innovation Education: Defining the Phenomenon*. Unpublished doctoral thesis.Leeds: University of Leeds.

[14]. Hamburg, I., Lindecke, C. and Thij, H.T. (2003). Social aspects of e-learning and blending learning methods. In *Proceedings of the 4th European conference E-comm-line.* Bucharest.

[15]. Hauber, J., Regenbrecht, H., Hills, A.,Cockburn, A. and Billinghurst, M. (2005). *Social Presence in two- and three-dimensional Videoconferencing*. London: Proceedings Presence Workshop.

[16]. Hennessey, S. and Deaney, R. (2004). *Sustainability and evolution of ICT supported classroom practice*. Retrieved (5.April 2009) from http://131.111.153.52/istl/SAE041.doc.

[17]. Henry, J. (1991). *Creative Management*, London: Sage Publications.

[18]. Hussain, H., Embi, Z.C. and Hashim, S. (2003). A Conceptualized Framework for Edutainment. *Informing Science: InSite - Where Parallels Intersect,* pp. 1077-1083.

[19]. Johnson, A., Moher, T., Choo, Y., Lin, Y.J. and Kim, J. (2002). Augmenting elementary school education with VR. *IEEE Computer Graphics and Applications*, March/April, pp. 6-9.

[20]. Jonassen, D. (2006). A constructivist'sperspective on functional contextualism. *Educational Technology Research & Development,* Vol. 54, No. 1, pp. 43-47.

[21]. Loiselle, J., St. Louis, M. and Dupuy-Walker, L. (1998). *Giving professional help to pre-service teachers through computer-mediated communication*. Paper presented at the Annual Meeting of the Association of Teacher Educators, Dallas

[22]. McLellan, H. (1996). Virtual reality.In Jonassen D. (Ed.), *Handbook of research for educational communications and technology,* pp. 457-487. MA: Kluwer-Nijhoff Publishing.

[23]. O'Quin K. and Derks, P. (1999). Humour and creativity: A review of the empirical literature. In: Runco, M. (Editor), *Creativity research handbook,* Vol. 1, pp. 223-252. Cresskill, NJ: Hampton Press.

[24]. Ogle, T. (2002). The Effects of Virtual Environments on Recall in Participants of Differing Levels of Field Dependence.PhD Dissertation.Virginia Polytechnic and State University. Blacksburg, VA.

[25]. Osberg, K.M. (1993). Virtual reality and education: A look at both sides of the sword.

[26]. Osborn, A.F. (1967). *Applied Imagination: Principles and Procedures of Creative Problem Solving* (Third Revised Edition). NY: Charles Scribner's Sons.

[27]. Oulasvirta, A. and Blom, J. (2008). Motivations in personalisation behaviour. *Interacting with Computers*, Vol. 20, No.1, pp.1-16.

[28]. Passey, D., Rogers, C., Machell, J. and McHugh, G. (2004). *The Motivational Effect of ICT on Pupils*. Department of Educational Research Lancaster University.

[29]. Patton, M.Q. (1990). *Qualitative Evaluation and Research[1]*. Methods (2nd ed.). Newbury Park, CA: Sage.

[30]. Paulus, P.B., Larey, T.S. and Ortega, A.H. (1995). Performance and perceptions of brainstormers in an organizational setting. *Basic and Applied Social Psychology*, Vol. 17, No. 1-2, pp. 249-265.

[31]. Prensky, M. (2005). *Engage Me or Enrage Me: What Today's Learners Demand. Educause Review,* Vol. 40, pp. 60-65. Retrieved (12. August, 2009) from http://www.hitl.washington.edu/publications/r-93-7/

[32]. Rickards, T. and Freedman, B. (1978). Procedures for management in idea-deficient situations: an examination of brainstorming approaches. *The Journal of Management Studies,* Vol. 15, No. 1, pp. 43-55.

[33]. Romiszowski, A.J. & Mason, R. (1996). Computer-mediated communication. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 438-456).New York: Simon & Schuster Macmillan.

[34]. Schrum, L. & Berenfeld, B. (1997). *Teaching and learning in the information age: A guide to educational tele- communications*. Needham Heights: Allyn&Bacon.

[35]. Smith, G.F. (2003). Towards a Logic of Innovation. *The International Handbook on Innovation.* Elsevier Science Ltd.

[36]. Stahl, G., Koschmann, T. & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 409-426). Cambridge, UK: Cambridge University Press.

[37]. Strauss, A. and Corbin, J. (1998). Basics of Qualitative Research: *Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks, CA: Sage Publications.

[38]. Taylor, D.W., Berry, P.C. and Block C.H. (1958). Does Group Participation When Using Brainstorming Facilitate or Inhibit Creative Thinking? *Administrative Science Quarterly,* Vol. 3, No. 1, pp. 23-47.

[39]. Taylor, R. (1980). *The Computer in the school: tutor*, tool, tutee. New York: Teachers College Press.

[40]. The Oxford Dictionaries Online (2011). Retrieved (5. April, 2011) from http://oxforddictionaries.com.

[41]. Thompson, L. (2008). *Making the team: A guide for managers (3rd ed)*. Upper Saddle River, NJ: Prentice Hall.

[42]. Thorsteinsson, G, Page, T. and Niculescu, A. (2010). Adoption of ICT in supporting ideation skills in conventional classroom settings', *Journal of Studies in Informatics and Control,* Vol. 193, pp. 309-318, ISSN 1200-1766.

[43]. Thorsteinsson, G. and Denton, H. (2003). The development of Innovation Education in Iceland: a pathway to modern pedagogy and potential value in the UK. *The Journal of Design and Technology Education,* Vol. 8, No. 3, pp. 172-179.

[44]. Thorsteinsson, G., Denton, H.G., Page, T. and Yokoyama, E. (2005). *Innovation Education within the Technology Curriculum in Iceland.* Bulletin of Institute of Vocational and Technical Education, pp 1-9. Graduate School of Education and Human Development. Japan: Nagoya University. ISSN 1348-4893.

[45]. Thorsteinsson, G. and Denton, H.G. (2006). Ideation in a Virtual Learning Environment: A Pilot Project from Iceland in Innovation Education. In Norman, E.W.L., Spendlove, D. and Owen-Jackson, G. (Eds), *The Design and Technology Association International Research Conference book*

2006. Telford, July 2006, pp. 155-164, Wellesbourne: The Design and Technology Association.

[46]. Thorsteinsson, G. and Denton, H.G. (2008). Developing an understanding of the pedagogy of using a Virtual Reality Learning Environment (VRLE) to support Innovation Education (IE) in Iceland: a literature survey. *Design and Technology Education: An International Journal,* Vol. 13, No. 2, pp. 15-26, ISBN 1360-1431.

[47]. Thorsteinsson, G., Page, T. and Niculescu, A. (2010). Using Virtual Reality for Developing Design Communication. *Journal of Studies in Information and Control,* Vol. 19, No. 1, pp. 93-106, ISBN 1220-1766.

[48]. Thurlow, C.,Lengel, L. & Tomic, A. (2004). *Computer Mediated Communication: Social Interaction and the Internet.* London: Sage.

[49]. Titus, P. (2000). Marketing and the creative problem-solving process. *Journal of Marketing Education,* Vol. 22, No. 3, pp. 225-35.

[50]. Van de Ven, A., Angle, V. and Poole, M.S. (2000). *Research on the Management of Innovation.* Oxford: Oxford University Press.

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