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LEARNING MATHEMATICS USING MULTIMEDIA IN ENGINEERING EDUCATION

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Abstract: Multimedia learning of mathematics encompasses learning from instructional material, both traditional (paper, blackboard, etc.) and computer based (graphs, animations, etc.), that combine words and pictures in the domain of mathematics. This paper has both a theoretical and practical orientation. On one hand, our aim was to present how students of two engineering faculties learn with multimedia and how to design multimedia environments that promote learning. In this study we present some of the most important principles of multimedia learning and design. We provide a definition of multimedia learning and multimedia presentation, present distinction between two approaches to multimedia design. On the other hand, the practical aim of this paper, based on the above factors of multimedia learning and design, was to prepare multimedia lessons (selected examples) in mathematics and present them to the students of two engineering faculties: the Faculty of Architecture and the Faculty of Civil Construction Management of the UNION "Nikola Tesla" University, Belgrade, Serbia. The main information source in multimedia lectures was software created in Macromedia Flash, with definitions, theorems, examples, tasks as well as in traditional lectures but with emphasized visualisation possibilities, animations, illustrations etc. Besides that, survey carried out at the end of this research clearly showed that students were highly interested in this way of learning.
Keywords: Multimedia learning, Multimedia presentation, Multimedia design, Multimedia example in mathematics, Engineering education

INTRODUCTION

Multimedia learning and multimedia presentation

Multimedia refers to the presentation of instructional material using both words and pictures [5, 6]. According to this, words – or the verbal form of the instructional material – can be either printed or spoken, while pictures – or the pictorial form of instructional material – can encompass static graphics, such as illustrations, graphs, maps, or dynamics graphics, such as animation or video. Multimedia instructional message or multimedia instructional presentation involving words and pictures that is intended to faster learning.

The case of multimedia uses the premise that learners can better understand an explanation when it is presented in words and pictures than when it is presented in words alone.

Cognitive theory, emphasises the importance of visualisation in learning, too. The principle of this theory is that there are two qualitatively different methods of learning: verbal and visual. Words, on the one hand, enable the description of the matter even from the abstract aspect, while pictures, on the other hand, enable the visual experience of the matter. These two methods of learning are complementary and not exclusive, so the overall conclusion is that the students should combine text and picture and, in this way, learn more readily, which is actually the final objective.

During past few years, multimedia learning has become very important and interesting topic in the field of teaching methodology. Mayer's and Atkinson's researches resulted in establishing the basic principles of multimedia learning and design, which were confirmed in our paper, too [1, 5, 6]. Nowadays, usage of different kinds of multimedia is largely included in the education because it allows the wider spectrum of possibilities in teaching and learning. Visualisation is very useful in the process of explaining mathematical ideas, abstract terms, theorems, problems, etc.

Modern methods in multimedia approach to learning include the whole range of different possibilities applicable in mathematics lectures for different levels of education and with different levels of interactivity [4], [7], [8], [9], [10].

This paper has both a theoretical and practical orientation. On one hand, our aim was to present how students of two engineering faculties learn with multimedia and how to design multimedia environments that promote learning.

Two metaphors of multimedia design and learning

According to the information acquisition view, learning involves adding information to one's memory. This view entails assumptions about nature of the learner, the nature of the teacher, and the goals of multimedia presentation. First, learning is based on information, an objective item, that can be moved from place to place (such as from the computer screen to the human mind). Second, the learner's job is to receive information; thus, the learner is a passive being who takes in information from the outside and stores it in memory. Third, the teacher's job, or, in the case, the multimedia designer's job, is to present information. Fourth, the goal of multimedia is to delivery information as efficiently as possible. The underlying metaphor is that multimedia is a delivery system. According to this metaphor multimedia is a vehicle for efficiently delivering information to the learner. Table 1 summarizes the differences between the two views of multimedia learning with explanations of starting points, goals and issues [5], [6].

Table 1. Two views of multimedia design

Design approach	Starting point	Goal	Issues
Technology-centered	Capabilities of multimedia technology	Provide access of information	How can we used cutting-edge technology in design multimedia presentation?
Learner-centered	How the human mind works	Aid human cognition	How can we adapt multimedia technology to aid human cognition?

The goal of multimedia is to help people develop an understanding of important aspects of the presented material. Table 2 summarizes the differences between the two views of multimedia learning [5], [6]. In this paper we favour a knowledge instruction because it offers a more useful conception of learning when the goal is to help people to understand and to be able to use what they learned.

Table 2. Two metaphors of multimedia learning

Metaphor	Definition	Content	Learning	Teacher	Goal of multi-media
Information acquisition	Adding information to memory	Information	Passive information receiver	Information provider	Deliver information; act as a delivery vehicle
Knowledge construction	Building a coherent mental structure	Knowledge	Active sense maker	Cognitive guide	Provide cognitive guidance; act as a helpful communicator

Design of multimedia lessons

Multimedia learning can be effective only if multimedia lessons are adequately designed.

For many years, the investigations on multimedia learning and their results have been rather unconnected and without a concrete effect on learning. But, today there are numerous studies that define clearly the factors affecting the multimedia learning and the principles of successful multimedia design.

There are twelve factors, each with a theoretical background, which can be defined as variable. The student's style is an independent variable, whilst learning is the dependent variable. Other elements are visual knowledge, audio knowledge, student control, attention, working memory, motivation, cognitive engagement, intelligence, transfer and length of data storage. All the factors are interrelated and have a complex effect on multimedia learning and design [3].

Some of the most significant principles of multimedia learning were established by [5], [6]:

1) Multimedia Principle: Students learn better from words and pictures than from words alone.
2) Spatial Contiguity Principle: Students learn better when corresponding words and pictures are presented near rather than far from each other on the page screen.
3) Temporal Contiguity Principle: Students learn better when corresponding words and pictures are presented simultaneously rather than successively.
4) Coherence Principle: Students learn better when extraneous words, pictures, and sounds are excluded rather than included.
5) Modality Principle: Students learn better from animation and narration than from animation and on-screen text.

6) Redundancy Principle: Students learn better from animation and narration than from animation, narration, and on-screen text.
7) Individual Differences Principle: Design effects are stronger for low-knowledge learners than for high- knowledge learners and for high-spatial learners rather than for low-spatial learners.

Table 3 shows in short the factors that make a multimedia presentation effective.

Table 3. Factors affecting the success of a multimedia presentation

Characteristics	Description
Multimedia	Present the text and picture together
Unity	Present the text and picture close to each other
Conciseness	Exclude the superfluous text and picture
Structure	Include textual and visual explanations of the presented, step by step

MATERIAL AND METHODS

Aim and questions of the research

The practical aim of this paper, was based on the above factors of multimedia learning and design, to prepare multimedia lessons on definite integral and to present one selected example. Thanks to the experiences of some previous researches and results, some of the questions during this research were:

1. What do students think about multimedia lectures and presentations? Do they prefer this or traditional way and why?
2. Do students think it is easier to understand and learn the matter individually and during the classes by multimedia lectures?

Participants of the Research

The research was conducted on two groups of 50 students of the first year: at the Faculty of the Architecture (25 students) and the Faculty of Civil Construction Management (25 students) of the UNION University, Belgrade, Serbia.

Multimedia learning of mathematics. Example

Lectures in both groups of students included exactly the same information on the finite integrals, i.e. axioms, theorems, examples and tasks like on the traditional class of math, but the main information source was software created in Macromedia Flash 10.0, which is proven to be very successful and illustrative for creating multimedia applications in mathematics lectures [2]. Our multimedia lecturing material was created in accordance with methodical approach, i.e. cognitive theory of multimedia learning [5], [6], as well as with principles of multimedia teaching and design based on researches in the field of teaching mathematics [1]. This material includes large number of dynamic and graphic presentations of definitions, theorems, characteristics, examples and tests from the area of the finite integrals based on step-by-step method with accent on visualisation. Important quality of making one's own multimedia lectures is possibility of creating combination of traditional lecture and multimedia support in those areas we have mentioned as the 'weak links' (finite integral definition, area, volume, etc.).

Example: Determining the volume of body by revolving.

Task: Determine the volume of a right circular cone with altitude h and base radius r.

Solution: The cone is generated by revolving the right-angled triangle OAB around the Ox-axis, which can be clearly shown by using animation (Figure 1).

Animation parts which represents the given task and the triangle revolution.

Numerical solution of given problem is also shown step-by-step, by using animation.

Slant height of the cone is defined as line:

$$y = x \cdot tg\alpha = \frac{r}{h} \cdot x$$

Therefore, according to the formula for calculus of volume:

$$V = \pi \int_0^h (\frac{r}{h} \cdot x)^2 dx = \frac{\pi \cdot r^2}{h^2} \cdot \frac{x^3}{3} \Big|_0^h = \frac{\pi \cdot h \cdot r^2}{3}$$

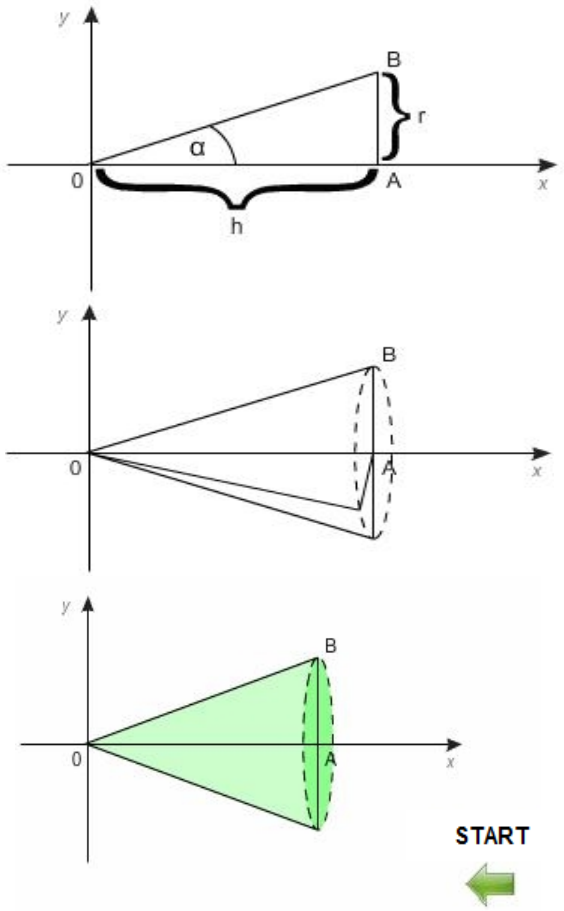

Figure 1. Example: Determining the volume of body by revolving

RESULTS

In summary, multimedia learning helps to promote a better understanding of how to foster meaningful learning through the integration of words and pictures (printed or spoken text and illustrations, graphs, maps, animation or video).

When asked whether they prefer classical or multimedia way of learning, 12% (3 students) answered classical and 82% (22 students) answered multimedia at the Faculty of Architecture, while at the Faculty of Civil Construction Management 20% (5 students) answered classical and 80% (20 students) answered multimedia, explaining it with the following reasons:

- 'It is much easier to see and understand some things, and much easier to comprehend with the help of step-by-step animation.'
- 'Much more interesting and easier to follow, in opposite to traditional monotonous lectures with formulas and static graphs.'
- 'More interesting and easier to see, understand and remember.'
- 'I understand it much better this way and I would like to have similar lectures in other subjects, too.'
- 'This enables me to learn faster and easier and to understand mathematical problems which demand visualisation.'
- 'Quite interesting, although classical lectures can be interesting – depending on teacher.'

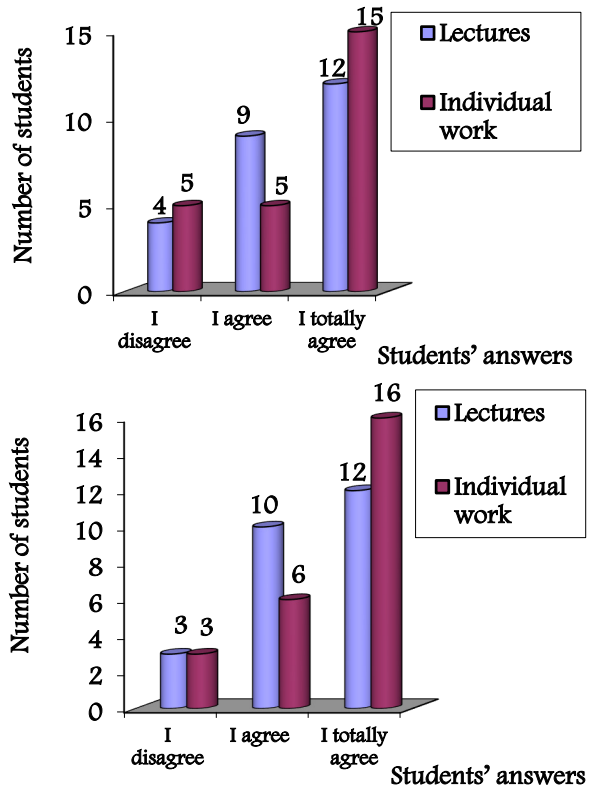

Figure 2. Students' answers to the question: Should PC be used in lecturing and learning mathematics? (a – Architecture, b – Civil Construction Management)

When asked whether it was easier for them to learn, understand and solve problems after having lectures and individual work with multimedia approach, students answered the question as shown in Figure 2.

DISCUSSION AND CONCLUSIONS

During past few years, multimedia learning has become very important and interesting topic in the field of teaching methodology. Mayer's and Atkinson's researches resulted in establishing the basic principles of multimedia learning and design, which were confirmed in our research, too [1], [5], [6]. Our multimedia lessons about the finite integrals, created in accordance with these principles, proved to be successful. According to the students' reactions, highly understandable animations from multimedia lessons are the best proof that a picture is worth a thousand words. Their remark, and consequently one of this research's conclusions, was that there should be much more of this kind of lessons in education, made – of course – in accordance with certain rules and created in the right way.

Many researches in different scientific fields, including mathematics, have proven that multimedia makes learning process much easier.

Researches on learning the finite integrals with software packages Mathematica and GeoGebra have shown that students who had used PC in learning process had higher scores on tests [4]. Although this research was conducted with different multimedia teaching tools for the same subject – the finite integral as one of the most important areas in mathematical analyses – our results only proved the universality of multimedia in the process of teaching mathematics.

Wishart's research included analyses of comments on how much multimedia approach affects teaching and learning processes [13]. Teachers emphasized that multimedia lectures have made their work easier and have proved to be motivating for students, while students said that multimedia lessons, in comparison with traditional methods, have offered better visual idea about the topic. As shown in Graph 2, great number of them insisted that multimedia tools enabled easier understanding, learning and implementation of knowledge.

Their remark, and consequently one of this research's conclusions, was that there should be more multimedia lessons, i.e. that multimedia is an important aspect of teaching and learning process.

One of this research's conclusions can be put in the way one student did it during the survey (by answering the question: What is multimedia learning): 'Multimedia learning is use of multimedia as an addition to the traditional way of learning. Multimedia enables us to have better understanding

of many mathematical problems and to experiment with them.'

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