MULTIMEDIA AS A COMPONENT/ELEMENT OF A CHEMISTRY COURSEBOOK

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Abstract

The key to teach effectively and efficiently is to combine various elements of representation and visualization, work interactively and make connections between the learner's emotions, images and sensations. A good example of how these principles are applied to teaching is a Polish chemistry coursebook Ciekawa Chemia (The Absorbing Chemistry). The coursebook includes a set of CDs which contain multimedia lessons supported with animations, simulations of processes and chemical phenomena, dynamic and three-dimensional models of elements and compounds, tests and tasks aimed at solving problems as well as film sequences presenting for instance chemical experiments. Thanks to these films, the learner can see particular elements of a given experiment in detail, analyse interrelations between them and memorize how the experiment is carried out as the films can be played repeatedly. Such a way of presenting chemical experiments can help both those teachers and learners who, for various reasons, cannot carry out certain experiments themselves, as well as those seeking inspiration for carrying out new experiments, and most of all those looking for proper didactic tools to explain difficult questions. It seems worth mentioning that the experiments presented on the CDs can be carried out safely and economically. Their visualizations allow to create images of experiments in the learner's mind which, though cannot replace carrying out experiments in reality but may well constitute a valuable educational tool.

Key words: *chemistry, didactics, experiment, multimedia.*

Introduction

1999 was the year of the educational reform in Poland. The reform concerned primary and secondary education and replaced the old model with a new division into six-year primary schools (children aged 7-13), three-year secondary junior schools (children aged 13-17) and three-year secondary schools (students aged 17-19) which educate students in various specialties. The old two-year and five-year vocational schools were replaced with three-year vocational secondary schools. Entrance exams were replaced by final tests taken by students finishing their secondary junior and secondary education, on the bases of which they may be admitted to another learning stage.

One of the reform's results was the appearance of a wide array of new coursebooks adjusted to new educational requirements both in terms of content, methodology and structure. All these changes took place due to the progress of computer programming, as well as because of the research on the effectiveness of utilizing IT in teaching and learning. The research showed the emergence of new didactic tools later applied to improving the media framework of teaching materials.

All these factors contributed to the creation of the Ciekawa Chemia ("The Absorbing Chemistry") chemistry coursebook (Gulińska H., Smolińska J., 2006). The coursebook and its facilities are designed to teach chemistry in Polish secondary junior schools (three-year schools in which chemistry is taught either according to the 2+1+1 or 1+1+2 models, where each number refers to the number of chemistry lessons taught weekly each year). The set comprises three coursebooks with CDs for students and two teachers books facilitated by multimedia components included in the attached CDs. The set, although a novelty on the Polish market, has become considerably popular among both chemistry teachers and students. It has been

presented at numerous nationwide and international conferences and methodical meetings, arousing much interest which resulted in the launch of comparative research at Tokyo University of Science.

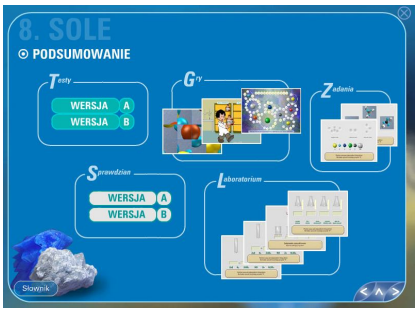
Figure1. *The Ciekawa Chemia* educational set (coursebooks with CDs, student's books and teacher's books).

The subject of our discussion will be the content of the CDs attached to the coursebook, both in terms of modules, interaction, visualization and self-discipline.

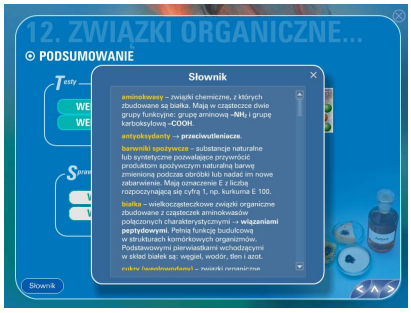
The modules

Each of the CDs was divided into lessons constituting separate entities which can however expand in the course of teaching. Each lesson is easily accessible, either from the contents menu or by proceeding from one lesson to another. A set of several lessons constitutes a chapter ending with a module called Recapitulation. There are additionally two independent modules, the Periodic Table and the Dictionary, which provide the users with quick access to the data they need at the moment. The student can either take advantage of these tools regularly after every lesson, or irregularly when he or she is troubled by intriguing questions. The modules can be chosen at random according to the teacher's methodical layout and the student's needs. They are also available in the Index of models, films, animations, tasks, games etc.

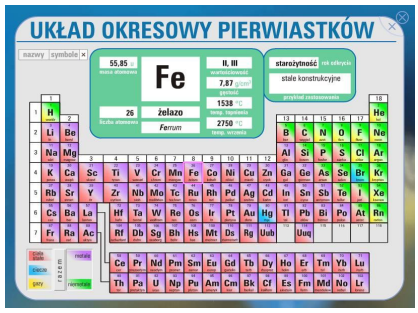
The Lessons module



The Recapitulation module



The Chemical Glossary module



The Periodic Table module

Figure 2. Modules in the Ciekawa Chemia CD.

The multimedia guide included on the same CD contains an interactive description of all modules available on the CD as well as information on each module together with directions of how to navigate through their respective elements.

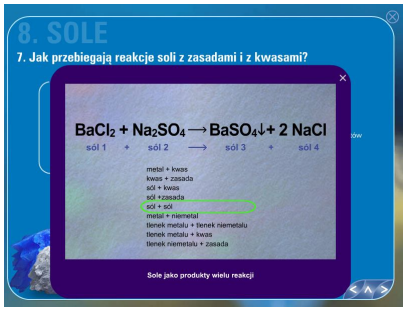
Interaction

The success of multimedia teaching depends highly on the interaction of the learner's mental make-up, the symbolic code of a given didactic tool, the content of a particular message and the type of task. The importance of this interaction for the ultimate teaching results is highlighted by methodologists, whose research led to formulating the rules of designing multimedia programs suited to individual skills (Skrzydlewski, 1990). According to those principles, the students of higher and lower intellectual capabilities can utilize didactic tools with better results if these tools stimulate them to absorb new information and structure it, direct their attention to crucial matters, present messages in a pace adjusted to the student's abilities so that new information can be processed (Lumsdaine, 1961). The individuals with higher intellectual potential can utilize multimedia tools better if they are rich in stimuli such as content, sound, animations or films, challenge them to put forward hypotheses or aside remarks and maintain high speed of presentations (Cronbach, Snow, 1977).

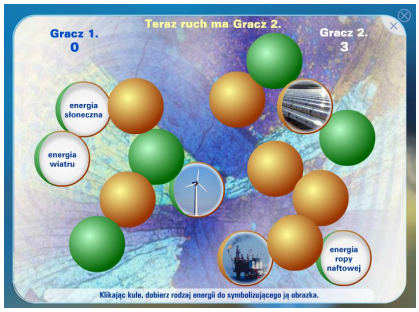
Bearing this background in mind, we provided the CDs attached to Ciekawa Chemia with the detailed user's interface. Within the interface, each elements can be selected arbitrarily and launched according to the rules set by the user. Illustrations are complemented with captions, whereas films and animations are accompanied by voice-over. Each film or animation can be stopped at a randomly chosen moment so that the user can approach a given problem in detail

and then resumed. All educational games are provided with clear instructions so as the user can focus solely on their content.

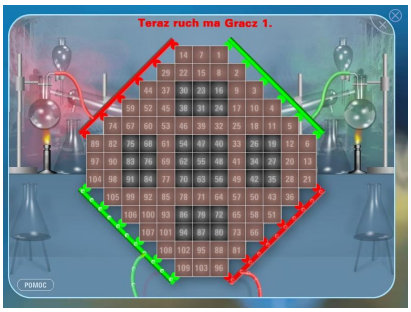
The interactive selection of films



The interactive selection of reaction formulas



Clear descriptions of educational games



The involving games

Figure 3. The interactive elements of the *Ciekawa Chemia* CDs.

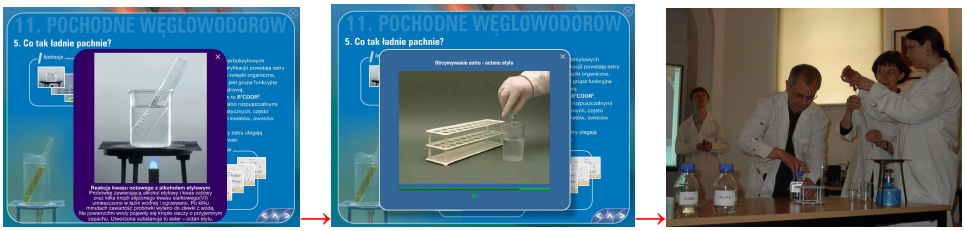
The multimedia designed in this way are aimed at accomplishing many educational goals despite the fact that until recently computer programs were thought to be the better the fewer educational aspects they focused on (Romiszowski, 1988). Methodologists warned against including too many simulations of processes and phenomena in the multimedia components, as they thought that this method, despite being aimed at teaching particular skills such as operating a given device, would only limit those skills to the computer environment. As the use of *Ciekawa Chemia* has proved so far, such a standpoint requires verification, as not only does the new multimedia software allow simulations, but it also promotes the student's individual laboratory work which results are later inserted into computers where they may direct the program further on. Various simulators, for example simulators of complex equipment, have become widespread in specialized workplaces where they help workers learn how to operate a given piece of equipment without putting their companies' property at risk. Skills learned this way can be then used in reality. Thus, multimedia software does not replace real environment, but rather introduces it to novices. The „unreal" teaching methods are here replaced by providing the learner with opportunities to take up real-life actions to which they were previously prepared as well as by showing them on the screen what the possible results of their actions can look like. This method is particularly vital in teaching chemistry and other natural sciences.

Visualization

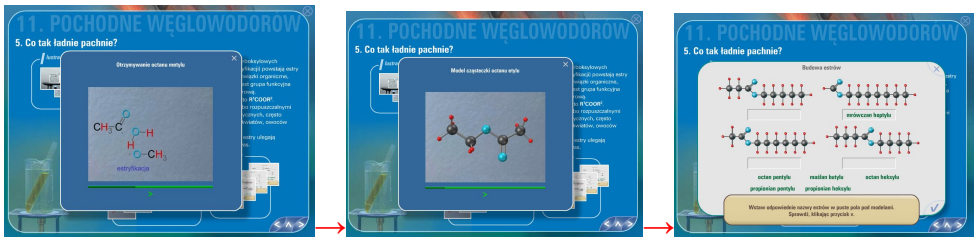
Every multimedia lesson included in the *Ciekawa Chemia* CDs contains animations, dynamic models and film sequences presenting, among others, the course of chemical experiments (Gulińska H., 2006). These films allow to observe various elements of a given experiments in detail, so as to prepare the student to analyse the interrelations between respective elements and memorize how the experiment is carried out as the films can be played repeatedly. Such a way of presenting chemical experiments can help both those teachers and learners who, for various reasons, cannot carry out certain experiments themselves, as well as those seeking inspiration for carrying out new experiments, and most of all those looking for proper didactic tools to explain difficult questions. The use of the multimedia software discussed in the article is aimed at visualizing the course of a proper chemistry lesson which is particularly helpful in the schools deprived of adequately equipped chemical laboratories. It seems worth mentioning that the experiments presented on the CDs can be carried out safely and economically. Their visualizations allow to create images of experiments in the learner's mind which, though cannot replace carrying out experiments in reality but may well constitute a valuable educational tool.

It can be admitted that multimedia software is an important didactic means in teaching chemistry, as it broadens the student's knowledge by presenting experiments which the student might be never able to see in reality, as well as it explains the experiments' course through animations, simulations and models, for example those of chemical compounds. It is almost impossible to overrate the value of real-life observation, however a possibility of carrying out at least the simplest experiments, even if it takes place in a virtual environment, is also crucial (Obendrauf V., 2006).

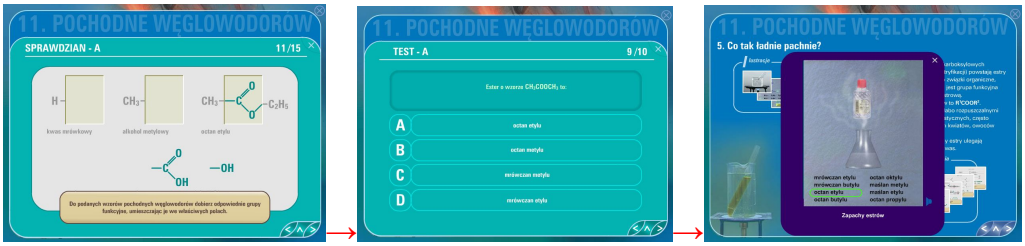
Below one of the possible uses of the *Ciekawa Chemia* CDs is presented. The enclosed illustrations and films help carry out an experiments (stage 1). The animations of mechanisms of reactions and models presenting the structure of compounds allow to interpret what was seen while the experiment was being conducted (stage 2). Tests and tasks help revise new information and practise the newly acquired skills (stage 3).



Stage 1. illustration → film sequence → laboratory work



Stage 2. animation of the mechanism → the molecule model → interactive tasks



Stage 3. test → multiple choice test → tasks

Picture 4. One of possible ways of using *the Ciekawa Chemia* CDs.

Bearing in mind the value of chemical experiments as a source of cognition, the authors of the coursebook were aware that the conducted experiments can be also a source of danger and that the only circumstance under which chemical experiments can be carried out is when the student is rightly prepared. Before they approach experiments in reality, learners carry them out repeatedly in virtual environment, having before acquainted themselves with health and safety rules included on the CDs. Thus, not only is the student prepared to carry out a given experiment safely, but also he or she can use both the equipment and reagents economically.

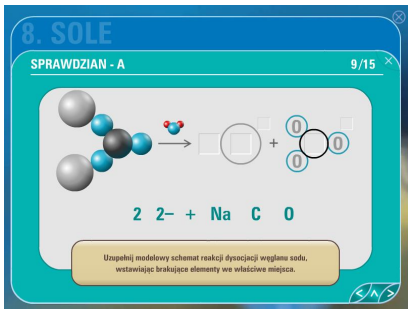
Figure 5. Inspiring the student. Creativity and safety in the lab.

Self-discipline

The multimedia programs which include interactive elements improve the student's learning efficiency, including the students who are able to process information which is provided to them in an incomplete, decontextualised form. This seems to be due to the nature of the new generation multimedia software which is suited to every type of didactic situations, as well as adjusted to individual abilities of the learner, who may be asked to deal with less or more complex types of tasks. Not only does the feedback included in this type of multimedia software help understand its content, but it also points at the key issues of a given program, leaving, however, the freedom to follow the guideline as it occurs in the case of decision-making games.

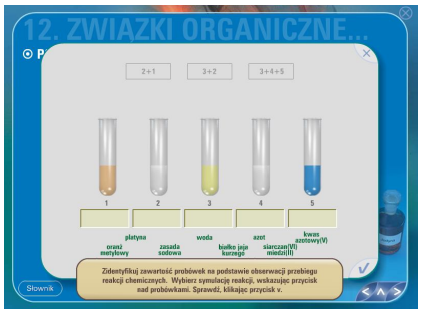
The CDs attached to Ciekawa Chemia help the student to carry out self checks of various types. This can be done with the help of different kinds of exercises, tasks and tests facilitated by interesting graphic elements and animations. The self checks aim at testing the student's knowledge of dealing with complex problems which demand proper knowledge, preliminary tasks and the ability to gather and process the necessary information. The student is often asked to simulate laboratory activities or do tasks which make him use the results of calculation in practice. The multimedia control unit included in the program can supervise such processes as constructing models, writing equations of reactions, tackling problems and simulating selected chemical reactions and processes.

The system of self assessment presented in Ciekawa Chemia allows to change the student's attitude towards tests. Usually stressful for many students, here the evaluation of their work has an utterly different character. Asked about their impressions on the system of self assessment introduced in Ciekawa Chemia, many students admitted it had many advantages over the traditional way of testing, because test questions were succinct and to the point, each student was assessed objectively as the program did not favour any individuals, the students were not interrupted while solving tasks and, finally because they had more time to deal with the tasks and rethink the order of operations. Moreover, the students who underwent this type of evaluation claimed the grades given by the computer, either as marks or descriptive comments, were fair and objective. Thus, within this system, the role of the teacher is limited to provide the criteria according to which the grade is given.

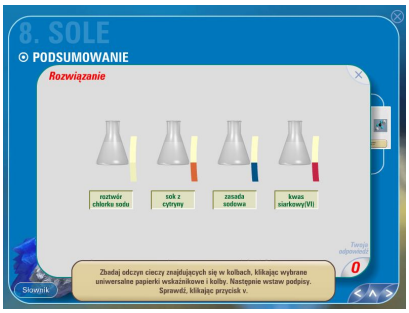


Tests

Interactive exercises



Virtual lab



Problem tasks

Figure 6. Methods of evaluation and self-assessment in the Ciekawa Chemia CDs.

CD Functions in the didactic process

The addition of CDs to the printed coursebook opens the door for new teaching devices accessible only within this teaching method. Not only do such CDs instruct, but they also perform the following functions:

- directive and analytical function (showing how to work and think creatively),
- simulative function (encouraging to do exercises developing diversified skills),
- self-study and educational function (facilitating self-discipline and self-assessment).

The application of the new ways of transmitting information and teaching the student self-discipline and assessment may individualise the pace and content of educational process, as well as structure the new knowledge, allow to fill the gaps in the knowledge of each student and help them acquire new skills. The emotional engagement, which often accompanies multimedia learning, can stimulate the student to learn more on their own outside the class, either individually or in groups. Such an attitude also develops the student's skills in utilizing their knowledge of IT for various purposes (Gulińska H., 2002).

Organizing the didactic process

Teaching students using multimedia CDs differs from education based on traditional, printed coursebooks, particularly for technical reasons. New data carriers, such as CDs, not only improve the quality of information transfer but also facilitate the access to a selected piece of that information. Such a method will surely influence learning methods, thus changing the role of the teacher. In order to take advantage of the didactic potential of multimedia teaching, the teacher has to provide the student with proper multimedia environment in which such means of teaching can be fully utilised.

From the technical point of view, it is important that the teacher devise a suitable teaching strategy. Such a strategy may be designed either to teach students basing on one copy of a given multimedia program (provided that they all work simultaneously), to teach small groups of students gathered around several computer posts, or to teach them individually.

One of the didactic tools helpful to the teachers without access to computer laboratories is an interactive display board (Gulińska H., Bartoszewicz M. 2006). Many Polish schools use StarBoard interactive display boards designed by Hitachi. Such boards may either be installed on the wall or kept portable so as to be used elsewhere. The user can write on the board with wipe-off marker pens and stick magnets to it. The board becomes interactive when connected to a computer and projector, thus allowing to display documents and films on it. Additionally, the board can be written on with electronic pen, while the files created this way may be later saved on the computer's hard drive. During classes, the teacher may work with Microsoft PowerPoint, Word and Excel files. All students participate actively in the lesson as they can come up to the board and do tasks or solve problems on it.

Observations made during the lessons taught using the interactive display board asserted that its use activates learning through observing, acting, feeling and thinking. The examined students engaged eagerly in all activities proposed to them during the lessons and managed to maintain their newly learned knowledge and skills. We need to remember, however, that these satisfying results might have been additionally boosted because the teaching methods and didactic tools used by the teacher were new to them.

Picture 7. A chemistry lesson taught using Ciekawa Chemia CDs and an interactive display board.

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