An Orientation Assistant (OA) for Guiding Learning through Simulation of Electronics Technology in Technology Education

Gisli Thorsteinsson

Design and Craft Department, Iceland University of Education, V/Stakkahlíð, Iceland

E-mail: G.Thorsteinsson@lboro.ac.uk

Tom Page

Department of Design and Technology, Loughborough University, Loughborough Leics., LE11 3TU, UK

E-mail: T.Page@lboro.ac.uk

Miika Lehtonen

Faculty of Education,

Centre for Media Pedagogy (CMP), University of Lapland, Rovaniemi, P.O. Box 122 FI 96101, Finland

E-mail: Miika.Lehtonen@ulapland.fi

Abstract: This paper puts forward the theoretical underpinning and central aspects of the development and application of the orientation assistant (OA) and presents results concerning its use in university studies. The (OA) is a software tool producing an interactive learning environment offering support in teaching and learning that uses local applications.

Gisli Thorsteinsson, is an Assistant Professor at Iceland University of Education, in the Department of Design and Craft. At present he is also a PhD student at Loughborough University, where he is exploring the values of using Virtual Learning Environment for ideation in general school education. Mr. Thorsteinsson has been the Chairman of the Association of Icelandic Industrial Arts Teachers since 1995 and is associated with the NST Coalition of Industrial Arts Teachers in Scandinavia. From 2000 he has been on the Board of 'Nordfo', the Pan Scandinavian co-operative researching art and design projects in Scandinavia. In 1999 he was involved in the National Curriculum development for technology education in Iceland and wrote the curriculum part for design and craft. Mr.Thorsteinsson has written numerous articles concerning design and craft education and has published several textbooks about innovation in education.

Tom Page, *Ph.D.*, is a lecturer of Electronic Product Design in the Department of Design & Technology at Loughborough University, England. He graduated from Napier in 1988 with a degree in 'Technology with Industrial Studies'. In 1992, he attained a M.Phil by research in engineering design methodology for his work at the Engineering Design Research Centre. On completion of this work, Tom took up a teaching post in Computer-Aided Engineering at the University of Hertfordshire. In 1995, he became a Chartered Engineer with full membership of the Institution of Electrical Engineers (IEE) and was promoted to senior lecturer in Computer-Aided Design and Manufacturing. Whilst at Hertfordshire, Tom pursued his research interests in Electronics Design for Manufacturing and Assembly which led to the award of a PhD in 2001. He is also a full member of the Institute of Learning & Teaching (ILT). His research interests include electronics design tools, electronics design for manufacturing and assembly and engineering/ technological education. To date he has over one hundred and twenty research papers in these areas.

Miika Lehtonen M.Sc., is a researcher at MOMENTS (Models and Methods for Future Knowledge Construction: Interdisciplinary Implementations with Mobile Technologies) -project [48] and Associate Professor (currently on leave of absence) of Media Education at Centre for Media Pedagogy (CMP) at University of Lapland, Rovaniemi, Finland. He has been editor and co-editor as well as author and co-author of several publications and articles in Finnish and English, in different conferences, books and scientific journals. Miika Lehtonen is currently finishing his Ph.D. degree and obtained his M.Sc. degree (Education) from the University of Turku, Turku, Finland. His research and development has recently focused on research & development of pedagogical models, tools and practices for network-based mobile education (NBME) and for the simulation based pedagogy. He has also published about the multi- inter- and multidisciplinary research on learning and about the cultural, mental and emotional aspects of NBME.

1. Introduction

In a somewhat lighthearted vein, one could say that metacognitive work on the part of a teacher in teaching – and the work of a magician in the creation of an illusion – are closely related. The magician's task is to create an emotionally engaging situation and atmosphere and guide the viewer to focus on the inessential by a certain tool or means. The aim of a teacher – or for the purpose in this work, the computer or network teaching method – is to guide a student or group of students to observe, do and discover what is essential in its content and to create a comfortable context and emotional state for learning. It might be said that both the teacher and magician try to guide observations and emotions and use different materials and distractions to that end. Adapting Galperin's terminology, we refer to this guiding our activity and observations in appropriate or inappropriate directions as cognitive orientation (Galperin, 1989, 1992; Podolskij, 1997; Talyzina, 1981; Lehtonen, 2003, 2005b; Lehtonen et al., to appear). In using computer and network based learning tools such as electronic circuit design and symbolic simulation applications (see Gredler, 2004), used in this research project (Lehtonen, 2002a, 2002b, 2002c, 2005b; Lehtonen et al., to appear), the idea presented above on steering and helping the student or group of students is at least as significant as in conventional teaching. The activity in which teachers guide students' learning (Uljens, 1997; Illeris, 2002) – will frequently not work in an optimal fashion solely by using the most modern tools (e.g., simulation tools, animation and video media). Provision must be made at the same time to guide students in using these tools effectively for their own studies and to empower the student (Galperin, 1989; Gredler, 2004).

2. Simulations and interactivity as a natural part of the studying process

The purpose of the work reported here is to present the pilot research undertaken in the development and the use of the ICT based tool orientation assistant (OA). It is a component of an action research project titled 'Web supported Mental Tools in Technology Education'. The aim of this research project is to test the effectiveness of simulation tools and modern network based platforms that support learning and develop the pedagogical model, namely 'Network oriented study with simulations'. The expected outcome of this research is a pedagogical model and enabling tools for the integration of simulation tools, modern network based solutions that support learning and other mental tools (e.g., Jonassen, 2000; Jonassen and Rohrer-Murphy, 1999; Vygotsky, 1978). This is combined with traditional and modern digital learning materials into a coherent context for normal teaching – studying – learning activity. The focus of the case study is the pedagogy (didactics) of technology education. Traditional and modern digital learning materials are examined in the context of the 'normal teaching-studying-learning process' (Uljens, 1997) at university level. For the purpose of this work, the term 'studying' (Uljens, 1997; Illeris, 2002) is used here instead of 'learning activity'. The project also analyses the advantages and disadvantages of different tools and media for the purpose of evaluating their suitability in support of teaching and learning in varying modes of use. Considerable efforts have been made to develop a pedagogical model that uses different kinds of interactive mental tools – simulations, literature, electronic documents, and interactive documents. However, especially interactive objects have been included, which we refer to as insight objects, in a way that would maximise their benefits but minimise their shortcomings in the students' study process (Lehtonen 2002a, 2002b, 2005a, 2005b; Lehtonen et al., to appear).

The particularly innovative aspect of the work has been its agent orientation – a pedagogical web agent orientation and the Orientation assistant (OA) (Figures 1–3), which is suitable even for slower mobile networks. The purpose of the OA is to guide or orient (Podolskij, 1997; Galperin, 1989, 1992) students in using local resources such as simulation tools (e.g., computer simulation/simulator programs) in a pedagogically sound manner (c.p., Gredler, 2004). It offers downloadable resources and digital objects to support and orient the study process. The OA was developed especially to overcome some of the problems which were observed when simulations that allowed rather open-ended problem solving approaches (Vygotsky, 1978; Jonassen, 2000; Gredler, 2004) have been used in different studies and teaching methods (Devedzic and Harrer, 2002).

In many cases, the problem has been that students are incapable of using the tool for deepening, creating or constructing their understanding and knowledge, as defined in module learning outcomes (Gonzales et al., 2001a, 2001b; Gredler, 2004; Miettinen, 2002). Furthermore, it has been observed that the students use such tools as simulations for short lasting purely amusing or 'playful' rather than goal directed purposes, instead of meaningful study use (Chen, 2002; Koopal, 1997; Gredler, 2004).

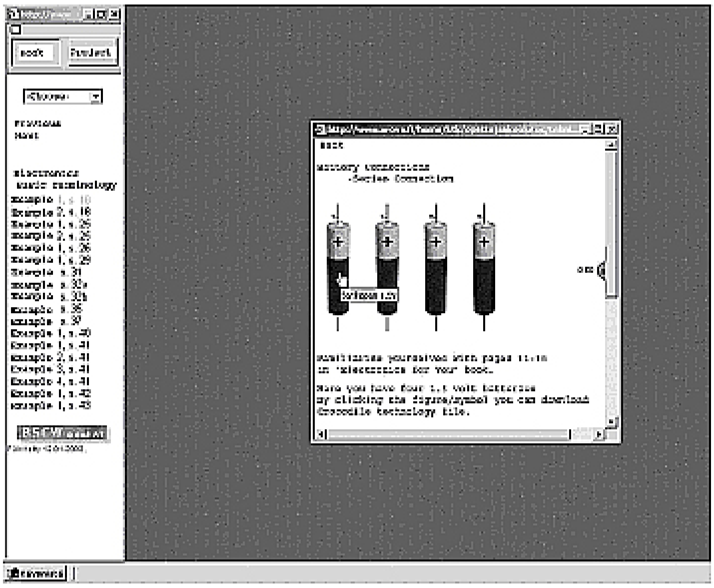


Figure 1: The OA

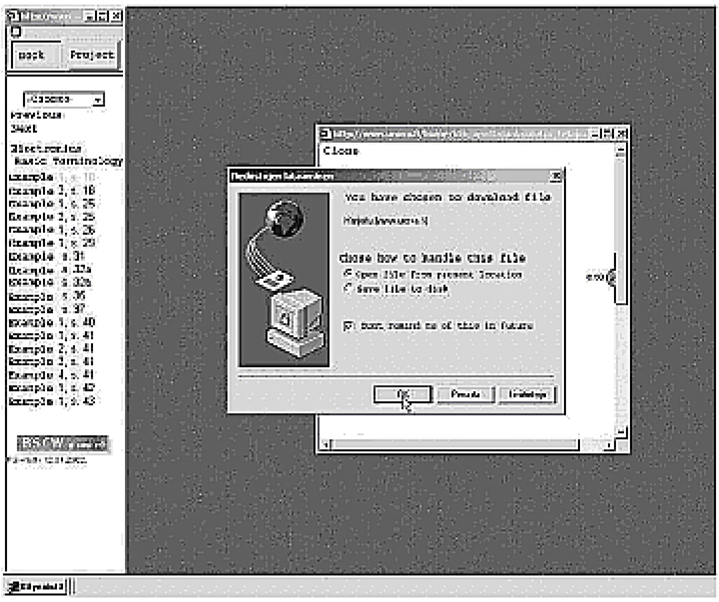


Figure 2: The OA showing downloadable local resources

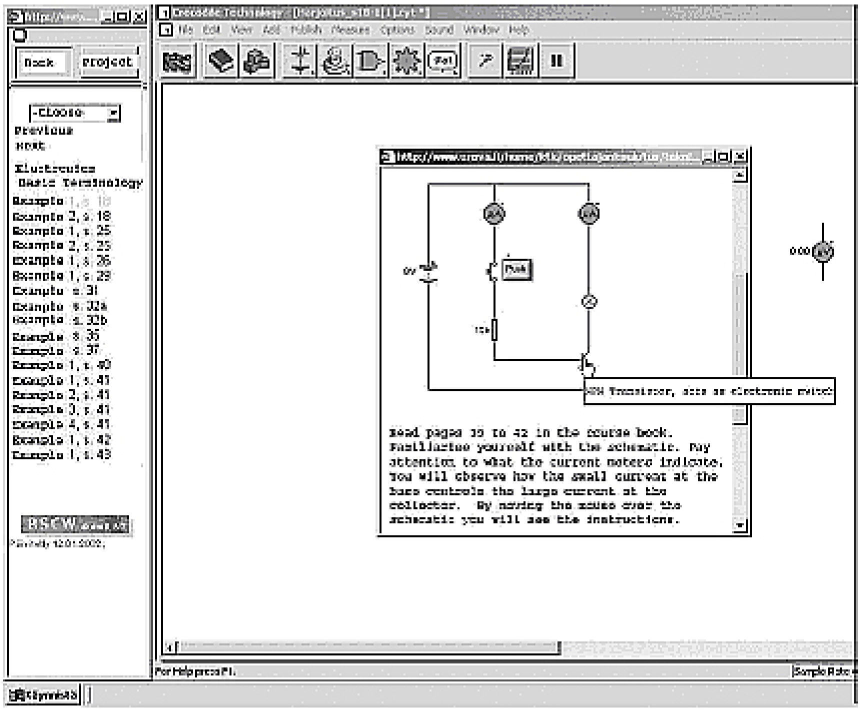


Figure 3: Example of interactive subtasks

Why web based learning with simulations? It is possible to develop local computer resources to simulate activities and learning but those are, in many ways, problematic in multi-user and multi-location environments where accessing and updating content resources are necessary. The web provides also the opportunity of integrating different collaboration tools which are needed and used in this project for group based study activity support. In addition, current standardised web technologies do not provide good platforms for purely web based simulation solutions or especially to be used in (slow) mobile networks and also a development of a good quality simulation programme is a challenging task in many ways. At the same time, there are many commercial well suitable and well functioning local simulation applications available. Therefore the development of web based orientation with local simulation application fulfills, in many ways, the project's needs in this area.

Web orientation was the goal to be achieved. In the initial phases this was attempted to be achieved by using the existing 'WWW learning environment applications' but unfortunately those did not meet our needs. Here the students found considerable difficulty in using multiple applications on the same computer screen. Particularly when the student was required to switch between the simulation program and the full screen browser window of the 'www learning environment'. This caused the students' attention to be directed away from learning activities to irrelevant activities such as switching between programmes.

The OA is a tool for guiding and orienting students' study activity, in approximating the phases derived from the System of Planned, Stage by Stage Formation of Mind Actions, or a system of PSFMA (Galperin, 1989, 1992; Podolskij, 1997). The subsystem Conditions for the formation of necessary orientation basis of action was of particular interest when developing the OA (Podolskij, 1997). The subsystem provides the learner with essential conditions for an ample guide to problem solving. Every student has a structure for internalising and becoming familiar with the subtasks concerned, for example, the content tools and the required activities. However, before being capable of using such as a part of larger problem based study activity, he/she needs to know what to do (see also Gredler, 2004). It is the view of the authors that the Galperinian (1989, 1992) or neoGalperinian (Podolskij, 1997) approaches to orientation that make use of web based learning have not been fully realised because the learning process orientation has typically been static, that the orientation bases are statically implemented as cards. We therefore argue that the full potential of the Galperinian theory (e.g., Galperin, 1989) may be found by developing conceptual, electronic interactive and adaptive WEB based tools, based on modern ICT e.g., www resources.

Despite the fact that the present research focuses on modern ICT based materials, the more traditional and established resources still maintain an important role to play. For instance, Min (1992, 2003) concludes that the use of written sources, books and handouts as parallel media, along with a computer, is often motivating; accordingly, no attempt has been made to transfer all such materials into electronic format. Min (2003) also puts forward that open simulation environments frequently work better when the instructions for their use comprise easily read and browsed (printed) documents, such as workbooks or printed pdf instructions delivered through web together with material on the computer display. From that viewpoint, the student should be given the opportunity to use the simulation tool and see the model behaviour in the (open) simulation program simultaneously with the instructional materials. In other words, he or she should be given opportunity to use the simulation tool as real tool in order to see and compare the effects presented in printed sheets or books. The OA may be seen to represent a missing interacting orientation link between the course literature and course tasks to offer base for stage by stage internalisation of the needed subtask skills and knowledge.

3. Pedagogy of the orientation assistant (OA)

The experimental OA is a WWW based application, illustrated in Figures 1 and 2. The OA has an all purpose database containing the guidance, content and orientation tools. These figures provide guidance for the study activity, including tools, for representing necessary subtasks, a general plan of final process achievement and a representation of the action tools being formed (orientation and execution tools). When a student or a student group has become familiar with the common aspects of the goals and the tools used in them, they are guided to open the real OA, which is a platform adaptive, interactive 'navigation area'. By mouse clicking upon its contents a smaller popup type window opens – orientation and interactive task windows on the screen. Here the research has drawn on usability studies and the ideas of cognitive load theory (Cooper, 1998; Wilson and Cole, 1996; Chandler and Sweller, 1991; Gredler, 2004).

In other words, the study tools have been built to avoid students having to split or divide their attention excessively among different focuses and activities. The idea is for them to use as little screen area as is required for a certain task and to use the browser windows providing GUI (Graphical User Interface) - type dialog boxes which offer the required orientation information for submitting certain tasks with local software (Min, 2003; Kaptelinin and Nardi, 1997; Wilson and Cole, 1996; Chandler and Sweller, 1991; Gredler, 2004). Moreover, efforts have been made to exploit playfulness, game basis and 'edutainment' (education and entertainment) as part of the nature of tools and materials to provide game like interactivity as factors that can enhance and diversify the learning process. Figure 1 is a screen capture of the OA system illustrating the behaviour of a basic electronic component; in this case a battery polarity and connection circuit.

The task orientation window enables students to find the information required to complete the task successfully in different interactive forms. In addition to this, students may download the needed files for the local simulation tool through which the task to be solved can start, see Figure 2. The file, which is based on the MIME type separation of files, the target application, can start. Finally the situation is similar to Figure 2 where the OA is available all the time and opens popup type interactive task orientation windows when needed. In the present research project, the tasks were connected to course literature through page numbers in the course notes. These were used to support a course in electronic design techniques (cp. Min, 1992).

The OA provides detailed functional descriptions of electronic components as well as self assessment questions relating to such. It is capable of being browsed through as if reading through a book on or referred to by using search criteria. A student, typically, would use an accompanying electronic circuit design software such as Crocodile Clips and as such, the OA can be accessed by the student during circuit design. For example, if the student was considering the most appropriate value of components to be used in design, he/she can refer to the OA to call up that particular component and select from a group of standardised and commercially available component values.

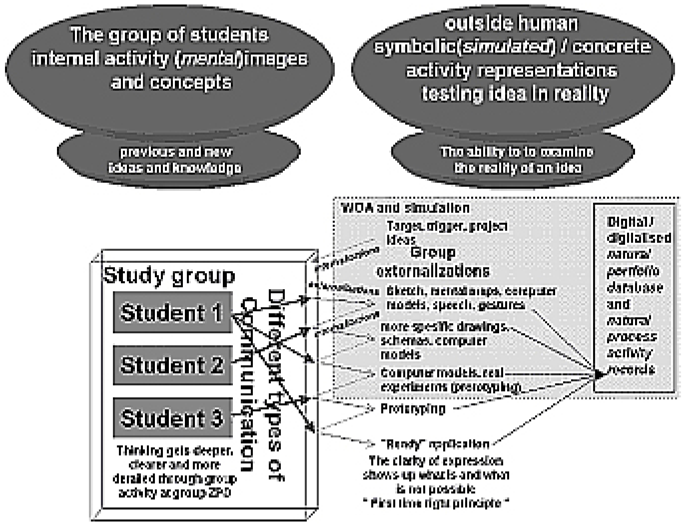
Figure 3 is an example of an interactive task dealing with the use and characteristics of a bipolar transistor and interactive representation formats of the tasks utilising interactive (HTML/JavaScript) applications. The idea of the OA is to guide or orient (Podolskij, 1997; Galperin, 1989, 1992) a student in using local resources such as simulation tools (e.g., computer simulation or simulator programs) in a pedagogically sound manner. The background for this was, as mentioned earlier, developed based on the Vygotskian and Galperinian or neoGalperinian theory (Vygotsky; 1978; Tella and Mononen-Aaltonen, 1998; Galperin, 1992; Podolskij, 1997). Because of the group study activity and support for collaboration between group members and between members in different groups, the WWW collaboration application BSCW© (Basic Support for Cooperative Work) was customised and programmed as part of the present web-based learning environment system to offer shared visualisation and collaboration as well as file storage and sharing space for all of the groups.

4. How OA, theory of teaching and learning support one another

The combined use of the OA and BSCW has been designed to orient the student's studying and learning activity as an individual and as a member of a group, i.e., small groups towards Vygotsky's zone of proximal development (ZPD). This is engendered through the use of instructional design solutions and information technology (Lehtonen, 2002; Ruokamo et al., 2002; Vygotsky, 1978; Wertsch, 1985; Bransford et al., 2000; Tella and Mononen-Aaltonen, 1998). The aim has been to create a process in which the topic being studied and such related subskills i.e., stage by stage formation of mind actions and knowledge are constructed by the learner in the group process. Through this kind of process the trial and especially errors are reduced to the level which maintains the study activity and motivation at the proper level (Galperin, 1989). In the initial stage of the process, students are engaged in network guided activities in which they externalise, communicate and visualise their ideas to others through speech (internally as well as externally). At the first phase of the pedagogical model, the orientation phase, the topic is studied through the guided orientation of books and laboratory manuals together with the OA. Students study, internalise, externalise, communicate and visualise their ideas to others through speech (internally as well as externally). This is facilitated through modelling tools and gestures as well as viability testing of their ideas using a simulation tool as illustrated in Figure 4. In this way, the topics are gradually internalised (Galperin, 1989, 1992; Podolskij, 1997) and it becomes possible to steadily reduce the guidance or orientation of study, ultimately permitting the testing and application of what has been learned in a problem based project.

The second Problem Based Learning (PBL) phase or Galperin's (1992) words 'refining through practise' of the pedagogical model (Figure 4). In this stage, the group is presented an ill defined open design problem to solve; first in a simulated environment and subsequently in reality situations in technology laboratory based on Kimbell (1987, 1997, 2000a, 2000b), Vygotsky (1978) and Podolsky (1997). Drawing on the ideas of Vygotsky (1978), Galperin (1989; 1992), Podolsky (1997) and Kimbell (1987, 1997, 2000a, 2000b), the internal and external speech and social interaction with the aid of the simulation as communication tools among the students occupies a central role in the learning processes. This is supported with the 'externalisation' – (interacting and communicating with material or immaterial symbolic visualisations) and internalisation phases where there is a deeper requirement for thinking and understanding. Finally, at the last stage, the group is presented with design problems to solve first in a simulated environment and subsequently in reality. The guidance tools and resources, book, and OA, remain at the student's and group's disposal throughout the process should they wish to resort to applying them. This can be considered extremely important, not only for guidance of the student but also as an element which can provide the student a sense of security and a reduced situational anxiety and emotional load, thus contributing to learning (Farnill, 2001; Min, 2003; Bransford, 2000; Lehtonen et al., to appear).

When the subskills that have been mastered following the process described, in which guidance is gradually reduced and different subskills practised. In addition, students' knowledge of electronics technology is gradually developed, learning activity can continue with a very open, problem-based period (Gredler, 2004). In this case, the students must not only test their knowledge and acquire new knowledge, but also apply what they have learned during the first stage of the teaching.



Source: Kimbell (1987, 1997, 2000a, 2000b); Vygotsky (1978) and Podolsky (1997)

Figure 4: The problem based learning (PBL) phase of the study model

5. Emotionality, game baseness, and edutainment as part of studying and OA

For the purpose of effecting improved attention among students, the activity structure and the tools used in it should produce and help to produce positive emotions, experiences and feelings in support of teaching as stated in the example where the work of a magician was compared with the work of a teacher or teaching application as OA (Lehtonen et al., to appear). It should be noted that the purely cognitive support, if such even exists is not enough for learning in most of the situations (Prensky, 2001; Galperin, 1989). The student should be also engaged emotionally for the studying and learning tasks. This support from the emotional viewpoint is necessary and can often be a necessary element, especially in the early stages of learning. Jonassen (2000) observed that interactive tools like open simulation tools motivate students precisely because the tools allow them to learn by doing instead of passively watching and listening to a presentation of how the activity is done by someone else (see also Bransford et al., 2000; Prensky, 2001). Moreover, one's own activity and work as part of a group, often in proper forms, engages emotions and experiences (Lehtonen et al., to appear).

Game baseness, playfulness and edutainment has a contribution to make here, in that the computer does not lose its significance as a tool; rather, its distinctive features are augmented to produce emotions in and entertain the user (Kangas, 1999; Lehtonen et al., to appear; Prensky, 2001), but keeping in mind not to orient him or her toward improper directions with the used hypermedia effects (Prensky, 2001). By referring playfulness and game baseness, we refer to Crawford's (1984) and Prensky's (2001) notes that the principal motivation for playing is a desire to learn and to learn how to control a situation. Both authors state that the desire to play is a mechanism that is built nto each and everyone of us which the designers of computer games make use of, for xample, ramping levels of difficulty (which keeps us at the zone of proximal development by Vygotsky), immediate feedback (which gives us feedback of success or not), and the use of multimedia to produce different effects (offering multimodal sensations) are some of the means by which these experiences are created in computer games.

These same principles should be wisely adapted to the computerised and web based studying and learning tools by reducing e.g., situational anxiety, which is an emotional response to a situation that is perceived as difficult and its characteristic features and producing at the same time, positive emotions or situational pleasure, a concept developed by (Lehtonen et al., to appear). It may be understood to be an emotional response to a situation that is experienced as easy or pleasant (cf. flow Csikszentmihalyi, 1992). An important aspect of this work is also in reducing mental load, a concept derived from Sweller's theoretic model of cognitive load (Chandler and Sweller, 1991; Sweller and Chandler, 1994; cp. Galperin's 1989 main burden of the work) by supplementing it with emotional load. Mental load implies an excessive burden in relation to a learner's emotional and cognitive resources that is caused by the structures and activities of study related equipment and materials, which diminishes learning capacity. A part of this load is due to learning of the issue being processed and another part to concurrent effects of negative emotions. This research attempted to accommodate edutainment through choice of a commercial simulation tool. The electronic design simulation software Crocodile Clips chosen for the research from among a number of potential applications has proven to be a successful one in many respects (the used conceptual and symbolic interaction model, usability factors, game baseness, playfulness and edutainment viewpoints).

6. Design based research for the model

The research project entitled 'Network-Based Mental Tools in Technology Education' tests this pedagogical model named 'Network oriented study with simulations' and tools (OA). These tests are case based research components of the ongoing MOMENTS (Models and Methods for Future Knowledge Construction: Interdisciplinary Implementations with Mobile Technologies) -consortium case-based research studies. This work is funded by the Academy of Finland and the Finnish Technology agency. This work is conducted at the University of Lapland. The research activity of the pedagogical model and OA is based on multiple mode data collection and mixed mode methods (Creswell, 2002). The research was carried out in the form of design based action research cases and the methodology used is both on qualitative and quantitative methods (Kemmis and McTaggart, 2000; Lehtonen, 2005a). The data collection methods used are quantitative and qualitative, partly technology based. In one data block, the students are also interviewed through stimulated recall interviews. The data which was collected for the first case included:

- queries (pretest, posttest)
- interviews
- participant and technology based observations
- the activity of the learners in groups are recorded with different technical means on audio and video.

Additionally, more precise information is sought through simultaneous screen recording for one group of students, which was used as the basis for the stimulated recall method data collection (Lehtonen, 2005a).

One student group's simultaneous screens were recorded on video while the students used OA, together with simulations. In these videotapes, the group and their computer screen appear in the same frame. The student groups were interviewed after the lessons using the stimulated recall method (STRI). Students were shown some problematic situations from the videotape and were asked questions to describe their thinking and problem solving processes.

The focus breakdown situations (Lehtonen 2005a; Lehtonen, et al., to appear; Nardi, 1997; Bødker, 1997) will be analysed directly from the tape for investigation of the potential causes of excessively heavy mental load situations. The groups' interviews were also recorded on videotape and audiocassette. The students' process output, both digital and later, material ones were also collected using the idea of a natural portfolio. The group comprising in the first case comprised third and fourth year students at university of Lapland. The first case study activities are currently under analysis and it took place in a 48 hour course module held in a university computer class and in technology labs. The data is been analysed just at the time using mostly qualitative means.

7. Conclusions and future work

In light of the current findings, the research project 'Web supported Mental Tools in Technology Education' has made it possible to test the theoretical bases described. Furthermore, it has yielded valuable information on how study using simulation tools and network applications that support these and more traditional media can be appropriately organised. Preliminary research findings from the case study support the effectiveness of the approach adopted. The pedagogical model containing excerpts from a textbook and a simulation supported by an interactive POA – WWW agent application seems to work as envisioned. (Lehtonen et al., 2004).

A preliminary analysis indicates that Galperin's ideas of the gradual internalisation of relevant subskills, by guiding the process through different orientation phases, seems to work in a network environment. The importance of taking edutainment into account in designing instruction also seems to be just as helpful.

The guiding/orienting function of this first stage can be considered very important in the light of the types of tools used in the present research and in simulation programs for electronics open problem solving. In commenting on such tools, Jonassen (2000) observes, '[the tools] enable learners to represent their own thinking in the ways that they explore, manipulate and experiment with the environment' (Gokhale, 1996). There is one problem associated with tools that make use of open-problem solving. It is that without proper teaching, learning process and sufficient practice in the use of the tool itself and control of the tool in the learning subject matter the proper learning cannot take place. In addition without real and proper enough experimenting with the tool and study of the tool in problem solving thereafter as well as acquisition and building up of sufficient knowledge and skills in the subject concerned as part of studying there rarely exists any high quality learning.

These tools lead to superficial and game-like study activity, which rarely results in high level learning. Here, one may refer to Podolskij's (1997) statement, based on neoGalperinian theory, that only when a learner has been helped to internalise certain routine activities and these no longer place an undue mental load on his/her thinking and activities should he/she be given tasks requiring creativity, such as open problem solving tasks (Albanesi and Mitchell, 1993; Norman, 1998). For this reason, the teaching described has been designed to include orientation as Galperin describes it. Which, in turn, seeks to ensure that subject matter is learned gradually, whilst at the same time students have an opportunity to regulate the orientation and support offered to them in accordance with their needs to the minimum level possible. Nevertheless, students may keep these available should they want to resort to them (Ausubel, 1968; Bruner, 1985). One interesting phenomenon is that the pedagogical model 'Learning through simulations' (Joyce et al., 1997), has yielded parallel evidence substantiating the results of Network Based Mental Tools in Technology Education.

The guiding/orienting function of this first stage of the pedagogical model can be considered, as expected, very important in light of the types of tools used in the present research and in simulation programs for electronics open problem solving. Moreover, some quite unexpected results were found, which related to the commercial simulation program usability characteristics and the most unexpected were problems related to the English language used in the program for the Finnish university student users.

What has also been seen in preliminary research findings is the need for a general understanding for the whole process, 'the general orientation base' in Podolskij's (1997) words. Here, the student group should possibly be directed to develop an electronic solution in the early phase of the pedagogical model in some manner. This can be very well facilitated through the OA and followed with guided laboratory practice to produce some simple working electronic device – from simulation to a ready made working system with real components. Through that kind of 'guided mini design process' – from mental to material reality the student group would very likely reach the general understanding of the whole process which helps them in two ways; to internalise the needed skills and knowledge by seeing the importance for those, whilst being capable of understanding the whole process in advance of the second problem based process (Gokhale, 1996; Gonzales et al., 2001b).

Further study and analysis will also produce a great deal of knowledge in this area, where teaching and learning resources are being organised and analysed. Evaluation of the preliminary conclusions, the future development of the OA will be targeted at least to developing a more interactive and adaptive user interface and using a variety of media types (gif/flash animation, streaming movie clips, sound e.g., as a parallel information (sense) channel and as a part of supplementary edutainment oriented solution.

REFERENCES

1. ALBANESI, M.A. and MITCHELL, S. (1993), **Problem-based learning: a review of literature on its outcomes and implementation issues**, *Academic Medicine*, ISSN 1040-2446, Vol. 68, No. 1, pp.52–81.

2. AUSUBEL, D. (1968), **Educational Psychology: A Cognitive View**, Holt, Rinehart and Winston, New York.

3. BRANSFORD, J., BROWN, A.L. and COCKING, R.R. (Eds.) (2000), **How People Learn**, National Academy Press, Washington DC.

4. BRUNER, J. (1985), Vygotsky: **A Historical and Conceptual Perspective,** Teoksessa: J. Wertsch, Culture, Communication and Cognition, Cambridge University Press, Cambridge.

5. CHANDLER, P. and SWELLER, J. (1991), **Cognitive load theory and the format of instruction**, Cognition and instruction, Hillsdale, New Jersey, Vol. 8, pp.293–332.

6. CHEN, T. (2002), **Design considerations for computer-based simulations in education**, *Proceedings.of the ED-Media 2001 Conference Tampere*, Finland, June 25–30, pp.293–294.

7. COOPER, G. (1998), **Research into Cognitive Load Theory and Instructional Design at UNSW**, University of New South Wales, Australia. [Online reference, see <http//www.gmp.usyd.edu.au/vguide/students/samplew/mscp/learningtopics/Kk9HHkf.html>, referred 22nd June, 2004].

8. CRAWFORD, C. (1984), **The Art of Computer Game Design**, McGraw-Hill, Berkley, USA.

9. CRESWELL, J.W. (2002), **Research Design. Qualitative, Quantitative and Mixed Methods Approaches,** 2nd ed., Sage, London.

10. CSIKSZENTMIHALYI, M. (1992), **Flow: The Psychology of Optimal Experience**, Harper and Row Inc., New York.

11. DEVEDZIC, V. and HARRER, A. (2002), **Architectural patterns in pedagogical agents**, in Cerri, S.A., Gouardères, G. and Paraguaçu, F.(Eds.): ITS 2002, LNCS 2363, Springer-Verlag, Berlin, pp.81–90.

12. FARNILL, D. (2001), **Communication in a Medical Emergency**, Dept of Behavioural Sciences, University of Sydney, Sydney [Online reference, see <http://www.gmp.usyd.edu.au/vguide/ students/samplew/mscp/learningtopics/Kk9HHkf.html>, referred 12th February, 2003].

13. GALPERIN, P.I. (1989), **Organisation of mind activity and effectiveness of learning**, Soviet Psychology, Vol. 27, No. 3, pp.65–82.

14. GALPERIN, P.I. (1992), **The problem of activity in soviet psychology**, Journal of Russian and East European Psychology, Vol. 30, No. 4, pp.37–59.

15. GOKHALE, A. (1996), **Effectiveness of computer simulation for enhancing higher order thinking**, Journal of Industrial Teacher Education, Vol. 33, No. 4, pp. 36–46. [Online reference, see <http://scholar.lib.vt.edu/ejournals/JITE/v33n4/jite-v33n4.gokhale.html>, referred 22nd June, 2004].

16. GONZALES, J.J., REITMAN, L. and STAGNO, T. (2001a), **An interactive system for teaching electronics**, Seminar paper, ED-Media 2001 Conference Tampere, June 25–30, Finland.

17. GONZALES, J.J., REITMAN, L. and STAGNO, T. (2001b), **An interactive system for teaching electronics**, Proceedings of the ED-Media 2001 Conference Tampere, June 25–30, Finland, pp.608–612.

18. GREDLER, M.E. (2004), **Games and simulations and their relationships to learning**, in Jonassen, D.H. (Ed.): Handbook of Research for Educational Communications and Technology: A Project of the Association for Educational Communications and Technology, 2nd ed., Lawrence Erlbaum Associates, Mahwah, NJ, pp.571–582.

19. ILLERIS, K. (2002), **The three dimensions of learning**, Contemporary Learning Theory in the Tension Field between the Cognitive, the Emotional and the Social, Roskilde University Press, Roskilde.

20. JONASSEN, D. (2000), **Computers as mindtools for schools**, Engaging Critical Thinking, 2nd ed., Prentice Hall, New Jersey.

21. JONASSEN, D. and ROHRER-MURPHY, L. (1999), **Activity theory as a framework for designing constructivist learning environments**, Educational Technology: Research and Development ETR&D, Vol. 47, No. 1, pp.61–79.

22. JOYCE, B., CALHOUN, E., and HOPKINS, D. (1997), **Learning through simulations**, Models of Learning – Tools for Teaching, Open university press, London, pp.120–205.

23. KANGAS, S. (1999), **Mukautuvat käyttöliittymät elektronisissa peleissä** (Adaptive user interfases in electronic games)', in Honkela, T. (Ed.): Pelit, tietokone ja ihminen, (Games, Computers and People), Suomen tekoälyseuran julkaisuja, Symposiosarja No. 15, University of Art and Design UIAH and Finnish Association of Artificial Intelligence, Helsinki, pp.128–134.

24. KAPTELININ, V. and NARDI, B.A. (1997), **Activity Theory: Basic Concepts and Applications**, [Online reference, see <http://www.acm.org/sigchi/chi97/ proceedings/tutorial/bn.htm>, referred 22nd February, 2004].

25. KEMMIS, S. and MCTAGGART, R. (2000), **Participatory action research**, in Denzin, N.K. and Lincoln, Y.S. (Eds.): Handbook of Qualitative Research, 2nd ed., Thousand Oaks, Sage Publications, CA, pp.567–605.

26. KIMBELL, R. (1987), **Design and technological activity**, A Framework for Assessment, Department of Education and Science, Assessment of Performance Unit, Her Majesty's Stationary Office, London.

27. KIMBELL, R. (1997), **Assessing technology**, International Trends in Curriculum and Assessment, Open University Press, London.

28. KIMBELL, R. (2000a), **Design for Learning**, Article and Seminar paper based on article, Kajaani Kytke 2005 – seminar 28.4.2000.

29. KIMBELL, R. (2000b), **Assessing Technology, Technology Education – from a Problem to a Solution**, Seminar presentation, Kajaani Kytke 2005 – seminar 28.4.2000.

30. KOOPAL, W. (1997), **Instructional Design for Computer Simulations**, Supervision: Min, R. and Moonen, J. [Online reference, see <http://www.gmp.usyd.edu.au/vguide/students/samplew/ mscp/learningtopics/Kk9HHkf.html>, referred 22nd June, 2004].

31. LEHTONEN, M. (2002a), **Toward the information age challenges in technology education. Modern learning methods and learning media supported and mediated learning processes as part of the new university technology education curriculum**, in Kantola, J. and Kananoja, T. (Eds.): *Looking at the Future: Technical Work in Context of Technology Education*, University of Jyväskylä. Department of Teacher Education. Research 76, Jyväskylä University Printing House, Jyväskylä, pp.99–119.

32. LEHTONEN, M. (2002b), **Simulaatioiden avulla tapahtuvan oppimistoiminnan mallin ja sitä tukevien Web-pohjaisten välineiden kehittäminen teknisessä työssä ja teknologiakasvatuksessa** (Development of simulation based learning activity model and the supporting Web based tools for technology education), Long paper, ITK'02 Confrence, Workshop of researchers, Organised by the Ministery of Education and University of Tampere Hypermedia Laboratory, 17.4.2002, Hämeenlinna.

33. LEHTONEN, M. (2002c), **Online interactive curriculum representation as one key to well structured students learning activity**, Proceedings of the ED-Media 2002 Conference, June 24–29, Denver, Colorado, USA, pp.1110–1115.

34. LEHTONEN, M. (2003), **Pedagogical pedagogical orientation agentin orientation and guiding studies of the local electricity simulations**, in Nichol, J. and Gavrilova, T. (Eds.): Proceedings of 11th International PEG Conference, Powerful ICT Tools for Learning and Teaching [CD-ROM], St. Petersburg, Russia.

35. LEHTONEN, M. (2005a), Opetus-opiskelu-oppimisprosessi analyysin kohteena MOMENTS-hankkeen, Network-Based Mental Tools in Technology Education tapaustutkimuksessa (The Teaching-study in-Learning process as a target for analysis in 'Network-Based Mental Tools in Technology Education' – case study)', in Levonen, J. and Järvinen, T. (Eds*.):* TUOVI II: ITK´04, Tutkijatapaamisen artikkelit (Hypermedialaboratorion verkkojulkaisuja – Hypermedia Laboratory Net Series), Tampereen yliopisto, Hypermedialaboratorio, Tampere [Online reference, see <2004http://tampub.uta.fi/>, referred 22nd March, 2005].

36. LEHTONEN, M. (2005b), **Simulations as mental tools for network-based group learning**, in Nicholson, P., Thompson, B.J., Ruohonen, M. and Multisilta, J. (Eds.): E-Training Practices for Professional Organisations, IFIP TC3/WG3.3 Fifth Working Conference on eTrain Practices for Professional Organizations (eTrain 2003) Open Working Conference, 7–11 July, 2003 in Pori, Finland, Kluwer Academic Publishers, Boston/Dordrecht/London, pp.11–18.

37. LEHTONEN, M., HYVÖNEN, P. and RUOKAMO, H. (to appear) **Learnt Without Joy, Forgotten Without Sorrow!: The Significance of Emotional Experience in the Processes of Online Teaching, Studying and Learning**, Paper to be presented at the NBE Network-Based Education 2005, Rovaniemi.

38. LEHTONEN, M., PAGE, T., THORSTEINSSON, G. AND RUOKAMO, H. (to appear), **Web-supported mental tools in technology education**, Journal of Technology Education.

39. MIETTINEN, R. (2002), **Varieties of constructivism in education**, Where do we stand? Lifelong Learning in Europe, January, Vol. 7, No. 1, pp.41–48.

40. MIN, F.B.M. (1992), **Parallel instruction, a theory for educational computer simulation**, Interactive Learning International, Vol. 8, No. 3, pp.177–183.

41. MIN, R. (2003). **Shortcomings of the Monitor. The Problem of Linear Presentation Media in Learning Situations; the Importance of Parallelism in Open Learning and Working Environments**, [Online reference, see <http://projects.edte.utwente.nl/pi/Papers/Monitor.htm>, referred 22nd June, 2004].

42. NARDI, B.A. (1997), **Context and Consciousness, Activity Theory and Human-Computer Interaction,** 2nd pr., MIT Press, Cambridge, MA, MIT Press.

43. NORMAN, G.R. (1998), **Problem-solving skills, solving problems and problem-based learning**, *Medical Education*, Vol. 22, pp.279–286.

44. PODOLSKIJ, A. (1997), **Instructional design for schooling, developmental issues**, in Dijkstra, S. *et al.* (Eds.): Instructional Design. International Perspectives, Vol. 2, Lawrence Erlbaum, Mahwah, NJ.

45. PRENSKY, M. (2001), **Digital Game-Based Learning**, McGraw-Hill, New York, NY, USA.

46. RUOKAMO, TUOVINEN, H., TELLA, S., VAHTIVUORI, S. and TISSARI, V. (2002), **Pedagogical models in the design and assessment of network -based education**, Proceedings of the ED-Media 2002Conference, 24–29 June, Denver, Colorado, USA, pp.1676–1681.

47. SWELLER, J. and CHANDLER, P. (1994), **Why some material is difficult to learn**, Cognition and Instruction, Vol. 12, pp.185–233.

48. TALYZINA, N. (I981), **The Psychology of Learning**, Progress Publishers, Moscow.

49. TELLA, S. and MONONEN-AALTONEN, M. (1998), **Developing Dialogic Communication Culture in Media Education: Integrating Dialogism and Technology**, University of Helsinki, Department of Teacher Education, Media Education Centre, Media Education Publications 7, ERIC ED426620, Helsinki, [Also available online, see <http://www.helsinki.fi/~tella/mep7.html>, referred 22nd June, 2004]

50. ULJENS, M. (1997), **School Didactics and Learning**, Psychology Press, Hove, East Sussex. Vygotsky, L.S. (1978) Mind in Society, Harvard University Press, Massachusetts, Cambridge.

51. WERTSCH, J.V. (1985), **Vygotsky and the Social Formation of Mind**, Harvard University Press, Cambridge, MA.

52. WILSON, B. and COLE, P. (1996), **Improving Traditional Instruction. Cognitive Load Theory**, [Online reference, see <http://carbon.cudenver.edu/~bwilson/cog/sweller.html>, referred 22ndJune, 2004].