The Annual Report of Educational Psychology in Japan
2002, Vol. 41, 27-29

準備委員会企画講演　2

Multimedia Learning

Richard E. Mayer
(Department of Psychology, University of California, Santa Barbara)

For purposes of our research, multimedia refers to the presentation of material using both words and pictures. The case for multimedia rests in 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. Multimedia messages can be described in terms of the delivery media (e.g., amplified speaker and computer screen), presentation mode (e.g., words and pictures), or sensory modalities (e.g., auditory and visual). The process of multimedia learning can be viewed as information acquisition (in which multimedia messages are information delivery vehicles) or as knowledge construction (in which multimedia messages are aids to sense making). Three possible learning outcomes are no learning (as indicated by poor retention and poor transfer performance), rote learning (as indicated by good retention and poor retention performance), and meaningful learning (as indicated by good retention and transfer performance). Meaningful learning outcomes depend on the cognitive activity of the learner during learning rather than on the learner's behavioral activity during learning.

A multimedia instructional message is a communication using words and pictures that is intended to promote learning. For example, a multimedia instructional message in a book could include printed text and illustrations, whereas a multimedia instructional message on a computer could include narration and animation. Examples of multimedia instructional messages include words and pictures intended to explain how lightning storms develop, how car braking systems work, and how bicycle tire pumps work.

Multimedia messages that are designed in light of how the human mind works are more likely to lead to meaningful learning that those that are not. A cognitive theory of multimedia learning assumes that the human information processing system includes dual channels for visual/pictorial and auditory/verbal processing, each channel has limited capacity for processing, and active learning entails carrying out a coordinated set of cognitive processes during learning. Five steps in multimedia learning are selecting relevant words from the presented text or narration, selecting relevant images from the presented illustrations, organizing the selected words into a coherent verbal representation, organizing selected images into a coherent visual representation, and integrating the visual and verbal representations and prior knowledge. Processing of pictures occurs mainly in the visual/pictorial channel, and processing of spoken words occurs mainly in the auditory/verbal channel; however, processing of printed words takes place initially in the visual/pictorial channel and then moves to the auditory/verbal channel.

Our research provides evidence for nine principles of multimedia design : multimedia, spatial contiguity, temporal contiguity, coherence, modality, redundancy, pre-training, signaling, and personalization. For each, I provide a statement of the principle, a theoretical rationale, and a summary of empirical evidence based on research conducted in our laboratory at the University of California, Santa Barbara.

Multimedia Principle : Students learn better from words and pictures than from words alone. *Theoretical Rationale* : When words and pictures are both presented, students have an opportunity to construct verbal and pictorial mental models and to build connections between them. When words alone are presented, students have an opportunity to build a verbal mental model but are less likely to build a pictorial mental model and make connections between the verbal and pictorial mental model. *Empirical Rationale* : In 11 out of 11 tests, learners who received text and illustrations or narration and animation performed better on transfer tests than did learners

who received text alone or narration alone, yielding a median effect size of 1.39.

Spatial Contiguity Principle : Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen. *Theoretical Rationale* : When corresponding words and pictures are near each other on the page or screen, learners do not have to use cognitive resources to visually search the page or screen and learners are more likely to be able to hold them both in working memory at the same time. When corresponding words and pictures are far from each other on the page or screen, learners have to use cognitive resources to visually search the page or screen for corresponding words and pictures. Thus, learners are less likely to be able to hold them both in working memory at the same time. *Empirical Rationale* : In 5 out of 5 tests, learners performed better on transfer tests when corresponding text and illustrations were placed near each other on the page (or when corresponding on-screen text and animation segments were placed near each other on the screen) than when they were placed far away from each other, yielding a median effect size of 1.12.

Temporal Contiguity Principle : Students learn better when corresponding words and pictures are presented simultaneously rather than successively. *Theoretical Rationale* : When corresponding portions of narration and animation are presented at the same time, the learner is more likely to be able to hold mental representations of both in working memory at the same time, and thus, the learner is more likely to be able to build mental connections between verbal and visual representations. When corresponding portions of narration and animation are separated in time, the learner is less likely to be able to hold mental representations of both in working memory at the same time, and thus, less likely to be able to build mental connections between verbal and visual representations. *Empirical Rationale* : In 8 out of 8 tests, learners performed better on transfer tests when corresponding portions of animation and narration were presented simultaneously rather than successively, yielding a median effect size of 1.30.

Coherence Principle : Students learn better when extraneous material is excluded rather than included. The coherence principle can be broken into three complementary versions : (1) Student learning is hurt when interesting but irrelevant words and pictures are added to a multimedia presentation, (2) Student learning is hurt when interesting but irrelevant sounds and music are added to a multimedia presentation, and (3) Student learning is improved when unneeded words are eliminated from a multimedia presentation. *Theoretical Rationale* : Extraneous material competes for cognitive resources in working memory and can divert attention from the important material, can disrupt the process of organizing the material, and can prime the learner to organize the material around an inappropriate theme. *Empirical Rationale* : In 11 out of 11 tests, learners who received concise multimedia presentations performed better on tests of transfer than did learners who received multimedia messages that contained extraneous material, yielding a median effect size of 1.11.

Modality Principle : Students learn better from animation and narration than from animation and on-screen text. *Theoretical Rationale* : When pictures and words are both presented visually (i.e., as animation and on-screen text), the visual channel can become overloaded. *Empirical Rationale* : In 12 out of 12 tests, learners who received narration and animation performed better on tests of transfer than did learners who received animation and on-screen text, yielding a median effect size of 1.13.

Redundancy Principle : Students learn better from animation and narration than from animation, narration, and on-screen text. *Theoretical Rationale* : When pictures and words are both presented visually (i.e., as animation and on-screen text), the visual channel can become overloaded. *Empirical Rationale* : In 2 out of 2 tests, learners who received narration and animation performed better on tests of retention than did learners who received animation, narration, and on-screen text, yielding a median effect size of 0.84.

Pre-training Principle : Students learn better when training on components precedes rather than follows a message. *Theoretical Rationale* : When students receive pre-training they are able to build mental models of how each part works (i.e., component models), thereby reducing cognitive load when they must build a mental model of the system (i.e., causal

model) from the multimedia message. *Empirical Rationale* : In 3 out of 3 tests, learners who received pre-training before the multimedia message performed better on tests of transfer than did learners who identical training after the multimedia message, yielding a median effect size of 1.39.

Signaling Principle : Students learn better when training is signaled rather than non-signaled. *Theoretical Rationale* : When students receive signaling they are better able to allocate attention to relevant material, thereby reducing cognitive load. *Empirical Rationale* : In 2 out of 2 tests, learners who received signaling performed better on tests of transfer than did learners who did not, yielding a median effect size of 0.60.

Personalization Principle : Students learn better when words are presented in conversational style rather than formal style. *Theoretical Rationale*: When students receive words in conversational style, they are more likely to accept the computer as a social partner and therefore try harder to comprehend the message. *Empirical Rationale* : In 5 out of 5 tests, learners who received words in conversational style performed better on tests of transfer than did learners who received words in formal style, yielding a median effect size of 1.55.

Our research also shows that some of these effects are stronger for low prior knowledge learners than for high prior knowledge learners and some are stronger for high spatial ability learners than for low spatial ability learners. Overall, research on multimedia learning provides an exciting venue for educational psychology.

Notes

The author's mailing address is : Richard E. Mayer, Department of Psychology, University of California, Santa Barbara, CA 93106, USA. The author's email address is :

On September 8, 2001, the author delivered an invited presentation on "Multimedia Learning" at the Japanese Association of Educational Psychology (JAEP) in Nagoya.

This summary, which reflects the content of the address, is based on the following sources : (a) Mayer, R. E. (2001). *Multimedia learning*. New York : Cambridge University Press, and (b) Mayer, R. E. (in press) Multimedia learning. In B. H. Ross (Ed.), *The Psychology of Learning and Motivation*. Vol.41. San Diego : Academic Press.