Multimedia software for representation of chemical reaction mechanism – high school and college level
Software multimedia para representación de mecanismos de las reacciones químicas – escuela secundaria y universidad

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Abstract

This article describes a multimedia software package entitled "The Mechanisms of Chemical Reactions" which contains animations illustrating the successive stages of selected organic chemical reactions, videos illustrating the execution of chemical experiments, as well as texts, dynamic models of chemical compounds, an interactive glossary, hypertexts, tasks, exercises and self-check tests. Furthermore, the authors presented this multimedia software in a class where there were computers and in a class where the interactive, Starboard was used. They also describe the initial results of their pedagogical research.

Key words: *multimedia, computers and education, organic chemistry, teaching and learning, StarBoard.*

Resumen

Este artículo presenta un software multimedia 'Los mecanismos de reacciones químicas', con animaciones que ilustran los niveles subsiguientes, posterior de reacciones orgánicas químicas, videos que ilustran la realización de las experimentos químicos, y también los textos, los modelos dinámicos de los compuestos químicos, el glosario interactivo, hypertextos, las tareas, los ejercicios y los textos para examinar por sí mismo. Además, los autores presentan este programa multimedia en la clase donde están los ordenadores y donde se usa StarBoard interactivo. Describen también los resultados de la investigación inicial pedagógica.

Palabras clave: *multimedia, computadores y educación, química orgánica, enseñanza y el aprendizaje, StarBoard.*

INTRODUCTION

Education in Poland is being conducted in the following stages:

- Stage I –grades 1-3 of primary school, integrated education in which only one teacher is responsible for a class;
- Stage II – grades 4-6 of primary school, education is based on groups of subjects;
- Stage III – middle school;
- Stage IV – high school or vocational school;
- Stage V – universities, polytechnic institutes.

The new education system which has been in operation since September 1st 1999, is presented in the following picture.

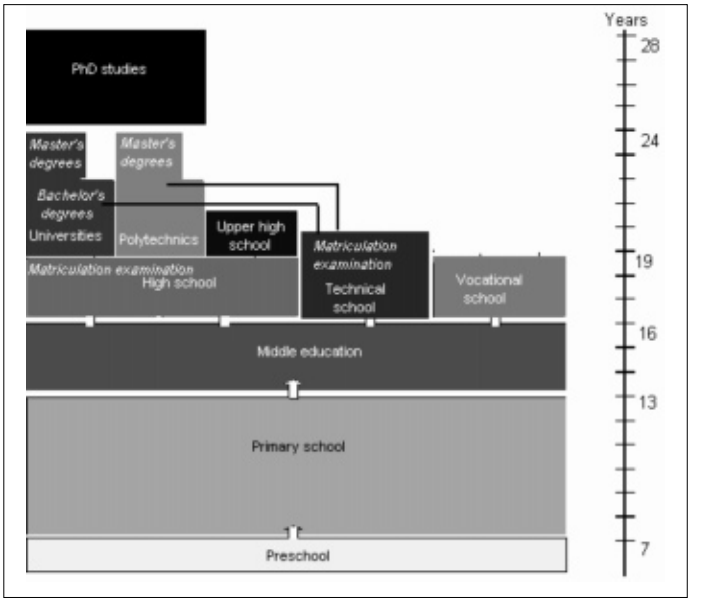


Fig. 1. Polish education system

This paper describes a multimedia software package **The Mechanisms of Chemical Reactions,** which contains animations illustrating the successive stages of selected organic chemical reactions, videos illustrating the execution of chemical experiments, as well as texts, hypertexts, interactive exercises and tasks. Furthermore, the authors present a class in which the multimedia software and the interactive, StarBoard, are used. They also describe the pedagogic research that is planned.

The traditionally accepted written notation for the mechanisms of chemical reactions, which frequently are of a multistage nature and include transitional products, does not have the capacity to provide the full explanation of the successive stages which is needed for a clear understanding of these stages.

The Polish multimedia publications market offers software which aids Chemistry teaching mainly in grade and junior high schools, leaving high school and university students and teachers unattended. A small preliminary survey carried out among the students of the Department of Chemistry at Adam Mickiewicz University indicates that they have some difficulty in understanding Organic Chemistry material, and especially the mechanisms of chemical reactions.

In order to meet their needs, the Institute of Didactics of Chemistry prepared a multimedia software package entitled **The Mechanisms of Chemical Reactions** which contains a set of visual teaching aids.

This software was prepared using Macromedia Authorware, which made it possible to prepare professional software containing the futures of modern media *solutions*: animations, films, simulations and interactive modeling. Authorware makes it possible to create applications accessible both from the Internet (Web) and available on CD-ROMs, or DVD-ROMs. Among all the authoring systems available, it continues to be one of the easiest to learn, allowing nonprogrammers in many cases to come up to speed quickly and start producing real multimedia-based applications (GANCI 1997).

Fig. 2. Macromedia Authorware and product: program Mechanisms of Chemical Reactions

Macromedia Flash was used to create animations since it makes it possible to work with vector graphics, imported images, bitmaps as well as with sounds. Through Action Script, an internal script language, Flash animations may co-operate interactively with the users. The mayor advantage of animations made in Macromedia Flash is their small files size that creates an opportunity to place them on a CD or publish in the Internet.

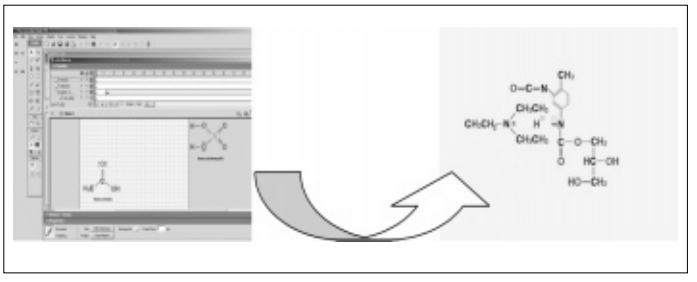


Fig. 3. Macromedia Flash and product: animation

The videos, which illustrate the series of chemical experiments in which the mechanisms discussed occur, were made at the film studio of the Institute of Didactics of Chemistry. Our studio is semi-professional. Some of its components include: a stand for performing chemical experiments, professional lighting, digital camera (Sony DCR-TRV 900E or Canon XM1) with a tripod, a computer equipped with the software necessary for transferring the film sequences to the hard disk.

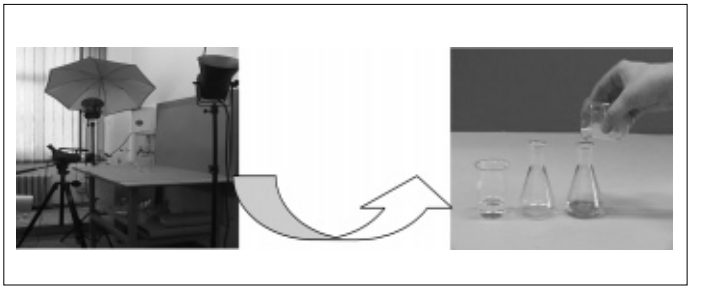


Fig. 4. Film Studio and product: film sequence

The films were put together using non-linear editing with Adobe Premiere. The non-linear editing of the digital video material means that daring every moment of the job the user has access to the entire movie on which he or she is working. To display a specific part of the project only requires double-clicking in the appropriate place on the time line (GULIŃSKA, BARTOSZEWICZ, 2005).

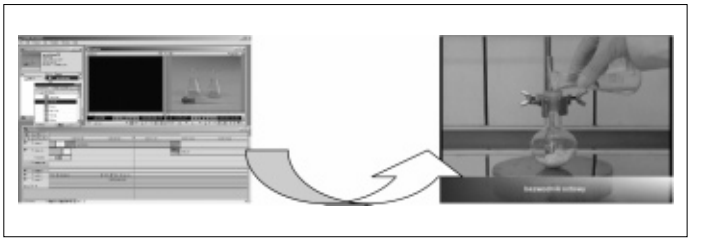


Fig. 5. Adobe Premiere Studio and product: film

The Mechanisms of Chemical Reactions was designed for university in department of chemistry and the natural sciences as well as for high school students.

The software consists of the following modules:

Nitration of benzene	Production of urna-formaldehyde resin
Bromination of benzene	Production of nylon nylonu
Dehydration of ethanol	Polymerization of styrene
Neutralization of formic acid	Esterification of carboxylic acids
Production of soap	Alkali hydrolysis of esters – ethyl acetate
Ammonia salts	Acidic hydrolysis of esters – ethyl acetate
Production of acetylglycine	Production of triethylborane
Production of sodium ethylate	Reaction of ethanol with bromohydrogen
Production of cyclohexane oxime	Production of phenylic-formalde hyde resin
Polymerization of methyl metacrylate	Soponification of fats
Depolymerization of polyethylene	Synthesis of aspirin with acidic catalyser
Polyuretanes	Synthesis of aspirin with sodium hydrogen

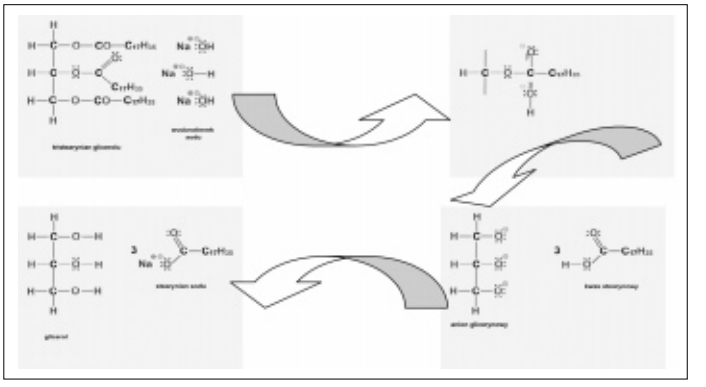
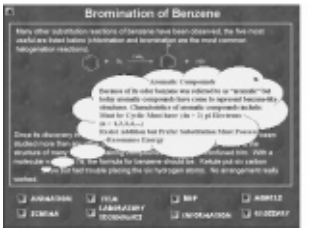


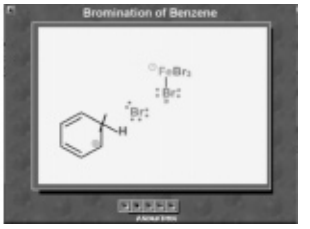
Fig. 6. Animations of the mechanisms of chemical reactions: Soponification of fats

Each of the above modules contains:

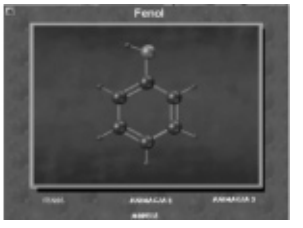
- texts and hypertexts relating to the subject of the experiment,



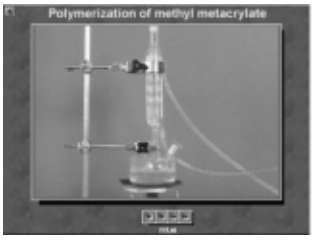
- a set of animations explaining the mechanism of chemical reactions,



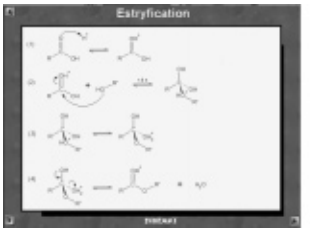
- dynamic models of chemical compounds,

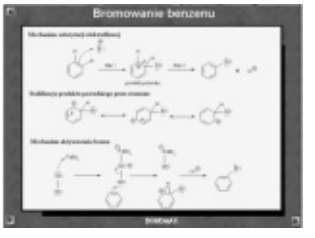


- a set of videos showing how the experiments are conducted

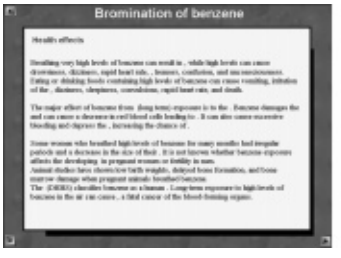


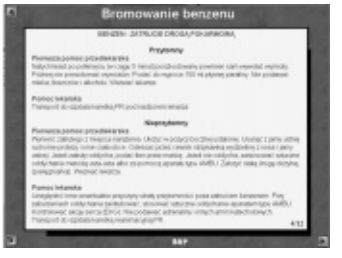
- schemes of the mechanisms of the chemical reactions,



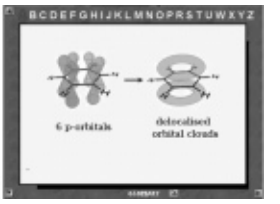


- a list of safety rules to be obeyed while performing experiments,

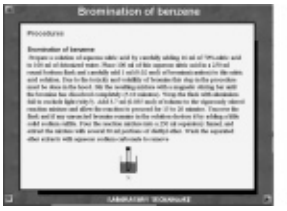




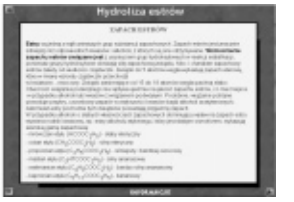
- an interactive glossary,



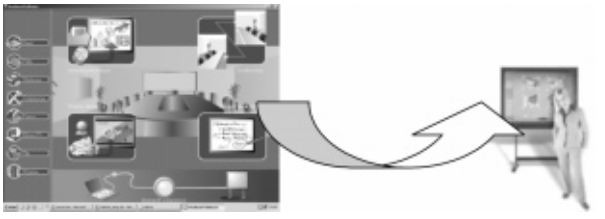
- information on laboratory techniques,



- information, problems, tasks, exercises and tests for self-study.



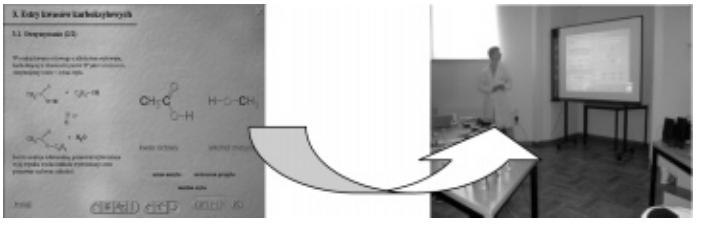
StarBoard - an interactive board, was used during computer assisted Chemistry classes. This board is a device which combines the elements of a screen for presentations, a self-copying board and a computer monitor. As the board may be connected to a computer via a cable or via an infra-red connection (wireless) it is possible to carry out dynamic work and continuously save the notes on the hard disk. An Electronic pen is the device with which the user may write on the board (no ink required – an alternative for the traditional whiteboard). The software of Starboard makes it possible to stop the presentation at any moment, transfer any of its elements to an environment compatible with its software and to modify it freely.



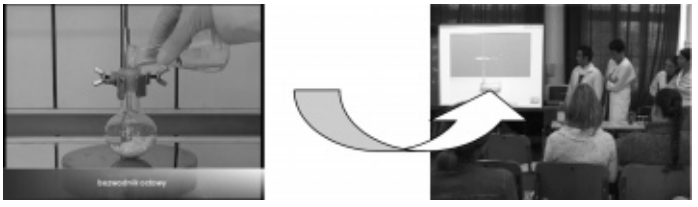
Initial pedagogic investigations (studies) were conducted with the two groups of students that were made up of the 3rd- and 4th-year chemistry students who studied at our University. Classes with the 1st group took place in a typical computer laboratory where every person had a computer with or multimedia textbook (Chemistry with elements of ecology) and the program Mechanisms of chemical reactions to his/her disposal. Classes with the second group were conducted in a chemical laboratory, using an interactive board or, in other words, a set which consists of computer, digital projector and StarBoard.

The scenario of computer assisted classes is presented below. *"The Mechanisms of Chemical reactions"* and the StarBoard were used during this class.

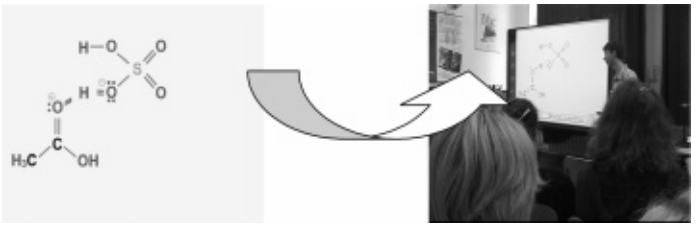
- Introduction to esterification reactions (multimedia software in cooperation with the board – texts, films and exercises).



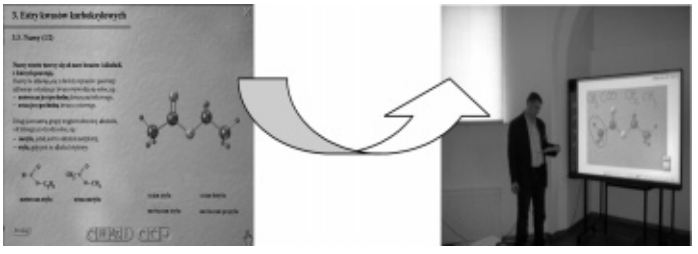
- Instructions for the experiment Production of ethyl acetate (having watched the video sequence showing ether production, the students carry out the experiment on their own and write down their notes on the interactive board).



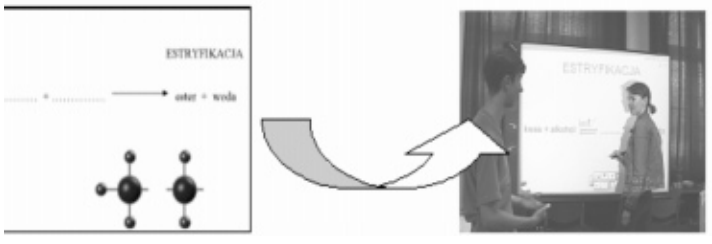
- The mechanism of esterification (an animation illustrating the stages of the reaction, including transitional products – the possibilities of the interactive board are used while discussing the sequence of esterification, the students activity might be expressed when they write down the equation of the reaction).



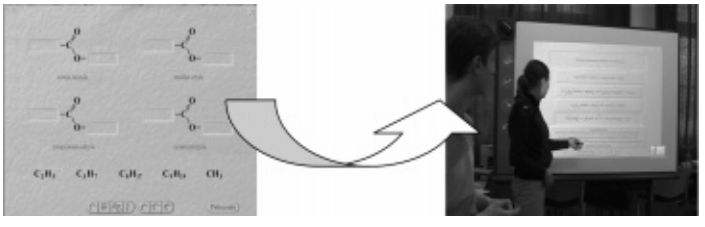
- Modeling the substrates and products of the reaction (an animation showing dynamic models of chemical compounds – the students build identical models of sticks and balls and then write down summary formulae and the names of compounds on the board – competition).



- Review of material with the use of interactive board (blank test).



- Test (interactive multiple choice test)



CONCLUSIONS

Lesson in computer laboratory	Lesson in chemical laboratory
1. The student has an opportunity to choose his/her pace of studying, depending on information possessed and skills. On the other hand, when not monitored by the teacher, students often omit the more difficult parts and concentrate on animations and movies.	1. Teacher controls the pace of study, can explain the more difficult problems without closing the application, which makes the lesson more fluent, but it also does not allow for supervision of the student in a totally reliable way.
2. Participant uses many program options on his/her own and learns the in structure what can cause distraction for the students.	2. The opportunity to use sources not included in the program eases teacher preparation and takes advantage of various types of files.
3. Student gets a chance to design and do experiments according to the instructions in the movie. Although it can create organizational difficulties and possible dangers based on lab's mistakes.	3. The watching of experiments on the big screen by the student group helps them learn about laboratory security precautions the secure way of lab's behaviour and proper manual activities. On the other hand, it can make individual learning difficult.
4. Results of the tests and interactive tasks are reliable because every student does them on his/her own. On the other hand, the teacher does not have a chance to supervise the manner, approach to solving problems.	4. Solving tasks and tests on the Starboard as a group eases review and discussion. On the other hand, it limits the student's self-control and self-assessment of work. Sometimes the students are not aware of their lack of knowledge.
5. Independent work in the front of the computer helps in the individualization of education, but also can ruin a lesson's structure.	5. Independent operation of the StarBoard by students guarantees their active participation in the lesson. On the other hand, appearing in the front of the class can be stressful.

The use of StarBoard and its software would allow the presentation of chemical reactions mechanisms in a dynamic way, thus replacing the omnipresent diagrams, drawings and static notations which illustrate the course of reactions by means of their equations. The StarBoard user may also print out the materials from the class which might eliminate the taking of detailed class notes from and direct the students' attention to the subject of the class. Additionally, the dynamic manner of teaching allows the teacher use problem tasks directly from components elements copied from the software presented, thus eliminating the need to prepare additional presentations; which will shorten the time the teacher must spend preparing for the class (GULIÑSKA, BARTOSZEWICZ 2005a)

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