
TEACHING SAFETY IN VOCATIONAL EDUCATION LABORATORIES VIA AN INTERACTIVE OPEN SOFTWARE APPLICATION

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Abstract

The goal of the presented work is to teach pupils of secondary vocational education the hazards of electricity, in a safe manner. For this purpose, an integrated software environment is selected, which provides the realization of dynamic activities that include simulations, feedback and interactions with pupils. Mainly through a proper planning and organization of teaching, the teacher may acquire educational benefits that cannot gain with traditional teaching. In this way, it is claimed that pupils approach the specific topic in an entirely personal way, both open and exploratory, by conducting an open experimental procedure that gives the initiative to engage in modelled and experiential situations. By trying to find answers to questions that are created, pupils discover the links between natural phenomena and formulate the corresponding physical laws.

Abstract in Greek

Στόχος της παρουσιαζόμενης εργασίας είναι η διδασκαλία μαθητών της δευτεροβάθμιας επαγγελματικής εκπαίδευσης για τους κινδύνους του ηλεκτρικού ρεύματος, με ασφαλή τρόπο. Για το σκοπό αυτό έχει επιλεγεί ένα ολοκληρωμένο πληροφορικό περιβάλλον, το οποίο προσφέρει στους μαθητές την πραγματοποίηση δυναμικών δραστηριοτήτων που περιλαμβάνουν προσομοιώσεις, ανατροφοδοτήσεις και αλληλεπιδράσεις. Μέσα κυρίως από ένα σωστό σχεδιασμό και οργάνωση της διδασκαλίας, ο εκπαιδευτικός δύναται να συγκεντρώσει παιδαγωγικά οφέλη για την διδασκαλία του που αδυνατεί να κερδίσει με μια παραδοσιακή διδασκαλία. Με τον τρόπο αυτό πιστεύουμε ότι ο μαθητής προσεγγίζει τη συγκεκριμένη διδακτική ενότητα με έναν τελείως προσωπικό τρόπο, ανοιχτό και διερευνητικό. Πραγματοποιεί μία ανοιχτή πειραματική διαδικασία που του δίνει την πρωτοβουλία να εμπλακεί σε μοντελοποιημένες αλλά και βιωματικές καταστάσεις. Ψάχνοντας να βρει απαντήσεις σε απορίες που του δημιουργούνται, ανακαλύπτει τις σχέσεις που συνδέουν τα φυσικά φαινόμενα και διατυπώνει τους αντίστοιχους φυσικούς νόμους.

Keywords: safety teaching, electricity hazards, vocational education, interactive software

Introduction

The educational research into didactics suggests that teaching methods play a more important role than teaching and learning environments. Nevertheless, where information and communication technologies (ICT) seem to excel markedly is in urging pupils to achieve a deeper engagement and a more positive attitude towards school (Kynigos & Dimaraki, 2002). According to the constructive and sociocultural approaches to knowledge, to “know” means to correspond the reality to transformation structures, which the cognition processes as a direct extension of knowledge. Therefore, to know a topic means to act on it, in comparison with these very transformative actions (Raptis & Rapti, 2006). In this respect, two relevant theories will be referred briefly: the constructivism of Papert (1980) and the sociocultural approach to knowledge by Vygotsky (1986).

The constructivism of Papert

The theory of Piaget laid the foundations of a pedagogical concept based on the self-activity of students and its creative role. From the model of cognitive adaptation results that children

learn through creative activities, during their interaction with the environment. Through such activities, concepts are built upon prior knowledge, via associations and connections. Besides the process itself, information and correlations are required, as skills that help the student to construct new knowledge. Finally, motivation plays an important role that, according to this theory, is always the interest shown for the satisfaction of a need.

Papert presented one of the first remarkable examples of the application of *neo-Piagetian* constructivism in teaching with the help of computers, which was a milestone for the further development of ideas about educational software. This environment, although initially limited to the development of certain cognitive models of logical-mathematical thinking by creating the micro-world of language Logo, gave the opportunity to other software developers to utilize the technological and pedagogical ideas of Papert, extending their applications to other cognitive areas.

The software environment of Papert includes empirical objects, which students manipulate at will, and procedures created in a micro-world, which favours the development of mental models that solve logical-mathematical and geometric problems (Raptis & Rapti, 2006). The ability to create repetitive processes, namely that can be continuously self-recalled, builds the student's experience upon which new knowledge will be constructed and which is not necessarily "compatible" with the empirical structures of the teacher who organizes learning, nor with those of his/her classmates. Papert's goal was to teach children to learn empirically, just like they learn their native language. The students learn by doing, through the recognition of errors, the discussion with their teacher and the reorganization of their thought to give such orders, in the strict sense and accuracy required by a computer. By programming, students adopt specific problem solving methods and, especially, they design step-by-step solutions and discover the possibility of finding more than one possible solution. They can also observe directly the effects of their applications. Students appreciate and study their mistakes and draw from them information that help them to finally solve the problem. Eventually, programming helps students to choose themselves the particular solving strategy to follow every time, the way they learn and, generally, helps them to develop reflective skills.

According to constructivism, the basic principles for the design of learning environments with a computer are (Boyle, 1997):

- to provide experiences that are related to the process of knowledge building;
- to provide experiences of multiple perspectives;
- to integrate learning in realistic environments, relating to the real world;
- to encourage the ownership of opinion and of expression in the learning process;
- to consolidate learning through social experience;
- to encourage the usage of multiple forms of representation;
- to encourage self-consciousness during the process of knowledge building.

Constructivism nowadays constitutes one of the dominant models in contemporary educational software design. It aims at providing learning activities, integrated in troubleshooting procedures that bridge the gap between *in-school* and *out-school* activities.

The sociocultural knowledge by Vygotsky

Vygotsky felt that the development of cognition is a process of social interaction, in which the dominant role is played by language. The basic principle of this theory is the "zone of proximal development", which is the unexplored region of a pupil's inner potential, who is in a situation of potential latent development. Here it is visible: the importance of adult mediation (teacher, parent) or of classmate and the role of the social environment on the cognitive development of a pupil. The individual is of course potentially able to go beyond the point of knowledge or skills, internalized by the environment, and to solve higher level problems. Yet, he/she needs: the help of others; the mediation of appropriate cultural tools and stimuli in

order to develop the level of cognitive functions and constructs for reaching the point of not only operating without assistance, but also to operate and proceed independently (Raptis & Rapti, 2006).

Another point of Vygotsky's theory that differentiated him was the importance given to the role of teacher in the educational process. The mediating role of teacher is more immediate and significant, like all other social partners, in the learning and development process. The teacher is neither just someone who gives a rich learning environment, nor even someone who gives assistance when requested, but he/she is an active shareholder in the learning process of communication; a mediator of the official culture and often a concept negotiator (Raptis & Rapti, 2006). But to do this, it is required that he/she can go beyond his/her own frame of reference; to find ways to transform the scientific discourse in the everyday's experience of students; to compose theory with practice in response to the demands of the zone of proximal development of students. Additionally, it is important that the teacher does not prescribe a strictly structured and predetermined course of instructions for all pupils, since in real educational routine this is impossible. The personalities of students, along with so many unforeseen factors, do not allow a strict planning of teaching.

Computer technology and learning process

The application of computer technology to a learning environment is focused on two directions: the mental tools and the information and communication tools (Kynigos & Dimaraki, 2002). The mental tools are related to educational applications that are often given the designation of *exploratory software*. The additional pedagogical value of the digital technology is precisely that it can offer multi-representational tools, through which students acquire notion expressing experiences and scientific argumentation, information management, action in diverse collectives, exercising in judgment and creative questioning (Kynigos, 2006). Teaching with the usage of computer technology facilitates the teacher to stimulate the interest of students, to encourage and enhance their participation. However, both the interest and the participation are neither ensured from the start, nor they remain constant during the teaching process and, most importantly, they do not necessarily ensure the exploratory character of learning.

Features of computational learning environments

The key features of a teaching intervention with such software that promotes inquiry-based learning are the following (Argyris, 2002):

- In the cognitive domain, knowledge is gradually discovered, but entirely through the interaction with the learning environment, rather than piece by piece.
- In the teaching domain, the teacher has no longer the role of authority, but he/she is an active participant and co-researcher, constantly drawing feedback.
- In the sociological domain, the interaction between students is encouraged, as well as the collective building of knowledge.
- Regarding the usage of computers, they are used as means of experimentation and investigation and not as a learning topic. They are used as knowledge construction tool, with which and not by which, students approach knowledge (Jonassen et al., 1998).

Of course, in a context of integration of such software in the classroom, an essential factor for the didactic usage of software is the dimensions of management and the strategies that are implemented, organized and activated by each teacher (Argyris, 2002).

Computational microworlds

The concept of *microworld* (*microcosm*) was originally used by Papert (1980). The microworlds are conceptual areas where the management of interconnected concepts, processes and representations is possible (Hillel, 1992). Namely, it is about computing

environments that incorporate specific concepts of a cognitive domain in the form of dynamic representations (Argyris, 2002). Furthermore, it is possible to construct new functions by the user and in this respect it seems that they can evolve in parallel with the knowledge of students (Hoyles, 1993). Moreover, a microworld enables the connection of these functions with some relationships (Laborde & Strasser, 1990). The possibility of creating new functions by combining existing ones is also inherent in the definition of a microworld. The possibilities of microworlds are further reinforced in cases where not only the manageability but also the configuration of the computing environment is provided to students. Therefore, it is concluded that “writing a program to deal with a problematic situation, makes students to externalize thoughts, ideas and opinions, to explore and transform them through the process of control and feedback – thus learning to be realized” (Argyris, 2002; p.103).

Microworlds and learning environment

A simulation environment is transformed into a learning one as long as the accompanying activities are such that help students to build or complete their knowledge and to develop elements of scientific research methodology. These activities, therefore, are the heart and soul of exploratory software, if we accept that appropriate activities constitute a *teaching intermediate* between the potential for simulations or modelling and the learning of a cognitive domain. On the other hand, software becomes educational in the computer laboratory not so much because of the many opportunities offered to students and teachers, but because of the accompanying activities. The selected teaching approach should be the one that an ITC environment is accompanied by pedagogical activities, in order to make it a learning environment. It is argued that these activities must have certain features, independently of their content (Dapontes, 1999; 2001; Rebrum, 1999):

- They cannot be identical with the known traditional exercises and problems, as it happens with most cases of physics software, of the *electronic book* category, and other ones characterized as exploratory.
- They must enable the teacher to invent activities, according to the needs of his/her own teaching, by providing the appropriate features, like multiple representations, algebraic values of sizes, multiple inputs, etc. (de Jong et al., 1998).
- They should serve specific objectives of teaching that remain marginal to traditional teaching and particularly those mentioned in the experimental research method and in transitions from one representation to another.
- They are presented in the form of worksheets, which are different depending on usage (collaborative learning in classroom or individual use at home).
- At least in a first phase, the coexistence of the two environments (paper-pencil and simulation environment) is imperative.
- They can be used in the conditions of a school computer laboratory, with one computer for every two or three students and the teacher to play the desired role of tutor.
- They do not replace teachers so much that to cancel their educational role.
- They do not replace the experiment and the culture of operating skills of students, in such a level that degrades the role of practicing or laboratory exercises.

It is obvious that any kind of microworld must be accompanied by a set of activities, studied by the teacher, which should take into account a number of parameters, from the cognitive goals of the course to the conditions of social interaction to be shaped in classroom. Obviously as well, teachers make plans naturally without prophetic abilities. Thus, they should make an estimate of all these parameters and devise some imaginary activities, which are based directly on the estimated parameters and beliefs.

These patterns of learning activities that form an imaginary picture of what will happen are called scenarios. Scenarios are more aimed at detecting possible future developments in teaching intervention, through the present. Their construction is basically a way to put

important questions of the form “what would have happened if ...” (Kynigos, 2006). The training scenarios essentially replace the stereotypical “lesson plan” of traditional teaching. This happens because the integration of computer technology in the learning process cannot be made without a consideration of: how students learn; social interactions that take place; exploitation of errors; the kind of student activities, etc.; i.e., all the factors not taken into account in the past, when lesson plans were designed. More specifically, an educational scenario, beyond the objectives pursued, considers the following issues (Kynigos, 2006):

- The types of activities, which students will be involved in.
- The social “orchestration” of a learning community.
- The spatial and temporal aspects of the environment.
- The types of meaning that students are expected to structure through the use of these technological tools.
- The management of teaching activity.

Consequently, the educational scenario differs substantially from the traditional lesson plan, which is a technical document with a predetermined linear structure. It also differs from the official curriculum, which is a centrally designed and developed body of knowledge, regarding text style and how to report on aspects of the educational environment. While a scenario is distinguished by clear references to activities and ways to use the tools in the teaching intervention, it does not obey to any particular textual type and it also lacks the prescriptive form of a systemic directive, thus providing the teacher with an important field of further design and final decisions.

The role of teacher in computational learning environments

As already analysed and argued by Vygotsky (see subsection: *The sociocultural knowledge by Vygotsky*), it is observed that the role of the teacher in a challenging learning environment is transformed into a mediating one; a teacher negotiator of concepts. In computer-supported learning environments, the role of the teacher becomes more demanding. The teacher is the one who should analyse conceptually the topic treated by the microworld and, considering the knowledge level of students, to design appropriate activities with interest and meaning for pupils (Argyris, 2002). Therefore, the planning of the entire activity acquires great importance to the development and success of the educational activity.

The teacher is also called to form a more advisory role, a role rather of a co-researcher and assistant of student efforts instead of an instructor, since the aim is for students to collaborate with each other, perhaps in small groups of three, to achieve the common goal, thus shifting the focus of the educational process from the teacher to the student, or more precisely, to a small group of students (Argyris, 2002). So, the teacher is called in a similar teaching intervention to generally advise during teaching, to help in the pupils’ disorientation, to encourage initiatives and correct actions and to discourage processes that lead to erroneous conclusions, to exploit mistakes and pupils’ questions putting concerns, to support the pupils psychologically, to urge them to work collaboratively, to promote their reflection and to consider about improving the teaching process.

A teaching application

The curriculum of secondary vocational education in Greece includes an introductory course of electricity, at the study direction of electricians (Dimopoulos & Pagiatis, 2000). A module of the syllabus is to teach pupils the hazards of electricity. This particular module can be also taught through another more general course, referring to health and safety in workplace (Chondrogiannis, 2006), that is mandatory for every study direction. Obviously, this module has to be taught not only in a safe but also interesting manner, because of its importance.

Trying to present this module in a new teaching framework that addresses learning in a computational environment, this exploratory application has been created with the help of an

interactive open software tool (see subsection: “The educational software”). The pupils are not forced to assimilate some knowledge offered, but are guided to a discovery process. Within the new teaching framework, it is claimed that the pupils (Theologis, 2011):

- reach the particular module in an entirely personal way, open and exploratory;
- perform an open experimental procedure that gives them the initiative to engage in modelled and experiential situations;
- search to find answers to questions that are created by discovering the links between natural phenomena and formulate the corresponding laws;
- become able to apply their experience in everyday life.

Module and teaching objectives

The teaching objectives concern three related aspects: the topic of the module, the learning process and the use of the computational environment. Regarding the topic, the pupils should:

- relate the quantities of voltage leakage, human body resistance and current leakage between them;
- formulate the previous relations with a mathematical expression;
- understand the impact made by the factor of *exposure time*;
- understand the risks involved in electricity applications;
- understand the need for proper grounding in electrical installations;
- be aware of the need to take appropriate safety measures;
- simulate the experiment by controlling various parameters.

Regarding the learning process:

- to experiment and study this phenomenon;
- to formulate hypotheses and findings and to verify them;
- to work out a dialogue and communication for a successful cooperation.

Regarding the use of the computational environment:

- to handle the sliders;
- to identify the buttons for changing the state of the screen-page;
- to identify the buttons that change the parameters of the experiment;
- to use the buttons for moving to the next stages.

The educational software

To implement the training scenario (see section: “The training scenario”), the use of an open-source software tool is suggested that allows multiple representations of natural quantities and ensures the interaction of pupils with each other, with the software tool itself, but also with their teacher. The selected herein software is the “MicroWorlds Pro” (LCSI, 2001).

For the proposed teaching process, an integrated information environment has been selected that provides the realization of a number of dynamic activities, which include simulations, feedback and interactions with pupils. Mainly through a proper planning and organizing of teaching, the teacher may gather educational benefits that cannot gain with traditional teaching.

The design of the module

The design consists of four screen-pages that are interconnected. The pupils are informed by screen-page 1 about the module and its purposes (Figure 1). They demystify the dangers of

electricity, as exploratory revealing those natural quantities that participate in the phenomenon of electricity leakage through the human body.

On screen-page 2 (Figure 2), the pupils perceive the presence of three variables: the human body resistance; the leakage voltage; the time exposure; and their desire to change them is created. They are usually impressed by the visual matching of the results. They can watch an image that represents the effects on the human body when traversed by electric current, which can be changed according to the value stated in the text box "LEAKAGE CURRENT".

The pupils try to correlate the experimental parameters and furthermore, by clicking on two related turtle-images, they are able to improve or even prevent the leakage. This way, they discover the rule of linking variables and they understand the need for proper grounding and appropriate safety measures. This effort is reinforced by an incitement of their teacher to group results and observations. The pupils answer questions on screen-page 3 (Figure 3) that guides them with suitable correct/error messages.

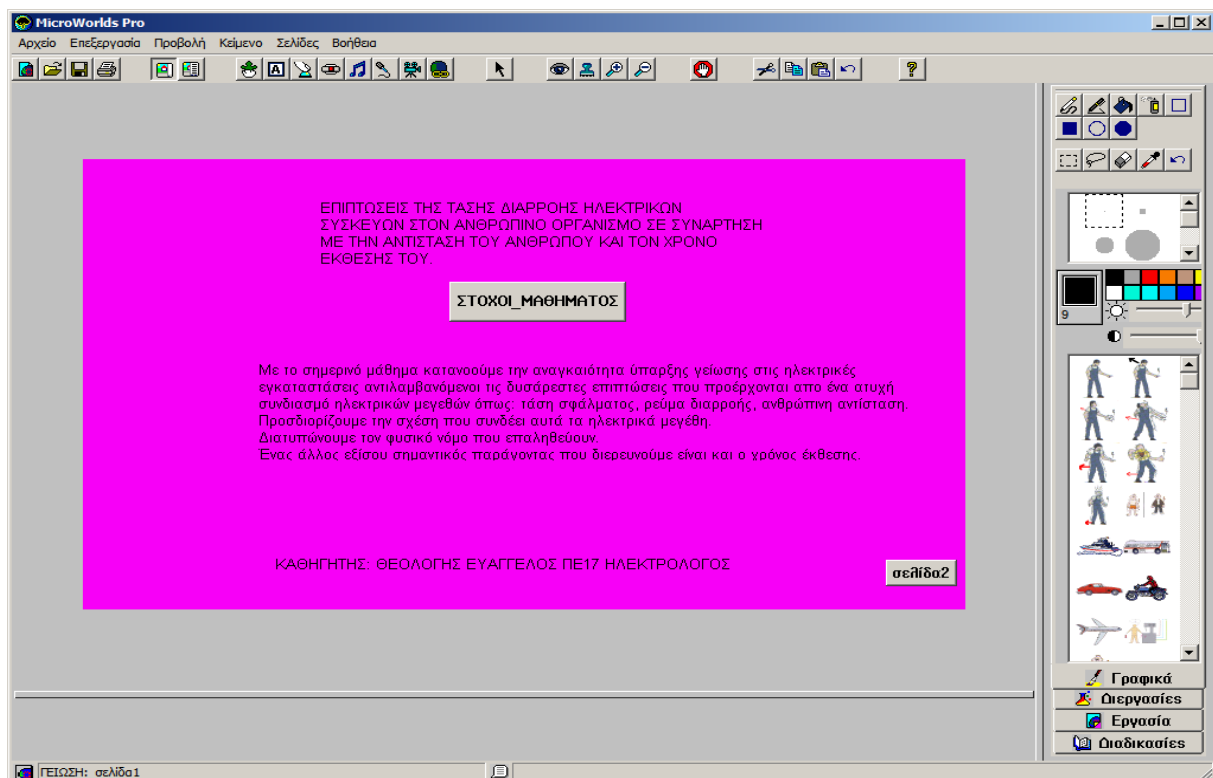


Figure 1. The first screen-page of the software tool

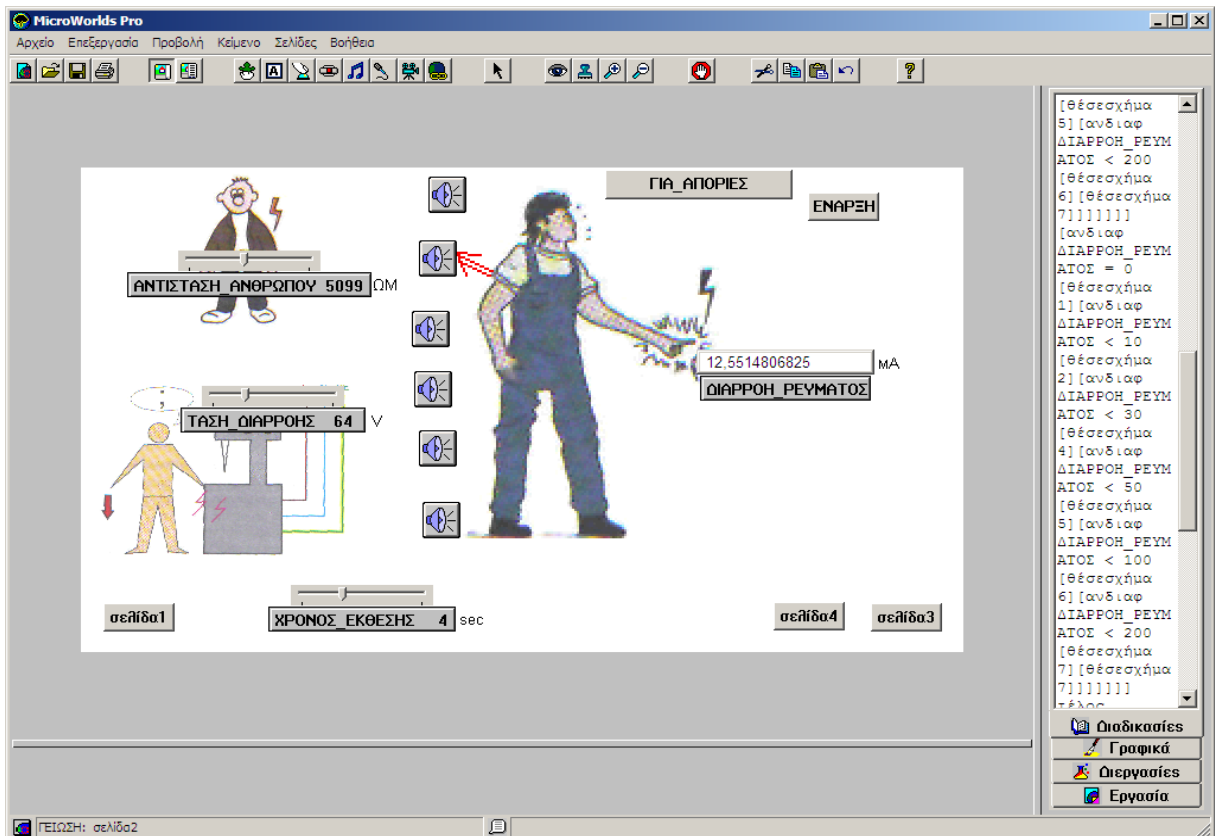


Figure 2. The second screen-page of the software tool

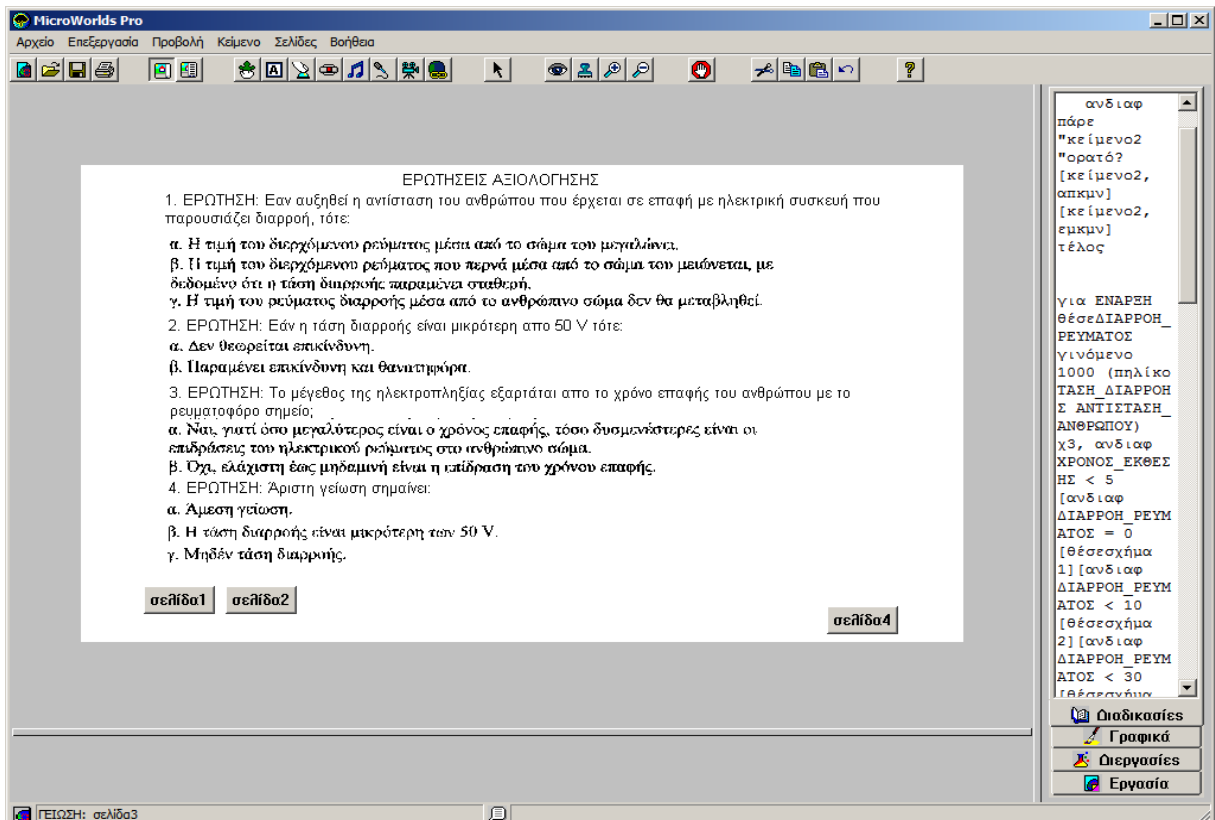


Figure 3. The third screen-page of the software tool

On screen-page 4 (Figure 4), the pupils play a repetition game, where after a random option of image-symptom matching, they are called to record the corresponding value ranges of the leakage current.

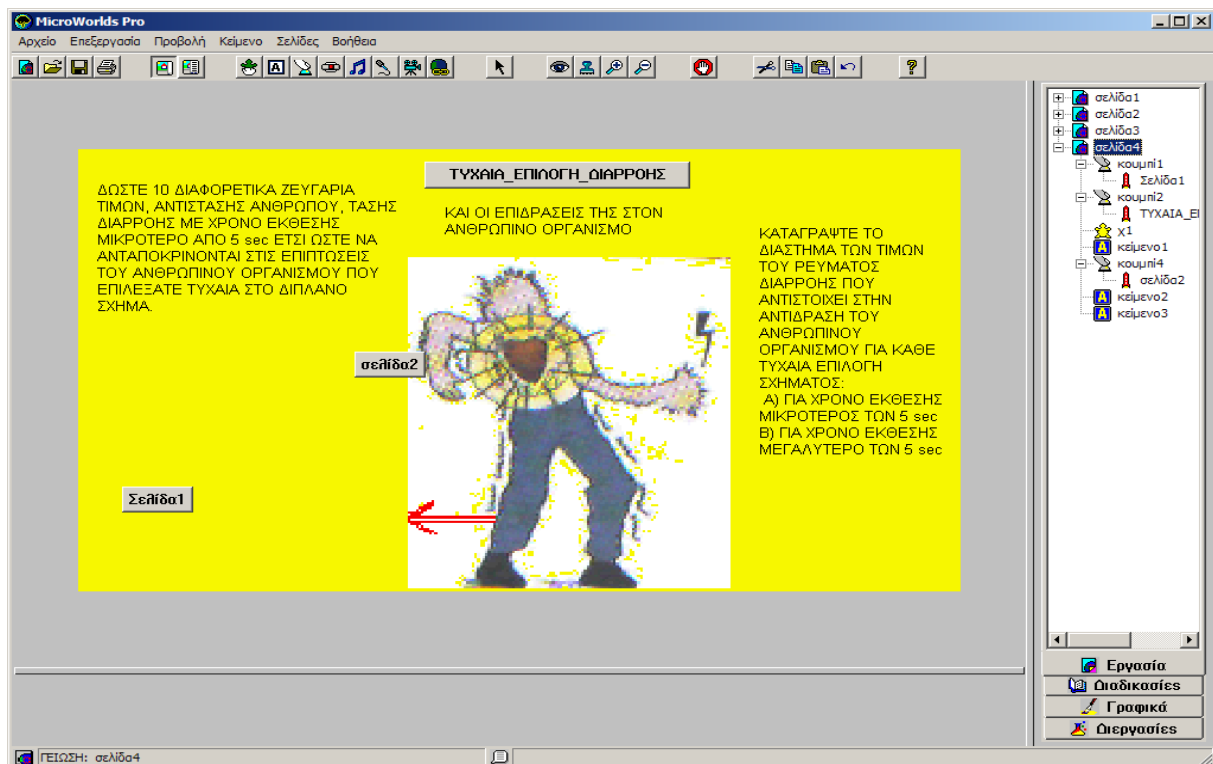


Figure 4. The fourth screen-page of the software tool

By the end of the process, the pupils are led to recognize the emergence process of two informative parts of text and six loudspeakers with information on repetition and consolidation.

The training scenario

The teacher monitors, guides, orients and answers questions. He/she doesn't have an "overprotective" profile, leaving pupils to experiment, make mistakes, be "lost" for a while, but intervenes when they are really disorientated, wasting much time on the wrong path. Depending on each team and each pupil, he/she can offer alternative considerations beyond the worksheet instructions. During the evaluation tests, he/she observes the success of teaching and makes a self-assessment of his/her own work. If necessary, he/she decides a change of strategy and process in teaching and if possible performs this change immediately (Dapontes et al., 2003). Accordingly, the proposed scenario is structured in three phases, following in the corresponding subsections.

Familiarization with the module and the software environment

At the first phase, pupils are initially divided into groups of three (3) persons. Then, the teacher starts a discussion in classroom, which motivates pupils to gather personal experiences that focus on this module. Namely, he/she tries to motivate pupils to ask themselves and reflect on their personal experience about the topic to be investigated, as well as to formulate, before operating the simulation software, some clear questions and concerns to be resolved. Each group can then record its concerns and what it expects to happen during the experiment (a prediction of the outcome of the phenomenon before the simulation).

In the second part of the first phase, the teacher presents the software tool that pupils will operate. He/she asks pupils to open the MicroWorlds Pro software tool and get used to the environment. Pupils make themselves familiar with the use of buttons for changing screen-pages and use the slide for editing the parameters: leakage voltage, human body resistance and exposure time. The utility of icon-turtles, depicted at screen-pages, is noted, along with how to intervene for changing the parameters of the experimental process.

Teaching the module

At the second phase, the pupils are initially informed about the topic and goals, on the first screen-page (Figure 1). Moving on to the second screen-page (Figure 2), they are confronted with the environment of the experiment's simulation, where they can change the values of leakage voltage, keeping constant the human resistance and the exposure time. The corresponding proportional change in the leakage current value through the human body is noted, while the effects on the human body can be observed. Additionally, each effect-image is accompanied by a sound button given for more information. Therefore, the pupils are led to the expression of the first rule, concerning the proportional relationship between leakage voltage and leakage current.

Then, the pupils may vary the value of human-body resistance, keeping constant the leakage voltage and the exposure time. They observe a change inversely proportional to the value of leakage current. Therefore, they are led to the expression of the second rule about the relationship between the human-body resistance and the leakage current.

The teacher may challenge pupils to think about ways of correlating all three factors: leakage voltage, human-body resistance and leakage current. Through constant experimentation, they are asked to achieve the same value in the leakage current with different value-pairs of leakage voltage and human-body resistance. Each pupil may find him/herself (depending on the degree of guidance provided by the teacher) the mathematical formula that expresses the relationship of the three factors. Then, the pupils change the value of the third slider, looking for the proper correlation with the leakage current. They are urged to find the threshold value of exposure time that is set in this slider, so as to aggravate the effects on human body depending on specific values of leakage current.

Interactive assessment – Reflection

The third phase is generally aimed at the reflection of pupils and teachers. After the completion of the experiment, pupils are called to perform an assessment test. This test provides feedback to pupils, because the choice of answer is accompanied by a message, whether the answer is correct or not. Thereby, an interactive self-assessment is offered, because for each error pupils may repeat the experiment and understand the reasons of it. They also repeat both the test and all the previous process, until the realization of the test is fool proof. Here, the assistance of the teacher will be needed to resolve queries. The completion of the assessment test will always be done with the help of the comments written by the students during the experiment.

Eventually, a discussion is conducted between pupils of all groups and the teacher. This discussion aims to gather all the conclusions and the resolution of past queries. The teacher concludes with a summary of all conclusions that achieved the teaching goals.

Conclusion

With the experience of integrating the specific application in the classroom (computer laboratory), it is claimed that the proposed method of teaching, integrated into a comprehensive computerized working environment, offers the realization of a number of dynamic activities that include simulations, feedback and interactions with pupils. The teacher is not guiding or over protective but monitors, directs, answers questions and allows students to experiment. Mainly through proper planning and organization of teaching, the teacher may gather educational benefits for his/her teaching that cannot gain with a more traditional approach. Pupils look for answers to their created queries, discovering the links between natural phenomena and formulating the corresponding natural laws. In conclusion, the recorded achievement of learning objectives leads to the acceptance of the diversity of this teaching method, because it reveals the investigative and personal way of pupils' learning.

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