Interview with Richard E. Mayer about Multimedia Materials and Textbooks

Gregor Torkar[1]

This interview is part of the focus issue entitled "The Role of Textbooks in Teaching and Learning Processes", which aims to investigate the advantages and disadvantages of using a textbook, as well as ways of adapting textbooks that provide teachers with an opportunity to personalise teaching material and enable students to be more actively involved in the learning process. The interview was conducted online (exchanging emails back and forth between Ljubljana, Slovenia and Santa Barbara, California, USA) in February 2021.

GREGOR TORKAR: I am aware that it is very difficult and responsible task to summarise all of the important achievements of the distinguished professor Richard Mayer, who has contributed so significantly to the field of education. Working at the University of California, Santa Barbara, Richard Mayer has devoted his entire professional life to educational psychology, making significant contributions to theories of cognition and learning, particularly problem solving and multimedia learning. His best known contribution to the field of educational psychology is multimedia learning theory, which postulates that optimal learning occurs when visual and verbal learning materials are presented simultaneously. Professor Mayer has received numerous prestigious awards for his outstanding scholarly contribution. Most notably, he was awarded the E. L. Thorndike Award for professional achievement in educational psychology and he is the winner of the 2008 Distinguished Contribution of Applications of Psychology to Education and Training Award from the American Psychological Association. He was ranked as the most prolific educational psychologist in the world for the period 1997–2001, and he is the author of hundreds of publications, including more than twenty books on education and multimedia.

Multimedia learning theory is a fundamental theory for the design and use of textbooks and other types of multimedia. Despite its modest length, this interview aims to point out some important directions related to ensuring the present and future quality of textbooks and other educational materials.

---

1   University of Ljubljana, Faculty of Education, Slovenia; gregor.torkar@pef.uni-lj.si.

GREGOR TORKAR: Distinguished Professor Richard Mayer, I am very privileged to have the opportunity to talk to you about your multimedia learning theory, which is a world-renowned and, above all, very effective educational theory. However, I would like to ask you first, if you don't mind, to begin with a few words about yourself and the professional path that led you to educational psychology.

RICHARD E. MAYER: Thank you, Professor Torkar, for your kind words. My professional path involves receiving a BA degree in psychology from Miami University (in Oxford, Ohio) and a PhD degree in psychology from the University of Michigan (in Ann Arbor, Michigan). After graduating, my path took me to a teaching position in the Psychology Department at Indiana University (in Bloomington, Indiana) for two years, followed by my move to the University of California, Santa Barbara, where I have served on the faculty for more than 40 years. My research focus has always been on the issue of how to help people learn in ways so that they can take what they have learned and apply it to new situations. My curiosity about this issue of how to promote transfer is what led me to the field of educational psychology.

GREGOR TORKAR: Let me start now with some basic questions about the multimedia learning theory that you break down in such detail in your books, especially in Multimedia Learning (2020) and The Cambridge Handbook of Multimedia Learning (2014). In the introduction to your book Multimedia Learning, you wrote that you explore ways that go beyond purely verbal learning. What exactly is multimedia learning and what do all the principles of instructional design (for example, coherence, signalling, redundancy, pretraining, segmenting, modality, personalisation, etc.) actually contribute to learning and teaching?

RICHARD E. MAYER: Multimedia learning is learning from words and graphics. The words can be spoken or printed; the graphics can be static (e.g., photos, drawings, charts, etc.) or dynamic (e.g., video or narration). I became interested in multimedia learning when my lab repeatedly found that people performed better on a transfer posttest when they had studied a lesson that included words and graphics rather than words alone. For example, we found better transfer test performance for students who saw an animation while they heard a narration describe how a bicycle tire pump works, rather than for students who only listened to the narration. In 13 experiments, we consistently found this pattern, with a median effect size greater than 1. We call this the multimedia principle: people learn better from words and graphics than from words alone. In trying to better understand how to optimise multimedia

learning, we found that not all multimedia instructional messages are equally effective. For example, in series of experiments, we found that people learn better from multimedia lessons when extraneous words and graphical elements are eliminated (i.e., coherence principle), when key words or aspects of graphics are highlighted during instruction (i.e., signalling principle), and when printed words are placed next to the part of the graphic they refer to (i.e., spatial contiguity principle). These techniques seek to reduce extraneous processing, which is cognitive processing that does not support the instructional objective and wastes precious processing capacity that could have been used for deeper learning. In another series of experiments, we found that people learn better from multimedia lessons when the lesson is presented in bite-size segments paced by the learner (i.e., segmenting principle), when students receive training in the names and characteristics of the key concepts before the lesson (i.e., pre-training principle), and when the words are spoken rather printed on the screen (i.e., modality principle). These techniques seek to manage essential processing, which is cognitive processing aimed at representing the core material in working memory. Finally, another series of experiments showed that people learned better when the words in a multimedia lesson are presented in conversational style rather than formal style (i.e., personalisation principle) and when the instructor engages in appropriate gesture, facial expression, body stance and eye gaze during instruction (i.e., embodiment principle). These techniques seek to foster generative processing, which is cognitive processing aimed at making sense of the material.

GREGOR TORKAR: Which principles of instruction design do you think should be consistently considered when presenting educational material in textbooks? Could you somehow rank them? Is it even possible to rank the importance of such principles?

RICHARD E. MAYER: In our analyses of textbooks used in California schools, the most grossly violated principle was the coherence principle. Books contained beautiful colour graphics that were not related to the essential lesson, and included interesting but irrelevant stories that can be called seductive details. If I had to choose one principle for revising textbooks, I would start by choosing the coherence principle and seek to remove irrelevant and distracting elements so students can focus on learning the essential material in the lesson. Next, I would add the spatial contiguity principle, which calls for removing the captions on figures and moving the essential text (in segments) next to the corresponding part of the graphic. When a textbook has graphics with long captions or legends, that is an indication of poor design.

GREGOR TORKAR: If I may ask one more sub-question about the presentation of multimedia material. I am aware that you also work extensively on e-learning, presented in your books E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning (2016) and Computer Games for Learning: An Evidence-Based Approach (2014). In your opinion, what are the most important advantages and perhaps also disadvantages of digital learning materials?

RICHARD E. MAYER: A consistent theme in research on technology-supported instruction is that instructional media do not cause learning, but instead, instructional methods cause learning. It is not computers per se that cause learning, but rather how we use computers to guide instruction in line with theories of how people learn. Thus, digital learning materials can be successful when they employ effective instructional methods and can be unsuccessful when they employ ineffective instructional methods. There may be some instructional methods that are better afforded by computer-based platforms than by textbooks, such as using well-designed interactive simulations, videos and animations. However, learning is caused by using appropriate instructional design with media such as simulations or videos or animations.

GREGOR TORKAR: The digital environment now allows much greater flexibility and personalisation of multimedia materials compared to traditional printed textbooks and other multimedia materials. We can incorporate animations, simulations, digital games, augmented and virtual reality, etc. into the materials, just to name a few. The question arises as to when more and more is too much (i.e., the redundancy principle) in the learning process? How do you see this development in education?

RICHARD E. MAYER: You raise an excellent point. We have found that learning in virtual reality is emotionally arousing (as measured by heartrate and skin conductance), which can lead to distraction. A solution can be to stop the VR lesson at various points and ask the student to summarise what has been learned so far. We have also found that games have many attention-grabbing elements that can be distracting and result in poorer learning than with conventional media. A solution to this problem is to add instructional elements, such as a worksheet that the player uses throughout a game. In short, new media such as games, simulations and immersive virtual reality – although motivating – can create extraneous processing in learners, so I recommend incorporating instructional features (such as self-explaining or worksheets) that prompt learners to reflect on what they are learning.

GREGOR TORKAR: Your multimedia learning theory is a "living" theory, if I may say, and subject to the process of new developments and (re) interpretations. In scholarly works based on your theory, I perceive that some authors draw a line between multimedia materials consisting of pictures and written words, and multimedia materials consisting of pictures and spoken words in defining multimedia learning. I point out this distinction being aware of the visual/pictorial and auditory/verbal communication channels (Paivio's dual channels) and the limited capacity of information processing. You deal with this issue, for example, when explaining narrated animations and of course in your famous figure of the cognitive theory of multimedia learning. Do you think that the notion of multimedia material should only apply to multimedia material using separate communication channels (visual and auditory), as some scholars try to interpret the theory, or not?

RICHARD E. MAYER: I agree that we can make a distinction between book-based multimedia involving printed text and illustrations versus computer-based multimedia involving spoken text and video or animation. However, in general, our research shows that the same basic principles – such as multimedia, coherence, signalling, segmenting, pre-training and personalisation – apply to both venues.

GREGOR TORKAR: As one of the many researchers referencing your work, I am very curious to know how you actually developed multimedia learning theory? What were the initial pieces of the puzzle that later led you to multimedia learning theory? Did you start from existing theories and assumptions (e.g., Paivio, 1986; Baddeley, 1992) in formulating the empirical studies and theory, or were you initially guided by the possibilities that arose from advances in educational technology, which gradually led you to formulate the theory?

RICHARD E. MAYER: You are right in suggesting that the cognitive theory of multimedia learning was influenced by pre-existing theoretical ideas, including Paivio's dual code theory, Baddeley's working memory theory, Wittrock's generative learning theory, and, of course, Sweller's cognitive load theory.

GREGOR TORKAR: Reading your recent scientific articles, I came across a study (Lawson et al., 2021) on the emotional role of animated pedagogical agents in educational material. I would like to use this as a starting point for forming a question about the role of teachers in the process of designing and using multimedia materials. What is the primary role of teachers in the process of multimedia learning and how is their role changing with the introduction of

new technologies, such as the aforementioned animated pedagogical agents or virtual reality, which is also the subject of your research interests?

RICHARD E. MAYER: Teachers are central to the effective use of instructional materials, mainly in their roles in selecting, implementing and, in some cases, creating multimedia instructional materials. An understudied aspect of multimedia learning concerns contextual studies that examine how teachers effectively use multimedia materials in their classrooms.

GREGOR TORKAR: I would like to move away from the main topic slightly and try to include the book A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives (2001) in the textbook discussion. You are a co-author of this book, as well. What is your view of the relevance of a revised Bloom's taxonomy to education today? How is it relevant to designing or using multimedia materials?

RICHARD E. MAYER: I was honoured to be asked by David Krathwohl – the last surviving member of the team that wrote the original document in 1956 – to be part of a team to write a revision of Bloom's taxonomy that was published in 2001. I learned a lot about the thinking that went into Bloom's taxonomy and I came away with a greater respect for the science of assessment – the scientific study of determining what students have learned. In my opinion, the science of assessment is an essential component in educational psychology, along with the science of learning and the science of instruction. What I appreciate most about Bloom's taxonomy is the focus on measuring transfer (i.e., the ability to use the learned material) in addition to retention (i.e., the ability to remember the learned material).

GREGOR TORKAR: In the last three or four decades, the way we access information and the way we learn has changed a great deal. Information and communication technologies have changed the learning environment and will continue to do so. What are the most important changes over this period that you think have benefited education the most? And secondly, which current technological innovations hold the most promise for education and will continue to do so in the future?

RICHARD E. MAYER: We now have easy access to a vast amount of information as well as exciting new information formats (such as interactive simulations and virtual reality), which has important implications for education. Students need to learn an expanded form of literacy that includes what I call multimedia literacy – the ability to understand multimedia materials and to create multimedia materials that others can understand. Another aspect

of multimedia literacy is that students need to be able to work with multiple sources of information, make judgements of credibility and relevance, and integrate the information. In short, we need to equip students with the skills they need for the world of multimedia information.

In terms of the promise of technology for education, I am interested in how we can design effective instruction with interactive simulations, games, animated pedagogical agents and immersive virtual reality. Although these media have promise, research is needed to determine how best to take advantage of that promise.

GREGOR TORKAR: The last question is also directed to the future. I try to follow your work and that of your younger colleagues, and am impressed by your drive and fresh ideas. What are your current and future research goals and what are the educational challenges that we should all address in the near future?

RICHARD E. MAYER: We are currently examining how the emotional stance of instructors (both animated and human) affects learning, how games can be used to train cognitive skills, how to design effective academic learning in immersive virtual reality, and how to incorporate prompts for generative learning activities in online multimedia lessons. Much of our work involves international collaborators, as the search for multimedia design principles is clearly a global effort. This global effort is indicated, for example, by the author list of the forthcoming third edition of The Cambridge Handbook of Multimedia Learning. Thanks again for your thought-provoking questions.

GREGOR TORKAR: Thank you professor for your valuable contribution to the focus issue of the CEPS Journal.