AN ORIENTATION ASSISTANT (OA) FOR GUIDING LEARNING THROUGH SIMULATION OF ELECTRONICS TECHNOLOGY IN TECHNOLOGY EDUCATION

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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.

Keywords: orientation assistant; network based learning; simulation; activity theory.

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).

Making simulations and interactive multimedia - 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 minimize 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 13), 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).

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 the opportunity of integrating different collaboration tools which are needed and used in this project for group based study activity support. In addition, current standardized 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 that had 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 the 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 distracted 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 a part of a 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 realized 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 internalization of the needed subtask skills and knowledge.

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).

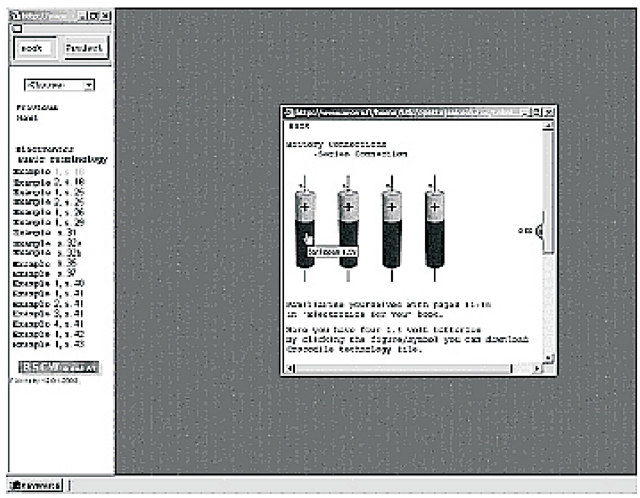

Figure -1 The OA

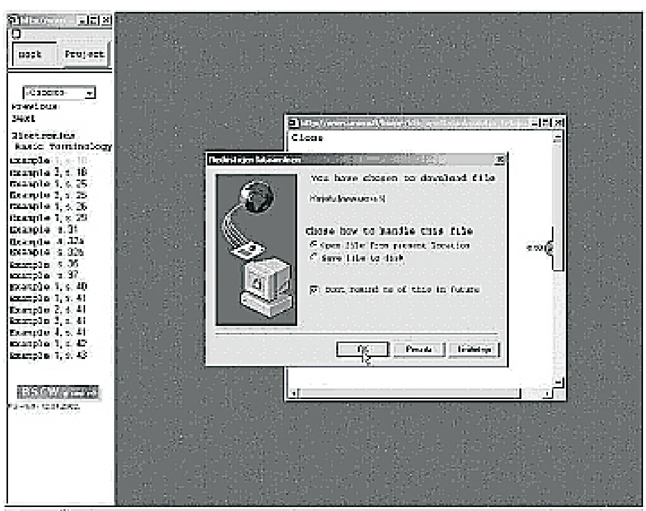

Figure 2 The OA showing downloadable local resources

In other words, the study tools have been built to avoid students having to split or divide their attention excessively over 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 windowsproviding 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 gamelike 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 is used.

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 as if reading through a book or referred 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 bi-polar 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 customized 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.

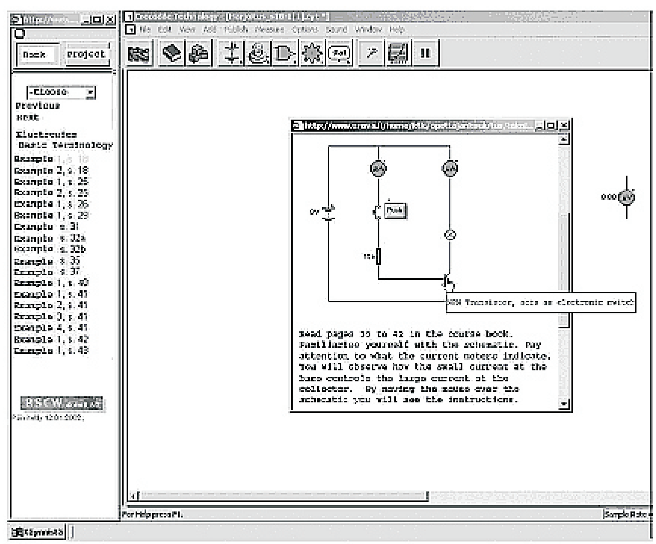

Figure -3 Example of Interactive Subtasks

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, especially errors are reduced to the level which maintains the study activity and motivation proper. (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 real 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, and 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 with the student's and group's disposal throughout the process if they wish to resort 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 have been mastered following the process described, 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.

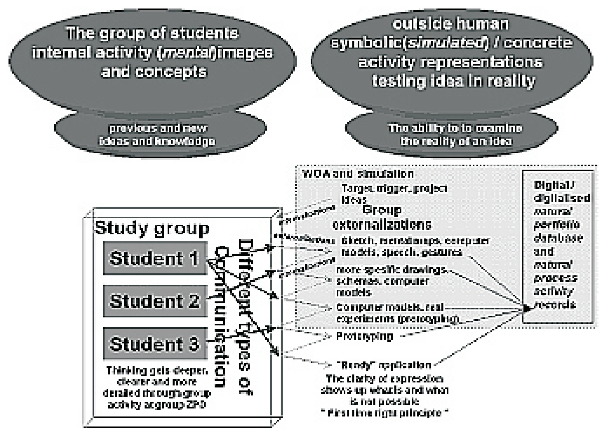

Figure 4 The problem based learning (PBL) phase of the study model

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

Emotionality, game baseness, playfulness 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 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 the authors state that the desire to play is a mechanism that is built into each and everyone of us which the designers of computer games make use of, for example, 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 multi modal sensations) are some of the means by which these experiences are created in computer games.

These same principles should be wisely adapted to the computerized 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 are 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 the continual learning of the issue and another part is 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).

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 has been analyzed just at the time of using most qualitative means.

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 internalization 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 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 and control of the tool in the learning subject matter, the proper learning cannot take place. In addition without real and proper experimenting with the tool and study of the tool in problem solving as well as acquisition and building up of sufficient knowledge and skills in the subject,high quality learning will rarely exist.

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 if they want to resort 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 to 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 organized and analyzed. Evaluation of the preliminary conclusions, the future development of the OA will be targeted at least to develope a more interactive and adaptive user interface and using a variety of media types (gif/flash animation, streaming movie clips, sound etc., as a parallel information (sense) channel and as a part of supplementary edutainment oriented solution.

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