THE ROLE OF WEB-BASED SIMULATIONS IN TECHNOLOGY EDUCATION

By

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ABSTRACT

This paper discusses the theoretical underpinning and main aspects of the development and application of the web-orientation agent (WOA) and presents preliminary results concerning its use in university studies. The web-orientation agent (WOA) is a software based tool which produces an interactive learning environment offering support and guidance in teaching and learning that makes use of local applications, in this case, an electronic circuit design and simulation application.

The WOA and its supportive role in the teaching-learning process is based on activity theory (Kaptelinin & Nardi 1997) along with the constructive view of teaching, studying and learning (Miettinen 2002). The study draws on learning psychology and user evaluation of the use of computer-based learning environments. The basic principles of such planning include activity theory in computer-based environments (Nardi 1997; Kapetelinin & Nardi 1997), the theory of internalisation (Podolskij 1997), the zone of proximal development (Vygotsy 1978; Tella & Mononen-Aaltonen 1998), the NeoGalperin model for stage-by-stage formation of mind actions, and the notion of reducing the cognitive load of students (Sweller & Chandler 1994; Wilson & Cole 1996).

The tool developed in this research seeks to move away from traditional methods taken from multimedia technologies towards maximising the scope of present computer screens in a way which permits learner application software to be used simultaneously alongside the web agent. The web-orientation agent is an interactive aid and guide which enables the student user to view multiple applications. Each of these applications use as small a part of the computer screen area. Furthermore, these applications demand as little of the student users' attention as the supportive information for study activity requires.

Keywords: Network-based Learning, Simulation, Teaching-studying-learning, Activity Theory.

INTRODUCTION

In a somewhat light-hearted vein, one could say that meta-cognitive 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 it's content and to create a comfortable context 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 P.J. Galperin's terminology, the author refer to this guiding of observations in appropriate or inappropriate directions as cognitive orientation (Galperin 1989, 1992; Podolskij 1997; Talyzina 1981).

In using computer and network-based learning tools, such as electronic circuit design and simulation applications, used in this research project (Lehtonen 2002 a, b, c), 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) - will frequently not work in an optimal fashion solely by using the most modern tools (e.g. 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.

Making simulations and media a natural part of the studying process

The purpose of the work reported here is to present the pilot research undertaken in the use of the ICT-based tool "*Web Orientation Agent*" (*WOA*). It is a component of a learning activity that is the focus of this research as part 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 other "mental" tools (Jonassen 2000). In addition, traditional and modern digital learning materials are examined in a context of "normal teaching-studying-learning" (Uljens 1997) at university-level. (The term "studying" (Uljens 1997) 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. As such, efforts have been made to use: literature; electronic documents; interactive documents; and different kinds of interactive tools, such as simulations, in a manner that maximises their benefits and minimises their disadvantages in the student's study process (Lehtonen 2002 a, b).

The WOA was developed to overcome some of the problems which were observed when simulations that allowed rather open-ended problem solving approaches (Vygotsky 1978, Jonassen 2000), have been used in different studies and teaching methods (Devedzic & 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 the module learning outcomes (Gonzales, Reitman & Stagno 2001 a, b). Furthermore, it has been observed that the students use such tools as simulations for "playful" rather than goal-directed purposes instead of meaningful study use (Chen 2002; Koopal 1993/1997).

Why web-based learning? 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 collaboration tools which are needed and used in this project for group-based study activity support.

Another problem encountered when developing the WOA emerged in the preliminary experiment with ready-made "WWW-learning environment applications" and local simulation tools. 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 programs. The WOA is a tool for guiding and orienting students' study activity, to approximate 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 WOA (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. 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 has typically been static, that is statically implemented. The author therefore argue that the full potential of the Galperinian theory 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 focusses on modern ICT-based materials, the more traditional and established resources still maintain an important role to play. For instance, Min (n.d.) 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 (n.d.) 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 together with material on the computer display.

Pedagogy of the Web Orientation Agent (WOA)

The experimental WOA is a www-based application, illustrated in Figures 1 and 2. The WOA 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 WOA, which is a platform-adaptive interactive "navigation area". By mouse clicking upon its contents a smaller popup window opens type 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 & Cole 1996; Chandler& Sweller 1991). In other words, the study tools have been built to avoid students from having to divide their attention excessively among different focusses 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 (n.d.); Kapetilin & Nardi 1997; Wilson & Cole 1996; Chandler & Sweller 1991). Moreover, efforts have been made to exploit "edutainment" (*edu*cation and enter*tainment*) 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

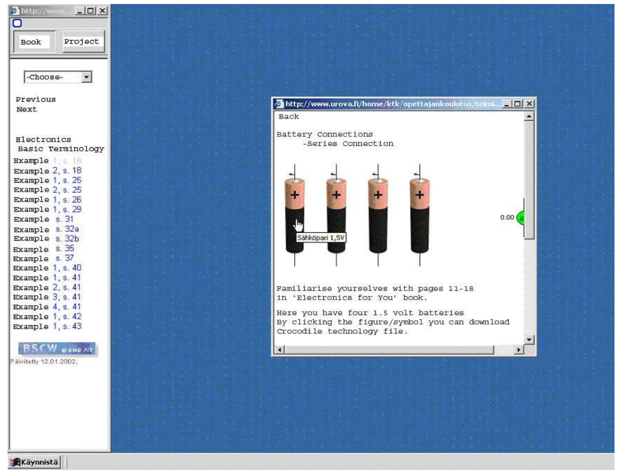

Figure I. The WOA.

screen capture of the WOA system illustrating the behaviour of a basic electronic component, in this case a battery polarity and connection circuit.

The task-orientation windows enables students to find the information required to complete the task successfully. In addition to this, students may download the needed files for the local simulation tool through which the task to be solved can start, (Figure 2) The file, which is based on the MIME-type separation of files, the target application can start. Finally the situation is like in Figure 2 where the WOA 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.

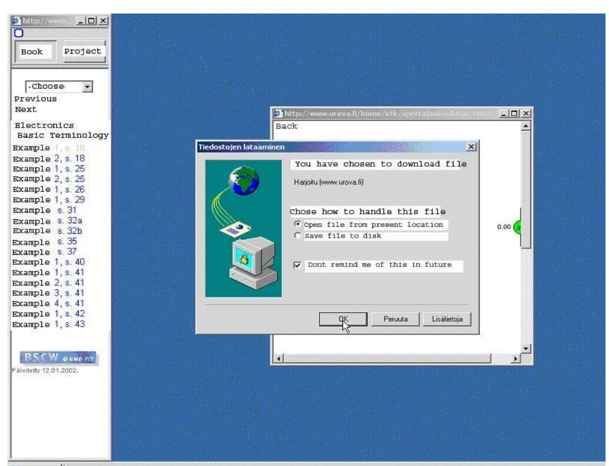

Figure 2. The WOA showing downloadable local resources.

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 WOA, is to guide or orient (Podolskij 1997and 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 & 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 collaboration and file storage and sharing space for the groups.

Preliminary research findings using methods such as simultaneous video, stimulated recall and group interviews support the effectiveness of this approach. A textbook and simulation in conjunction with an interactive WOA - www agent application to support them work very well together as envisioned.

How WOA, theory of teaching and learning support one another

The combined use of the WOA 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, Vygotski 1978, Wertsh 1985, Bransford et al. 2000 and Tella & 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. 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). 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. Drawing on the ideas of Vygotsky (1978) and Galperin (Galperin 1989; 1992, Podolsky 1997) and Kimbell (1987, 1997, 2000 a, b), the internal and external speech and social interaction among the students occupies a central role in the learning process. This is supported with the "externalisation" (interacting with material or immaterial electronic representations of the process) and internalisation phases where there is a

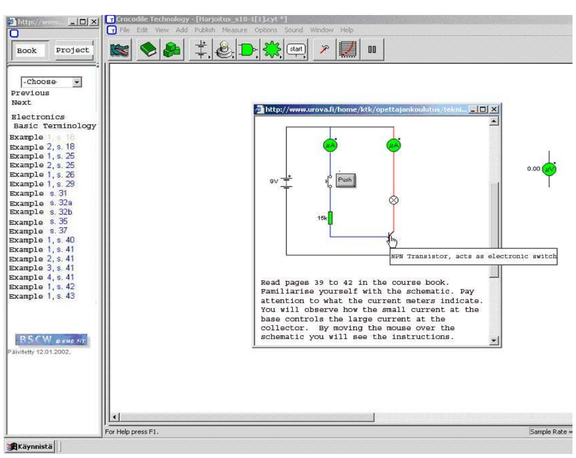

Figure 3. Example of interactive subtasks.

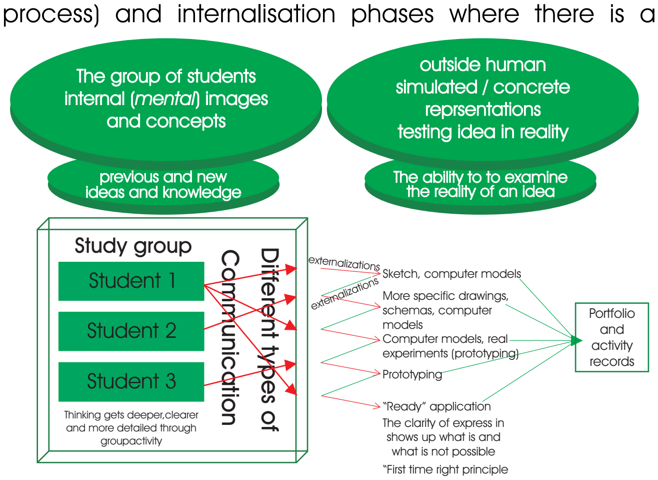

Figure 4. The study model Kimbell (1987, 1997, 2000 a, b); Vygotsky (1978); Podolsky 1997).

deeper requirement for thinking and understanding. Finally, at the last stage, the group is presented with design problem to solve first in a simulated environment and subsequently in reality. The guidance tools and resources, book and WOA, 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, thus contributing to learning (, Farnill 2001; Min n.d.; Bransford 2000). 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. 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.

Games and Edutainment as part of studying and WOA

For the purpose of effecting improved attention among students, the tools should produce experiences and feelings in support of teaching. This support is necessary and can often be a necessary element in early stages of learning. Jonassen (2000) observed that such interactive 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 (Bransford et al. 2000). One's own activity and work as part of a group often engages emotions and experiences. 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; Ruokamo et al. 2002). Crawford (1984) notes that the principal motivation for playing is a desire to learn as well to learn how to control a situation. He maintains that the desire to play is a mechanism that is built into each and every one of us which the designers of computer games make use of. For example, ramping levels of difficulty, immediate feedback, and the use of multimedia to produce different effects are some of the means by which these experiences are created in computer games.

This research attempts to accommodate edutainment through choice of a commercial simulation. 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, edutainment factors).

Conclusion 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. A preliminary analysis indicates that P. J. 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 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). It is evident that from, Gonzales, Reitman & Stango (2001) and Chen (2002), one problem associated with tools that make use of open-problem solving is that without teaching, learning and sufficient practice in the use of the tool itself, control of the tool, and without experimenting with 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. These tools lead to superficial and game-like study activity, which rarely results in high-level learning. Here, one may refer to Podolskij's (Podolskij, 1997) statement, based on neo-Galperinian theory, that only when a learner has been helped to internalise certain routine activities and these no longer place an undue cognitive load on his/her thinking and activities should he/she be given tasks requiring creativity, such as open problem-solving tasks (Albanese & Mitchell 1993). 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).

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 WOA 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.

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