

Comparative Study of Effectiveness of the Multimedia Handbook and Internet Methods in Education of Students and Teachers of Science

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The pedagogical experiment performed has proved the increase in the educational efficiency achieved by the students learning from the multimedia version of the handbook on “Experiment in chemistry” at the Faculty of Chemistry, Adam Mickiewicz University. The results of the tests checking the students’ and teachers’ knowledge have shown that in the field of chemical experiment, the blended learning is much more effective than that from a conventional written handbook. The authors also assumed the hypothesis that the use of the blended learning mode would be highly effective in education in other scientific areas of experimental nature, which, however, should be confirmed by further studies.

Keywords: blended learning, distance learning, Web-based learning, laboratory instruction, chemical experiment, graduate education

Introduction

The growing need for self-education has led to development of new techniques of education and new didactic means (Boschmann, 2003). The most important feature differing from this style of learning from traditional one is the lack of direct control and verification of a teacher. Instead, other elements of controlled learning must be introduced. The effectiveness of self-education depends on the contents and structure of the communications addressed to the learning person. Many solutions have been proposed to improve the self-education effectiveness and many have been based on the modern information technology permitting the use of a large variety of didactic means and methods (W. Horton & K. Horton, 2003).

Base on basic assumption of present behavioural theory, didactic means should fulfil determined criteria, among others: the dual channel assumption, the limited capacity assumption and the active processing assumption. Some main principles of multilateral education are determined, such as multimedia principle, contiguity principle, coherence principle, modality principle, redundancy principle, interactivity principle, signaling principle and personalization principle (Robinson, 2004; Mayer, 2002).

First educational films about chemistry had been already known in 20th years of last century. Those films gave basement to trial of multimedia education (Kramer, 1924). Although the registration of sequence on film reel created some limits, especially in case of created animation of different chemical processes. Next stage in

multimedia means development were VHS (Video Home System) reel. They were common used, because they were cheap, easy in use and allowed for independent preparation for the educational film. There was registration of the run of chemical experiments which was instruction for students' preparation to laboratory activities (Pantaleo, 1975; Burnett & Lion, 1977; Fortman & Battino, 1990). Development of electronics on the end of 20th century gave possibility to register picture and voice in digit format. It significantly made possibility of multimedia educational means with usage of digital media like CD, DVD and now Blu-ray, more efficiently. Also, film cameras gave possibility to record picture of high resolution $1,920 \times 1,080$ marked as HD (High Definition). Using those present didactic means, research with applying CD media initially named videodisc in chemical education were conducted (Russell, Staskun, & Mitchell, 1985). Accessibility of new communication way among people in global range is Internet which gave basement to prepare innovative educational methods (Wikipedia, n. d.). At the beginning, Internet was used to send matter in form of hypertext (Tissue, 1996). Next, messages in form of simple graphics and animations were sent via Internet (Mounts, 1996; Chasteen, 2001). Base on development of Internet technology, new solutions which concerned teaching methods appeared. Further development of detailed didactics, and among them, chemistry didactics also gave basement to Internet usage as a media to support chemistry education by teaching at a distance (Boschmann, 2003; Hoole & Sithambaresan, 2003; Harpp et al., 2004; Casanova, Cicelli, Kimbrough, Heath, & James, 2006).

Implementation of teaching methods at a distance in case of chemistry education is not an easy task, because most classes are practical and executed in chemical laboratory. Solution, which allows integrating teaching via Internet with practical activity of learning in laboratory, has to be found. One of the distance education methods is blended learning, which was applied classes with students.

For a few years, the Faculty of Chemistry offers the facultative subject on experiment in chemistry. The relevant materials are presented in the form of lectures and laboratory classes. The choice of the laboratory experiments is made taking into consideration of the following objectives:

- (1) Presentation of the methods of experiments in science and chemistry in particular;
- (2) Development of manual abilities by performing experiments at different levels of difficulty;
- (3) Development of the ability of presentation of experiments in different conditions, e.g., different scale;
- (4) Development of the abilities to recognise chemical transformations in everyday life and the natural environment;
- (5) Development of the habit of learning before the experiment about the physical and chemical properties of the substances used in the experiment, the specification charts of hazardous substances and preparations;
- (6) Learning the principles of handling hazardous or toxic waste and methods of their utilisation.

The subject "Experiment in chemistry" is also taught to teachers of science at different levels of education, working on improvement of their qualifications attending postgraduate courses for teachers. To help the students and teachers learn the materials on experiment in chemistry, a special handbook in the conventional printed form has been prepared. The handbook gives the principles of safe work in a chemical laboratory, storage and utilisation of the laboratory waste followed by the instructions to 100 chemical experiments divided into ten thematic groups. These groups are: colour reactions, red-ox reactions, energy effects of different chemical reactions, chemical reactions of the analytical importance, chemical reactions of neutralisation, gas production, chemistry in the environment, photochemical reactions, photographic processes and precipitation reactions. The detailed description of the experiment is followed by problems to solve, related to the

experiment or phenomena or processes related to the experiment and photographs illustrating the experiment. The final chapter of the handbook provides explanations of the courses of the chemical experiments described, so that the learning person could verify the conclusions drawn. The same materials were also covered in the multimedia handbook available on the Internet. It presents the instructions to the same experiments as in the conventional printed version, but the difference is that the experiments are illustrated by short film sequences. The reagents, laboratory equipment and the key fragments of the experiment are shown in photographs. At the stage of the handbook preparation, the students and teachers were asked to indicate the most interesting experiments, which were subjected to the meritorial and methodical verification. Only then, the work on the multimedial handbook was completed. To compare the effectiveness of education with the use of the conventional printed and the multimedial versions of the handbook, a pedagogical experiment was performed. The multimedial version is available on the Internet (Jagodziński, Wolski, & Burewicz, n. d.; Jagodziński, Wolski, & Piłat, n. d.).

The Principles of the Pedagogical Experiment

Students and teachers asked to participate in the pedagogical experiment were randomly divided into two groups: the experimental group and the control group. The control group members were learning from the printed version of the handbook, while those of the experimental group used the multimedial version available from the Internet. To eliminate the error of pedagogical measurements, the use of the multimedial version of the handbook was verified (Russell et al., 1985). Each member of the experimental group had his/her own user's name and access password. The number of logs-in and the time of work with the handbook for each student or teacher was recorded in the database. Each group included 28 students and 70 teachers, and, however, some persons had to resign or withdraw from the experiment, so that finally participants included 26 students and 67 teachers from the control group and 27 students and 66 teachers from the experimental group. The learning of the students and teachers was divided into two stages, according to the principles of the method of blended learning. The method of blended learning applies a combination of exposition to different modes of educational communicates and modes of learning based on the layer of communication among all elements of the process (Throne, 2007; Mantyla, 2003.) The first stage was the preparation to the performance of the experiments. The control group members realised it by learning from the printed version of the handbook, while the experimental group members realised it by using the Internet version of the handbook. The members of these two groups were supposed to read the detail instructions for the experiments, read about the experiment performance, learn about the processes taking place in the experiment and their explanations including the relevant chemical equations to be able to answer the questions of the control block. Prior to the pedagogical experiment, the members of the two groups were asked to take a pre-test in order to assess the level of their initial knowledge, and after the completion of the course, they were asked to write a post-test. The test tasks corresponded to the four taxonomic categories of the education aims. The first group of tasks corresponded to the taxonomic category of "memorisation of information" (A), the second—to the category "understanding of information" (B). These two categories were included in the "level of information". The third group of test tasks corresponded to the category of "application of information in a typical situation" (C), and the fourth—to the category "application of information in a problem situation" (D). The last category had the highest taxonomic value, and together with C, they were included in the "level of abilities". At the second stage of the study, members of the two groups were performing the experiments in laboratory classes. The time for

performance of one experiment was estimated by dividing the class duration by the number of experiments completed in one class. For the students, the class nominally lasted 90 minutes, but the actual time devoted to the experiments was assumed as 70 minutes, as the first ten minutes were taken by the preparation and the last ten minutes were taken by results collection and cleaning. For the teachers, the class nominally lasted 135 minutes (3×45 minutes), but the actual time devoted to the experiments was 95 minutes, as the first 10 minutes were taken by the preparation, and the last 10 minutes were taken by results collection and cleaning and in the middle of the class where there was a 20-minute break. On a certain day of the week, the students and teachers could consult the academic tutor by the Skype communicator, all the time they could consult the tutor via e-mail. The mean time of work with the conventional handbook was calculated either on the basis of the information given by the control group members or the database information recorded for the users of the Internet version of the handbook (Burewicz, Jagodziński, & Wolski, 2007).

Results

The effectiveness of education was assessed on the basis of the differences between the pre-test and post-test results for the two groups: experimental and control. The results were given in Table 1. Analysis of these results permitted estimation of the effect of the blended learning in education in the chemical experiment by students and teachers.

At the end of the laboratory classes, the students and teachers were asked to report the number of chemical experiments performed in order to calculate the mean time needed for performance of one experiment. The mean times needed to perform one experiment in the two groups were given in Table 2.

Table 1

Educational Effectiveness in Particular Taxonomic Categories and for All Categories Together

Taxonomic category	Educational effectiveness (%)	
	Students	Teachers
A	47.1	6.1
B	22.7	12.2
C	35.1	18.2
D	60.1	39.6
Total ABCD	36.7	28.5

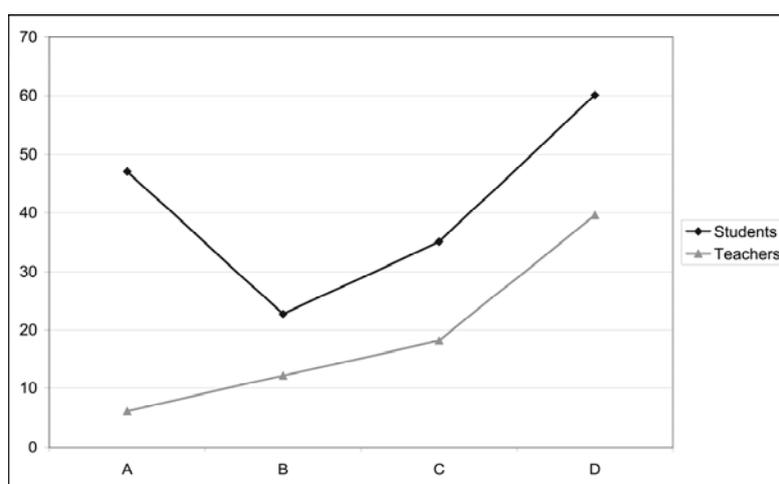


Figure 1. Comparison of the education effectiveness of the Internet multimedial handbook in blended learning for students and teachers in particular taxonomic categories.

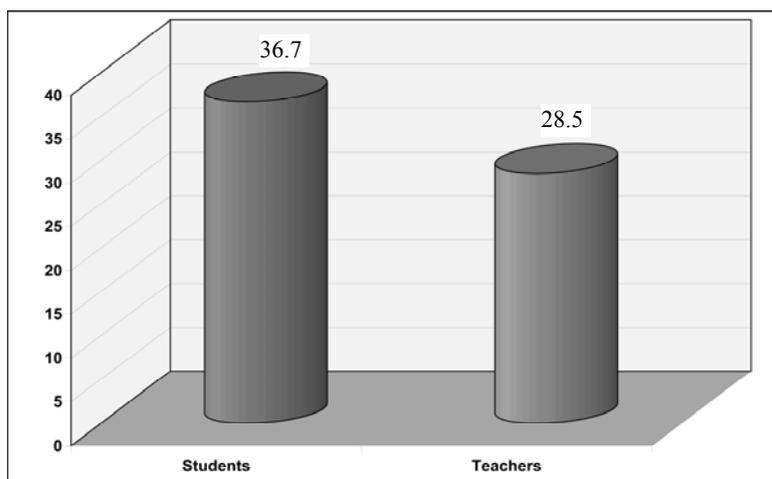


Figure 2. Educational effectiveness of the multimedial handbook available on the Internet in blended learning estimated for the students and teachers taking part in the pedagogical experiment.

Table 2

The Effective Time of Laboratory Work, Number of Experiments Completed in One Class and the Mean Time Needed to Perform One Experiment in the Experimental and Control Groups of Students and Teachers

	Students		Teachers	
	Control group	Experimental group	Control group	Experimental group
Effective time of laboratory work	70 minutes	70 minutes	95 minutes	95 minutes
Number of experiments completed in one class	6	8	8	10
Mean time needed to complete one experiment	11 minutes 40 seconds	8 minutes 45 seconds	11 minutes 53 seconds	9 minutes 50 seconds

On the basis of the data obtained from the control group members and the database for the experimental group members, the mean time spent on working with the printed and multimedial versions of the handbook to learn about one thematic group was assessed (see Table 3).

Table 3

The Time of Work With the Printed and Multimedial Version of the Handbook to Learn About One Thematic Group of Experiments of the Control and Experimental Group Members

	Students		Teachers	
	Control group	Experimental group	Control group	Experimental group
Mean time of working on one thematic group	2 hours and 20 minutes	2 hours and 45 minutes	1 hour 50 minutes	2 hours and 30 minutes

Discussion of Results

The study was undertaken to assess the education effectiveness of the multimedial handbook available from the Internet, prepared to assist teaching the subject “Experiment in chemistry”. The assessment was made for students of chemistry and teachers of science at all levels participating in the postgraduate course aiming at improvement of their qualifications, at the Faculty of Chemistry, Adam Mickiewicz University, Poznan. The results of the pedagogical experiment, presented in Table 3 for particular taxonomic categories of education aims, have shown that the method of blended learning with the aid of the multimedial handbook has increased the education effectiveness. For students, the educational effectiveness analysed together for all taxonomical

categories was by 8.2% higher than that for teachers. Figure 1 revealed a significant difference in the educational effectiveness between the students and the teachers in category A. This difference is a consequence of the fact that the teachers achieved much better results of the pre-test than students. The results presented in Table 2 showed that the students and teachers from the experimental group were able to perform a greater number of experiments in one class than members of the control groups. The multimedial handbook permits detail observation of the experiment repeated any time, which definitely facilitates the performance of the experiment in laboratory and shortens the time needed to perform one experiment. Although the printed version of the handbook presented the photographs illustrating the course of the experiments, members of the control groups needed more time for completion of one experiment. The time needed for work at home with the handbook for preparation to the laboratory classes for the students and teachers from the experimental group is longer than that from the control one (see Table 3). The possible reason is that when working with the multimedial version of the handbook, learning about a given experiments requires watching a film sequence and it takes more time.

Concluding Remarks

The educational effectiveness of learning with the help of the multimedial version of the handbook presenting materials for experiment in chemistry has been assessed at the Chemistry Teaching Laboratory, the Faculty of Chemistry of Adam Mickiewicz University. The results obtained have revealed the improved education effectiveness in the students and teachers working with the multimedial version of the handbook in the method of blended learning.

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