MULTIMEDIA APPLICATIONS IN EDUCATION

M. Jancheski[1], S. Jancheska[2]

[1]*Ss. Cyril and Methodius University, Faculty of Computer Science and Engineering (MACEDONIA)*
[2]*New Your University Abu Dhabi (UNITED ARAB EMIRATES)*

Abstract

The continuous development of information and communication technologies undoubtedly leads to the development of multimedia and its increased use in many other fields, including science and education.

Multimedia is a medium that combines several content formats: text, graphic, animations, audio (sound, music, speech) and video. The modern educational process cannot be imagined without multimedia. Multimedia has a huge impact on both classical and distance education. It can be used at all levels of education and applied to various fields. It can positively affect students' acquisition of knowledge and skills. Multimedia has the power to improve the process of teaching and learning, to increase the interaction between students and teachers, but also to encourage inspiration, excitement and motivation among students. Multimedia tools create effective learning environments that allow students to explore, experiment, hypothesize, ask questions, and provide answers to a variety of real-world situations.

In the first part of the paper, we analyze Meyer's cognitive theory of multimedia learning and its basic principles as a theoretical basis. Through the prism of this framework, we dedicate a special section to the pedagogical basis and standards in the application of multimedia in education. We also analyze several multimedia applications, including animations, simulations and computer games. For the same specific teaching content, we create different models of multimedia applications. Through concrete examples, we demonstrate the benefits and advantages, but also the disadvantages of these models' application. In the final part of the paper, we provide appropriate recommendations to educators, educational institutions and education authorities regarding the importance and proper use of multimedia in education.

Finally, this paper attempts to answer the following questions: What should be the preparation of teachers to use multimedia in teaching and learning? How to make an appropriate choice of multimedia tools? Which are the necessary conditions for proper use of multimedia tools? Which criteria should be taken into consideration when adapting multimedia content to students? How to properly combine multimedia tools? To what extent the application of multimedia should be included within one lesson? How to effectively recognize the concepts and phenomena in the curriculum in which the adoption of multimedia can play a key role?

Keywords: multimedia, education, animations, simulations, computer games.

1 INTRODUCTION

Multimedia is a medium that combines several content formats: text, images, animations, audio (sound, music, speech) and video. Digital multimedia is a computer-controlled integration of the above content formats where any type of information can be presented, stored, transmitted and processed digitally (M. Lang, 2005). Interactive digital multimedia is a system that allows users to customize and select information that they view and receive by actively engaging with the system (for example, interactive television), as opposed to passive multimedia where the end user has no control over timing, order or content (e.g., videotape or linear presentation) (Lang, 2005). [7]

Multimedia has a huge impact on education. It can be used at all levels of education and finds application in various fields. It can positively affect students' acquisition of knowledge and skills while also encouraging their inspiration, excitement and motivation.

2 THEORETICAL FOUNDATIONS

2.1 Cognitive Load Theory and Dual Coding Theory

Multimedia materials can be developed through different approaches; among the most important ones are Dual Coding Theory and Cognitive Load Theory. These two theories have slightly different assumptions about the working memory structure and capacity of the learner which directly impacts one's learning process.

Cognitive Load Theory tries to unveil the relationship between the capacity of the learner to understand and store the presented information in the long run and the load of the learner's working memory which is largely determined by the complexity of the way the information is being presented. More precisely, this theory suggests that a learner has a limited amount of memory and concentration to pay attention to what is being explained and displayed; thus, it is important to find the right balance between maximizing the utilization of teaching tools and materials, and minimizing the cognitive load of the learner. For instance, if one is being taught a complex concept, it would be more favorable to utilize concise ways to explain it through a limited amount of teaching resources. It would be counterproductive to attempt to explain it using heavy screen design, such as an abundance of text, visualizations, and animations, all at the same time. These teaching tools and materials can be useful for the learner when they are used at the right time in an adequate amount. [12]

Dual Coding Theory, on the other hand, relies on the fact that there exists only one working memory which consists of two different parts: verbal and nonverbal. This theory argues that the combination of materials and tools can stimulate the different parts of the learners' brain, thus supporting the combined utilization of visual and auditory elements in the teaching process. Previous work on Dual Coding Theory has discovered that a learner can process visual information faster and easier than textual one. It would be thus useful for teachers to limit the use of frequent textual references to certain extent and focus on creating visualizations which will help the students grasp the material better. This multidimensional approach to teaching has the potential to facilitate students' learning of complex material by stimulating all parts of their brains while not overloading their cognitive processing abilities. Visualizations, a field largely dependent on multimedia materials and tools, is the key player in achieving this goal. [12]

2.2 Cognitive theory of multimedia learning

Richard E. Mayer is a Professor of Psychology at the University of California and a world-renowned scholar in the field of multimedia learning. He studied the impact of combining both words and images on the learning process which he later called the cognitive theory of multimedia learning. According to Meyer's research on cognitive theory, multimedia may help students and teachers learn more effectively and meaningfully through the "dual coding" of information through which the learner processes text and images simultaneously. This dual coding has been shown to aid learners' working memory. [10]

Among Mayer's great contributions are the twelve principles of instructional design that are based on experimental research studies and grounded in a theory of how people learn from words and pictures. The acceptance and observance of these principles can lead to a significant improvement in the quality of learning. These multimedia teaching principles are the result of the work of his team at the University of California on over a hundred different studies.

In the first edition of his book "Multimedia Learning", Mayer identified seven principles that characterize the potential of rich media as a teaching and learning tool which can enhance learning.[3] (see Table 1)

Table 1. The first seven principles with explanation [9].

Multimedia Principle	Deeper learning from animation and narration than from narration alone
Spatial contiguity Principle	Deeper learning when corresponding text and animation are presented near rather than far from each other on the screen
Temporal contiguity Principle	Deeper learning when corresponding narration and animation are presented simultaneously rather than successively
Coherence Principle	Deeper learning when extraneous narration, sounds and video are excluded rather than included
Modality Principle	Deeper learning from animation and narration than from animation and on-screen text
Redundancy Principle	Deeper learning from animation and narration than from animation, narration and on-screen text
Personalization Principle	Deeper learning when narration or on-screen text is conversational rather than formal

The second edition of the book Multimedia Learning in 2009 [10] is supplemented by five new principles (see Table 2).

Table 2. The next five principles with explanation [10].

Signaling Principle	People learn better when the essential material is highlighted (signaled method) rather than not highlighted. These signs direct the user's attention and processing during the multimedia presentation.
Segmenting Principle	People learn better when a multimedia lesson is presented in short, user-paced segments rather than as a long, continuous presentation (unit)
Pre-training Principle	People learn better from a multimedia lesson when they know the names and characteristics of the main concepts
Voice principle	People learn better when the narration in multimedia lessons is spoken in a friendly human voice rather than a machine voice
Image principle	People do not necessarily learn better from a multimedia lesson when the speaker's image is added to the screen

One of Meyer's main arguments states that people learn better when multimedia messages are designed in a consistent manner with how the human mind works and are combined with research-based principles. These principles have been empirically tested and are based on scientific research within the multimedia learning research program at the University of California. Meyer insists on conducting rigorous empirical tests prior to the adoption of any design principles. In the first edition, Mayer reported on 45 experimental comparisons involving transfer test performance carried out by him and his colleagues, whereas that number has increased to 93 experimental comparisons in the second edition.

Compared with the first edition, besides the growth of the research base and the growth in the number of principles, the second edition includes theoretical reorganization of the principles and the boundary conditions of the principles. Furthermore, the underlying theory has been expanded to incorporate the triarchic model of cognitive load, which consists of extraneous, essential, and generative cognitive processing. Correspondingly, the twelve principles of multimedia instructional design have been reorganized into three categories (Table 3):

Table 3. Three categories of principles [10].

Principles for reducing extraneous processing	Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles
Principles for managing essential processing	Segmenting, pre-training, and modality principles
Principles for fostering generative processing	Multimedia, personalization, voice, and image principles

3 IMAGES

An image is essentially a visual presentation of a surface (wall, canvas, monitor screen, paper, etc.) whose purpose may be to inform, illustrate, or entertain. There is a reason behind the famous quote stating that "A picture is worth a thousand words". Previous studies and practical research have shown that people generally understand and remember the picture faster than the text (Gagné, 1987). People are more easily attracted to images, especially those displayed on a computer screen. Textbook images or even more attractive digital screen images can be a good replacement or complement to the content of the text and help students visualize objects, concepts, ideas and connections. According to Fenrich (1997), "the combination of text and graphics increase recall, both simple and complex skills, and help learners to retain knowledge." Leshin et al in 1992 stated that "Imagery can be used with all media. However, it must be emphasized that pictorial embellishments alone will not facilitate learning." Abstract concepts or phenomena as well as complex processes usually cannot be easily described and explained with text. Therefore, it is recommended to visualize them with an appropriate selection of images. The utilization of pictures in the teaching process can attract students' attention and help them maintain the interest for the specific topic content-wise. To ensure the effective use of the benefits of images in teaching and to avoid creating negative effects, teachers should be well aware of the possibilities and limitations of tools for working with images in the teaching and learning process, especially in terms of content whose visual elements play a very important role in teaching. [13]

According to the “Concept for making a textbook and methodology for evaluating a textbook”, prepared by the Bureau for Development of Education of the Macedonian Ministry of Education, the selection and formatting of visual attachments should always be used to correspond to the content to which they are attached and should be appropriate to the age of students for whom the textbook is intended. The text, according to the Concept, should always be a key source of knowledge for students who can read; the largest number of illustrations should be included in the textbooks elementary grade students and should gradually decrease in the higher grades. Visual aids are always expected to "revive" the text as well as to encourage and to increase motivation; they should be closely related to the goals of the curriculum and should not to be used "at any cost" and/or out of context. The concept also emphasizes that special attention should be paid to the educational function of the chosen visual attachments. They should arouse students' interest and thinking about appropriate activities covered by the program, and promote civic, religious, ethnic, racial and gender equality. [14]

In [13], the author tries to elaborate in terms of the application of images on the three learning domains originated by Benjamin Bloom, a famous educational psychologist from the middle of the last century:

- Cognitive domain: images help students to acquire knowledge;
- Psychomotor domain: images help students to apply skills;
- Affective domain: images help students connect attitudes and feelings.

According to the Concept, the list of possible types of visual attachments that can be found in Macedonian textbooks includes: pictures, reproductions of works of art; children's drawings; illustrations from various scientific disciplines and areas; maps: geographical and historical; schemes: organizational chart; tabular scheme; stem pattern; diagrams; graphs: linear, columnar, circular; pictorial; comics; photos; illustrations derived from the text, etc. [14]

Digital images can also be classified according to their functions and purposes: pictorial (images that show things, such as photographs, drawings, sketches, and paintings); schematics (images that link up components or related parts, such as concept maps, wiring diagrams, and flow charts); symbolic (images that represent messages, give direction, or help navigation, such as logos and trademarks), figural graphics (images that represent ideas rather than physical objects, such as charts and graphs) Bullough (1988). [13].

3.1 Applications of images in education

In education, the proper use of images can significantly strengthen the effectiveness and efficiency of teaching and learning. All in all, the good use of images can achieve following goals:

- Assisting teachers in transmitting abstract ideas and concepts;
- Assisting teachers in presenting and delivering teaching content;
- Assisting students in visualizing complex processes;
- Helping students recall information;
- Attracting students' attention;
- Replacement of a long text description;
- Improving a pleasant learning environment;
- Stimulating the interest in learning. [13]

4 ANIMATIONS

We are witnessing a rapid development of computer animation, which began in the sixties of the last century. This has been accompanied with an explosive evolution of computer hardware and software technology as well as a rapid growth of computer graphics theory, computer animation permeates, involved in every aspect of life, including television, movies, education, industry, science, and more.

Animations can be created by rapidly and successively displaying a series of ordered still images where each image is slightly different than the previous one. In this manner we are creating the illusion of a motion, i.e., the eye and the brain of the viewer are tricked into viewing the series of the images as a continuous motion. Studies have shown that one can see smoothly moving objects in images if a frame rate is greater than 10 frames per second. Frame rate is expressed as the number of frames per second (fps) of animation. Frame rate for cartoons is about 15 frames per second, and for film (movie) is 24 frames per second. Video frame rates are approximately 30 frames per second. The acceptable speed for computer games is at least 30 frames per second. ([18], [19])

Interactive animation is essentially a dynamic and visual presentation of phenomena or events that allows users to observe, i.e., follow a certain process through time and space. The users can control the course of the animation, but they cannot influence the initial placement of the animation objects, nor the outcome of the visual presentation, i.e., the final placement of the animation objects.

Modern computer animation techniques include special effects, photorealistic scenes, or vivid characters in movies, video games, and commercials. Recently, researchers, engineers, educators and artists from all over the world have been working hard to expand the application of animation. [1]

Computer animation is widely used in various fields, such as movie special effects, advertising, cartoons, computer games and computer simulations, etc. Contrary to the traditional perspective of computer animation as part of computer graphics, many researchers point out that it is an interdisciplinary subject combining several areas, such as image processing, digital signal processing, machine vision, and artificial intelligence.

The following is a list of different types of animations: Frame-based animation; Computer-generated animation; Computer-aided animation; Vector-based animation; Sprite-based animation; Character animation; Spline-based animation; 2D animations and 3D animations.

According to Nielson (2000) and Vossen (1997), teachers use animations: 1) to capture students' attention or to warn observers of new information; 2) demonstrate navigation in a certain direction; (3) to create icons for activities that cannot be adequately expressed with a two-dimensional static image. [16].

5 SIMULATIONS

Simulations are widespread in many areas, such as education, from preschool to university, healthcare, the armed forces, and the economy. Simulations can help to study real or imagined events or phenomena. Representing reality is a great challenge, and the constant development of information technologies allows it to be presented more credibly.

Simulations are computer models of real or assumed situations or natural phenomena; they contain rules and strategies that allow flexible and variable activity to be developed, and the cost of user errors is very low [5]. It is sometimes impossible to imitate reality in detail, but technology becomes good enough that in a specific context it can convince students that they are facing an accurate representation of reality. This belief, according to Shank & Cleary (1995) [8] is enough to think about how to use simulations to learn in an authentic way, i.e., to behave in a way that is similar to how we would behave in the real world.

Regarding the scientific-teaching context, it is important to list some of the main motives for performing simulations. Hartmann [2] recognizes simulation as: technique (for examining the detailed dynamics of a system), heuristic tool (for developing hypotheses, models and theories), substitution for experiment (for performing numerical experiments, tool for experimenters (support for experiments) and as a pedagogical tool (for a better understanding of processes).

According to Plass, Homer and Hayward (2009) [5] simulation differs from static visualization because of its dynamics, and differs from dynamic visualization (animation) in that it enables user interaction.

5.1 Applications of simulations in education

Simulations have the potential to be used in several approaches to teaching and learning. For example, they can be used as a didactical tool, as models and conveyance for complex concepts, for discovery learning, and experiential learning. As a result of implementing properly designed simulation activities, the role of the teacher changes from a mere transmitter of information to a facilitator of higher-order thinking skills (Woolf & Hall, 1995). De Jong (1991) identifies four characteristics contributing to the success of computer simulations for instruction: (a) a computational model underlying the simulation, (b) the presence of clearly stated instructional goals, (c) the ability of the simulation to evoke exploratory learning, and (d) the opportunity for learner activity. [2]

In different courses in education, students do not have the opportunity to get acquainted with certain phenomena or events in real life. Numerous experiments in the field of natural sciences can be very expensive and inaccessible to many students. Simulations are very useful there. Students can use the event management simulation. Any factor that influences the considered event or occurrence in the simulation can be represented by a parameter. By changing the values of the parameters, the student can observe the dependence between the different factors and draw appropriate conclusions. In that way, he/she will master the teaching material much more effectively than through other forms of learning, such as reading the textbook, following the teacher's oral presentation and the like. Furthermore, simulations can be easily customizable and allow students to work on tasks or projects that would otherwise be physically or logistically impossible, impractical or dangerous. Simulations are cheaper, safer, and more accessible than real objects in many educational situations, thus avoiding exposing students to risk. ([3], [4])

Simulations are not just an interactive model or set of facts with which a student interacts. They provide a framework for students to build their own knowledge. They are an educational experience where learning is both interactive and dynamic. Computer simulations increase the effectiveness of learning environments where students can explore, experiment, ask questions, and make hypotheses about real-world situations (natural or social) that might otherwise be inaccessible. [4]

In [2] Y. Baek summarizes the characteristics of a digital simulation in teaching and learning: “It has an adequate model of a complex real-world problem or situation with which the student interacts, a defined role with a set of available actions, a data-rich environment that permits a range of strategies from a variety of perspectives, feedback in the form of changes in the problem or situation, embedded instructional goals, and mechanisms for active participation and the promotion interest, which elicits deeper, more expedient, and better retention of understanding of a concept, mastery of a skill or strategy, or acquisition of knowledge.” The first four of these characteristics are identified by Gredler in 2004.

According to Clark et al. in 2009, simulations used in science education should be classified according to four basic criteria: 1) the degree of user control, 2) the degree and nature of the surrounding leadership framework to which simulations are embedded, 3) how the information is presented, and 4) the nature of what is being modeled. [5]

While there are obvious advantages to utilizing digital simulation for teaching and learning in education, challenges exist as well. For instance, the physical interface used to perform digital simulations can be complex and difficult for teachers and/or students to grasp right away. In particular, if they have not worked with digital simulations before and are not getting adequate training, the lack of confidence in their skills can result in a less positive attitude towards the learning process supported by such digital tools. In short, it would require an additional effort and willingness from the teachers and the students to implement them in the courses on a daily basis. It is important to also recognize that some digital simulations might not have a complete capacity to follow delayed responses. They could also require users to be attentive between different senses for different tasks as multisensory inputs can cause undesirable feelings and unprecedented perceptions. As a result, users might lose their orientation which is an important factor in the learning process from simulations. We also recognize the need to emphasize the importance of precise perceptions of location at each time point throughout the simulation since it is a fundamental factor for a smooth learning experience. Finally, we would like to point out that creating, developing and maintaining digital simulations might pose additional costs as it can be an expensive and a complex process involving different stakeholders. [2]

A variety of free and commercial simulations are available on the market. In our opinion, one of the best online libraries of free interactive simulations, mainly related to science and math, is PhET interactive simulations (http://phet.colorado.edu/). The interactive simulation site PhET is hosted by the University of Colorado (USA). Each simulation targets a specific concept in the natural sciences or mathematics. These simulations are intended for teachers or students who have minimal knowledge of the concept and who have not attended any training for the use of simulations. ([3], [5])

6 COMPUTER GAMES

Terms as computer games, television games and video games have generally become synonymous today because of the blurry boundaries between computing and video technology. The terms computer game and video game are usually used interchangeably, and the term “digital game” incorporates both. The term “digital game” usually refers to games played using a personal computer or personal game machine. Prensky (2001) defines digital games by a set of key characteristics including: rules, goals and objectives, outcomes and feedback,conflict/competition/challenge/opposition, interaction and representation of story. [6, 21, 22]

According to Hays (2005) and Clark et al. (2009), computer games differ from computer simulations in two ways: (1) they provide feedback to measure the player's progress toward goals, and (2) the player's actions and game playing strategies influence the state of the game—the overall digital "world" and the player's further interactions with it. [23] Bean (2006) argues that imitating something real is the element that distinguishes a simulation from a game. [21] Kaufman (2010) distinguishes simulations from games, by defining simulations as "activities that include exploration and practice within models of reality but without competition, scoring, and winners/ losers". [21]

Computer games are flexible tools; they can be adopted to different instructional modes, including the traditional in-person system, online classrooms and blended ones, finding its place in both formal and informal education. They are available on different platforms, anywhere, at any time. They can be played on personal computers, games machines, games consoles, handheld devices, palmtop and laptop computers, and mobile phones. They can be available in various forms: CD-ROM-based, DVD-based or Internet-based, both offline and online. They can be played individually, against the computer, or against other people, face-to-face or online. They can be also collaborative (multi-user/multiplayer). Computer games represent safe platforms for trial-and-error experimentation without posing any harm. [6]

6.1 Applications of computer games in education

According to many scientific investigations and projects, computer games had significant educational value and could be extremely useful if they become a part of the school curriculum. The numerous benefits of using games in educational environment (presented in detail in [6]), are the best answers to the question: Why should we use computer games in education? The lengthy list of advantages of computer games includes: enhancement of knowledge and learning outcomes of students, meaningful learning process enriched with practice, acquisition of computer literacy, development and improvement of cognitive abilities and skills (visual, spatial, attention and memory) and brain functions, development of positive attitudes toward technology, conceptual thinking growth, stimulating curiosity and motivation to learn, encouraging active, critical, autonomous and group learning processes, increased interaction and collaboration between students etc.

Furthermore, computer games can have a significant role in students' well-being. Besides computer games used for enhancing the health education, there are also various educational computer and video games that have been developed to help children with: 1) different health problems, 2) chronic diseases, like diabetes, asthma, cancer, psychiatric disorders etc. in order to enhance treatment compliance. 3) special needs, including visually impaired people. [6]

Learning though play has the potential to positively impact the psychological, sociological, and intellectual developments of children that could be helpful for their learning in university later on. Thanks to the rapid technological developments today, learning in a fun way can be accomplished with videos and computer games.

While acknowledging the benefits of computer games in education, we also draw attention to some disadvantages such as: lack of an empirical framework for integrating computer games in the classroom, limited knowledge about the design and development of computer games among teachers, possible intention among students to win rather than to learn, difficulties with evaluating computer games for appropriateness for educational use, existence of really poor educational software on the market, the best computer games solutions may be expensive and/or culturally inappropriate, possible negative psycho-social tendencies (such as social isolation, addiction, violence), technical and financial requirements (high-speed Internet access, software and computer games of high quality) etc.

7 CONCLUSIONS

While dealing with a new learning material, students are encouraged to utilize animations related to the material to help them advance their knowledge in depth and breadth. Animations can serve as valuable assets to the learning process because they offer a more well-rounded experience compared to traditional textbooks. The pictures in the textbooks are motionless and capture only one situation of a certain process or event. In contrast, animations can realistically and visually describe an event or process in part or in full. Serious animations are based on strict application of the laws in the field, i.e., in the background of the animation there is a programming code, which incorporates the relevant laws, rules and formulas in the field that determine the event or process being described.

When showing the animation, the student has no opportunity to influence what the animation shows, captures or demonstrates. Simulation, unlike animation, offers the opportunity to interact with students. They can change the parameters in the simulation themselves and thus get a lot of animations through the simulation.

Previous work has shown that computer games have a valuable role in education when properly implemented in the school curriculum. The advantages of using computer games in a learning environment interfere with the benefits of using images, animations and simulations as they all fundamentally aim towards stimulating the visual parts of the brain leading to a more effective learning experience.

Animations, simulations and computer games should be carefully chosen. They can be applied throughout the learning process, from primary education to higher education. Just as certain science textbooks and content never lose their relevance, there are animations, simulations and computer games that can be always applicable to facilitate the learning process.

There are currently numerous sources of animations, simulations and computer games. Some of them are available as free, open and free software, while the rest are commercial (shareware, freeware, etc.) The multimedia tools that are present on the market today are characterized by differences in the format, available languages and adopted to a limited number of educational areas.

Each animation, simulation and computer game should capture one aspect, one knowledge. If necessary, there are numerous possibilities for multiple animations and/or simulations and/or computer games to be integrated into a more complex system. The output (output) result(s) of one simulation/computer game could be input data for the next simulation/computer game, or to program the display of a certain animation after the completion of another animation.

To conclude, multimedia is a powerful learning tool in education. Its wide range of tools offers a different perspective to the material presented to students which can be fun and interactive. It provides a significant amount of freedom to teachers and students by enabling them to combine a variety of tools in order to facilitate the absorption of the existing educational materials. We are aware that multimedia tools require a prior knowledge and instructions on their usage which can be achieved through trainings for teachers and students. Multimedia tools can also require appropriate hardware, software and high-speed Internet access which can pose a financial challenge for the educational institutions. However, the advantages of multimedia usage overweigh the potential disadvantages as presented in our paper.

8 RECOMMENDATIONS FOR MULTIMEDIA IN EDUCATION

Multimedia tools used in education should have well-defined learning objectives and content. They must correspond to the curriculum and be designed in a manner to attract, engage and reward students. They must include features that enable quality learning and encourage interaction.

Educational institutions, teachers and scientists should be continuously well informed about new multimedia products on the market, and be aware for their advantages and disadvantages. They are also responsible for the relevant and periodical evaluation of the selected multimedia tools in terms of their appropriateness and suitability for use in education. It is desirable for teachers to be able to take advantage of the benefits offered by the broad field of multimedia.

Taking into account all the advantages of multimedia, it is highly recommended that learning based on animations, simulations and computer games becomes mandatory: in regular classes, in the education of preservice teachers and in the lifelong (continuous) education of in-service teachers. It must include all aspects of multimedia, including theories, technologies, standards, and good practices. Furthermore, it is highly desirable for teachers to be trained to: 1) create new multimedia applications in accordance with the curriculum, 2) be actively involved in designing and developing multimedia applications dedicated to their students, and/or 3) be able to make changes to the existing multimedia applications and adapt them to the needs of students as individuals or groups of students. In any case, we should be aware that this will be a challenge for only a small percentage of teachers. Finally, promotions of multimedia competitions among students, continuous cooperation between all stakeholders in the field of education are also highly desirable. [6]

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