JULIÁNA LITECKÁ [1], ZUZANA MITAĽOVÁ [2]

# The Importance of the Multimedia Cognitive Learning Theory for Teaching of Technical Subjects

[1] ORCID: 0000-0002-1577-3140, Assistant Professor, University of Presov in Presov, Faculty of Humanities and Natural Sciences, Department of Physics, Mathematics and Technology, Slovak Republic
[2] ORCID: 0000-0002-2546-4640, Associate Professor, Technical university of Kosice, Faculty of Manufacturing Technologies with Seat in Presov, Slovak Republic

**Abstract**

The paper deals with the current requirements and direction of technical education within the framework of the curricular reform in Slovakia and its transition from education to student learning. The theoretical study approximates Mayer's theory of multimedia education in relation to the causes of cognitive overload, on the basis of which the principles of multimedia design were specified, which we consider crucial for the effective starter of changes in technical education.

**Keywords:** multimedia cognitive learning theory, multimedia design, technical education

## Introduction. Technical education in Slovakia

Every advanced society considers it necessary to participate in technical and technological progress. The basic pillar for securing human resources can be considered technical education, which is included in the educational system of each country, while each country, as pointed out by Dostál (2023), has a curriculum specifically adapted to the economic and cultural-social conditions in which the country is located. The Slovak Republic (SR) places emphasis, even in the currently ongoing education reform, on technical education from an early age of the child, appropriate to his level of development. As part of pre-primary education – ISCED 0, the Slovak curriculum incorporates technical education into the thematic area "I am" in the form of the development of the perceptual-motor area of the individual, which is focused on fine motor skills, work with various

materials, work techniques, technical creativity, and elementary basics of work with a computer.

On a relatively wider scale in the Slovak Republic, technical education is defined within primary education – ISCED 1 and lower secondary education – ISCED 2 in elementary schools. Technical education is implemented through the educational field Man and the world of work, the basic building blocks of which are three components: Technology, Entrepreneurship and initiative, Career education. All three components are interconnected so that emphasis is placed on the development of technical, creative, and critical thinking in the educational field. Emphasis is placed on developing technical and professional literacy among pupils. The term technical literacy refers to the ability of pupils to use, manage, evaluate, and understand technology. To become a technically literate individual, the student should understand what technology and technology are, how they work, how they shape society and how they are shaped by society. In addition, a technically literate student has certain abilities to think technically and work with technical devices, which allow him to use their ingenuity in designing and building things, in solving practical problems of a technological nature.

Secondary vocational education is divided into 27 groups of branches. The outcome of technical education at secondary vocational schools is a qualification in the fields of mechanical engineering, construction, electrical engineering, etc. This also includes qualifications in the field of crafts or in the production or repair of various technical equipment. A student acquires a technical education by teaching and subsequently mastering technical subjects. (Kučerka, Kmec, 2017).

According to the Act on Universities, the Ministry of Education of the Slovak Republic publishes and administers the system of study fields of the Slovak Republic, based on which universities can only admit students to accredited study programs, i.e., j. programs that meet the standards of study programs in the fields of study included in the system. The study program clearly specifies and communicates the level of qualification that students acquire by successfully completing it, while the qualification corresponds to the relevant level of education according to the European qualification framework. Graduates of technical fields are therefore highly specialized professional employees who have highly specialized knowledge, skills, and abilities for the performance of a given technical profession.

In all these levels, an important role is played by the teacher and his forms and means of education, which he uses to achieve the set educational goals. Multimedia education, especially due to the development of digital technologies, has become very popular and is often used in the teaching of technical subjects. Although most models of multimedia learning focus on cognitive factors, as reported by Um, Plass, Hayward and Homer (2012), this form of learning can also influence positive emotions and attitude towards learning.

**The subject matter of the study. Multimedia cognitive learning theory**

The main representative of multimedia cognitive theory learning is Mayer, he is an American educational psychologist and professor of psychology at the University of California, Santa Barbara (UCSB), where he has been working since 1975. The multimedia cognitive theory learning tries to explain the processes that occur in the minds of students during meaningful learning from multimedia teaching. Mayer and Moreno (2003) define multimedia as the use of words and images (verbal and visual). The theory has clear implications for the design of teaching to facilitate multimedia learning, especially for how to cognitive apparatus. Mayer's cognitive theory of multimedia learning is based on three assumptions about how people process information: the dual-channel assumption, the limited-capacity assumption, and the active processing assumption.
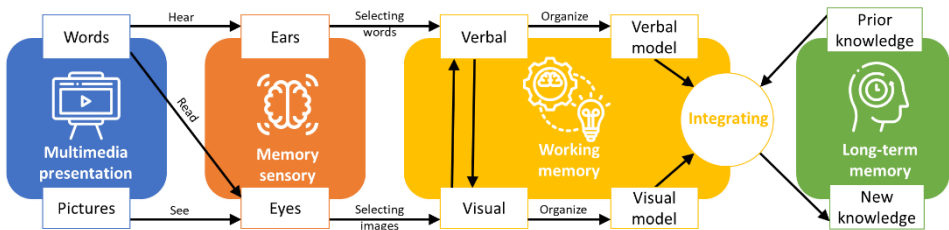


**Figure 1. Diagram of Mayer's cognitive processing events**

According to Mayer (2009a, p. 63), the dual-channel assumption dictates that "people have separate channels for processing visual and auditory information". The first is the visual-image channel, which processes images seen by the eyes (including words displayed on the screen). The second channel is the auditory-verbal channel, which processes spoken words. The limited-capacity assumption suggests that people have a fixed limit to the amount of information they can process at any given moment. The active processing hypothesis states that people do not learn by passively absorbing information. Instead, they must engage in active cognitive processes, namely identifying and selecting relevant material, organizing it into visual and/or verbal models, and integrating these new models with prior knowledge. The multimedia cognitive theory learning fundamentally argues against a "knowledge transfer" approach to learning in favor of a learner-centered "knowledge construction" model. He argues that students are not "empty vessels" waiting to be filled with information but must instead work to synthesize words and images into meaningful information that is stored in long-term memory.

**Research methodologies and tools. Cognitive load**

Mayer's overarching thesis is that people learn better when they use pictures and words together. An important question remains how to maximize the effec-

tiveness of multimedia messages based on the specifics of how people process information during learning. Mayer's theories reject multimedia learning as knowledge transfer (transplantation of information from instructor to student) and response reinforcement (enhancement of memorization through practice and hands-on methods). Instead, the theory embraces a knowledge-building perspective: "that multimedia learning is a sensory activity in which the learner tries to construct a coherent mental representation from the material presented" (Mayer, 2009a, p. 17). The focus of education, not only on technical subjects, is shifting from memorizing lessons and memorizing isolated facts to the systematic and deliberate development of versatile and functional literacy in accordance with the demands of society, which can be applied in everyday personal and social life and in fulfilling one's personal, educational, cultural, and social needs. The reason is that the breadth of acquired knowledge is no longer enough. Both the teacher and the student face more demanding goals: it is about the depth of learning, the ability to put things in context.

In connection with multimedia cognitive theory learning, it is also necessary to point out its limits, which are associated with cognitive overload. According to cognitive load theory, short-term or working memory has a limited capacity and can only efficiently process a few pieces of information at a time. If a person's working memory is overloaded, that person may not be able to process anything well, leading to poor comprehension, retention, and learning. (Sweller, 2011) One should be aware of three types of cognitive load: internal (related to the teaching content); germane (related to the activities students do); and external (everything else) (Nguyen, Clark, 2005). In each of these areas, the load on working memory needs to be minimized so that people can process information more efficiently and learn better. A closer examination of these theories and their interrelationship can be used to search for and determine the key principles of multimedia learning.

**Development (analysis of research results) Principles of multimedia learning with overload limitation**

Researcher Mayer in his review of thirty years of online education research (2018) states that students will be increasingly exposed to online learning, in formal and informal contexts, so the design of online teaching and multimedia learning will continue to be an important practical and theoretical challenge. This brief history review provides an example of applied cognitive psychology by focusing on the application of learning science to the practical problem of online instruction. Based on cognitive learning theories relevant to multimedia learning, such as cognitive load theory (Paas, Sweller, 2014; Sweller et al., 2011) and the multimedia cognitive theory learning (Mayer, 2009b, 2014), Mayer states three goals of instructional design for online and multimedia education:

1. Reduce extraneous processing – eliminate aspects of a lesson that prime the learner to engage in cognitive processing that does not serve the learning objective.

2. Manage essential processing – scaffold the lesson in ways that ensure the learner can process the relevant material.

3. Foster generative processing – include features in a lesson that prime the learner to exert effort to make sense of the material.

As can be seen in the overview mentioned above, Mayer's 30 years of research into techniques to reduce extraneous processing has created a substantial research base and yielded several research-based design principles relevant to online and multimedia learning:

1. Principle of coherence – states that people learn best when extraneous, distracting material is not included. It is necessary to use only the information that the student needs. And most often that means simple text and simple visuals that are directly related to the learning topic.

2. Signalling principle – basically means that people learn best when they are shown exactly what to pay attention to on the screen. If there is a lot of information on the screen, the student cannot distinguish which is the most important.

3. Redundancy principle – this principle suggests that people learn best with narration and graphics, as opposed to narration, graphics, and text. The theory is that if you already have narration and graphics, the text on top is just redundant information. And that can be overwhelming for a student.

4. Principle of spatial contiguity – this is about the actual space between text and visuals on the screen and states that people learn best when the relevant text and visuals are physically close together.

5. Principle of temporal contiguity – states that people learn best when matching words and visuals are presented together rather than sequentially.

6. Segmentation principle – states that people learn best when information is presented in segments rather than in one long continuous stream. Mayer found that when students could control the pace of their learning, they performed better on memorization tests.

7. Pre-training principle – states that people learn more effectively if they already know some of the basics. This often means understanding basic definitions, terms, or concepts before starting to teach. And that makes intuitive sense.

8. Modality principle – states that people learn better from visuals and spoken words than from visuals and printed words. It simply means that if there are visuals and too much text, students will be overwhelmed. The

9. Multimedia principle – states that people learn better from words and pictures than from words alone. This principle is kind of the basis of all of Mayer's principles, that images and words are more effective than words alone.

10. The voice principle – states that people learn better from a human voice than from a computer voice. While Siri and Alexa are close, there is no substitute for the human voice. It is important to note that the studies are still rather preliminary for the voice principle. But it still makes sense to use a human for your voiceover.

## Conclusions

To be able to introduce effective curricular reforms in technical education, it is necessary to bear in mind that not only content changes are sufficient, but also changes connected with the forms and methods of teaching. Multimedia for learning refers to the process of building a mental representation from words and images in different contexts. They are designed to aid learning with tools that can be used in presentations, classroom or laboratory instruction, simulations, e-learning, computer games, and virtual reality, allowing students to process information in both verbal and visual form. For their effectiveness to be effective, it is necessary to eliminate possible aspects of cognitive overload in their design in the form of a design of multimedia teaching aids, to which specified design principles are applied, so that the student can independently acquire the knowledge he needs to acquire.

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