5 Principles of Multimedia Learning

5.1 Multimedia Learning: Expectations and Reality
5.2 Cognitive Theory of Multimedia Learning
5.3 Mayer's Principles of Multimedia Learning (Cont'd.)
5.4 Further Theories of Multimedia Learning

References:


Summary CTML

• Cognitive Model of Multimedia Learning
  – Based on dual coding assumption (verbal and pictorial channels)
  – Stressing capacity limitations of working memory
• Multimedia Principle:
  – Cognitive load on knowledge construction processes can be reduced by multicodality
• Spatial and Temporal Contiguity Principle:
  – Learning is improved if corresponding codes in multicodal messages are presented together in time and space
• Modality Principle:
  – Multimodal messages, in particular using spoken instead of written narration, can improve learning
• Coherence Principle:
  – “Extra” informations (words, pictures, sounds, music) hurts learning
• Redundancy Principle:
  – Several encodings of the same information interferes with learning (in particular, parallel presentation of identical text, written and spoken)
Results on Animation?

• Animation is "the process of generating a series of frames containing an object or objects so that each frame appears as an alteration of the previous frame in order to show motion" (Baek/ Layne 1988)

• "a series of varying images presented dynamically according to user action in ways that help the user to perceive a continuous change over time and develop a more appropriate mental model of the task" (Gonzalez 1996)

• Separate interaction and animation:
  – Sequence of frames creating impression of motion (possibly without interaction)
  – User control (interaction)
  – Two types of user control (interaction):
    » Control over pace and direction of frame succession (VCR-like control)
    » Capability to act on objects appearing within frame
PLEASE STOP PLAYBACK NOW AND FOLLOW THESE INSTRUCTIONS!

We want to study the everyday skill of tying shoe laces!

Have a look at these three online resources on how to tie shoe laces:

Number 1: How to tie a Shoe Lace in 1 Second
https://www.youtube.com/watch?v=wMuNjnNyaiA

Number 2: How to Tie Shoe Laces Step By Step
https://www.youtube.com/watch?v=MhXXYuCpVwc

Number 3: Ian's Shoelace Site
http://www.fieggen.com/shoelace/knots.htm

From which of these instruction sites did you learn best?
Experiments on Animations in Learning

• Rieber et al 1989:
  – Animated lesson for Newton's laws of motion does *not* lead to better comprehension for elementary school children

• Byrne, Catrambone, Stasko 1999:
  – Benefits of using animation are equivalent to the benefits of prompting learners to make predictions

• Hegarty et al. 2002:
  – Students studying animation with oral commentary do *not* perform better than those who study equivalent static graphics with written text
  – In both cases, performance was significantly improved by prediction questions

• Possible explanations:
  – Continuous animations miss clear phase pictures
  – Animations may be helpful for learners with low ability to mentally simulate the processes
QUESTIONS

• Do the results reported on the last slide relate to your experiences with the shoe lace experiment?
  – Were the continuous video presentations superior to the step-by-step drawings?
• Which of the animations studied in our example would you suggest to children to learn how to tie their shoe laces?
• **YOU MAY WANT TO PAUSE AND REPLAY PARTS OF THE VIDEO HERE. THIS IS OK AND RECOMMENDED.**
Individual Differences Principle

• Mayer (2001):
  – Design effects are stronger for low-knowledge learners than for high-knowledge learners
  – Design effects are stronger for high-spatial learners than for low-spatial learners

• Good instructional message:
  – Contiguous
  – Coherent
  – Modality efficient
  – Non-redundant

• Who benefits most from good design?
How Well Do Well-Designed Multimedia Resources Assist You In Learning?

- Have a look at the material on right.
- If your expertise level is low, and assuming you have to pass a test on meteorology soon:
  - Which one is more helpful?
- Same question, if your expertise level is high!
How does prior knowledge influence learning?

Theory A: Knowledge main effect
- Independent of design

Theory B: Knowledge as compensator

Theory C: Knowledge as enhancer

Experimental results: Tend to support theory B.
Expertise Reversal Effect

• Expertise reversal
  – Instructional technique is effective for dealing with novices
  – Becomes less effective when dealing with experts

• Examples:
  – Learning from worked examples vs. abstract descriptions
  – Variability in various exercises
  – Imagination of pre-learned knowledge

• Redundancy effect as explanation for expertise reversal:
  – Novices: Some explanatory material is essential
  – Experts: The same material becomes redundant!

• Other explanations for expertise reversal effect:
  – Zone of proximal development (material of adequate difficulty)
  – Flow experience (equilibrium between task and abilities)
Further Individual Learner Differentiations

• Field dependence
  – Field dependent learner:
    Holistic approach, typically interested in literature or history
  – Field-independent learner:
    Separate and analytic processing of information units, typically interested in mathematics and sciences
  – Ongoing studies...

• Verbalizer, Visualizer
  – Verbalizer:
    Prefers text for information presentation
    Learns well by hearing and talking
  – Visualizer:
    Prefers pictures for information presentation (combined with text)
    Learns well by looking and drawing
  – Mixed empirical results on influence on learning effectiveness
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References:


Modified Model of Multimedia Learning (Schnotz)

- Words
- Pictures
- Ears
- Eyes
- Auditive WM
- Visual WM
- Propositional Representations
- Mental Models
- Long-Term Memory (LTM)
- Cognitive Schemata
- Working Memory (WM)
- Sensory Memory (SM)
- Multimedia Presentation
- Verbal channel
- Pictorial channel

Filter
Cognitive-Affective Theory of Multimedia Learning CATLM (Moreno 2005)

Multimedia Presentation | Sensory Memory | Working Memory | Long-Term Memory
---|---|---|---
Words | Ears | Sounds | Verbal Model | Semantic Memory | Prior Knowledge
Pictures | Eyes | Images | Pictorial Model | Episodic Memory
Tactile | Olfactory | Gustatory | Selection | Organization | Integration

Motivational, affective and metacognitive processes
Stay Critical!

• Do you think the CTML theory is universally applicable?
• Can you find possible shortcomings in the methodology of how CTML was developed?
• May alternative and even contradicting theories be possible?
• **PLEASE STOP PLAYBACK AND TAKE A FEW MOMENTS TO THINK!**
Content Dependencies

• Comparison of different media (e.g. book vs. computer)
  – Applied to learning of historical facts vs.
    applied to learning a programming language

• Comparison of different codings (e.g. static picture vs. animation)
  – Applied to explanation of a mechanical clockwork vs.
    applied to explanation of learning theories

• Comparison of different modalities (e.g. visual vs. auditive)
  – Applied to unknown vocabulary (including pronunciation) vs.
    applied to architectural styles of churches

• Comparison of different degrees of interactivity
  – Applied to a mathematical/geometrical model vs.
    applied to a philosophical approach

• Combination of various aspects
  – Well/ill-adapted presentation of mathematical model vs.
    well/ill-adapted presentation of philosophical approach
Novelty Effect, Willingness to Suffer

• Novelty effect
  – Using innovative (unknown) media may lead to wrong conclusions
  – Some users have difficulties to adapt to the new media
  – Some users are fascinated by the new media
  – Long term effects may differ drastically from short term experiment results

• Willingness to suffer
  Example: Comparison of a learning game with a traditional lecture
  – Expectation about own contribution varies with chosen medium
  – Learners using the game expect they have to suffer less
Predictions, Test Adequacy

• Learners’ predictions
  – Well known effective pedagogical tool
  – How can we compare a book with an interactive presentation by keeping the same level in invoking learners’ predictions?

• Adequacy of tests
  – Do tests use the same modalities/codings as the learning material? (e.g. pictures vs. words)
  – What is the effect if the test stipulates a transfer between modalities/codings?
Learning Time

• Time to get acquainted with the new material
  – Sometimes limited to a few minutes
    (e.g. some of the Mayer et al experiments)
  – Sometimes without limitation

• What is learning time?
  – Independent variable (setting a limit)
  – Dependent variable
    (asking when the time was enough and recording the time)
  – Control variable/covariate
  – Not considered
  – Used for elimination of excess values

A covariate is a variable that is possibly predictive of the outcome under study.
Empirical Evidence (CTML)

- Do you know what the numbers (1 – 5) in the graphics from the last lecture actually mean?
- Typical subjects for Mayer et al.'s experiments are female college students.
  - Do you think this has an influence on the results reported?
Cognitive Flexibility Theory CFT (Spiro)

- Rand J. Spiro et al. (published 1988 - 1995)
- Over-simplification of complex information can hurt learning efficiency
  - Applicable mainly for low-structured and highly complex knowledge
  - Enable problem-based learning!
  - Follow a constructivist approach
- Recommendation: Multiple representations of knowledge
  - Unidimensional representations may lead to misunderstandings
  - E.g. textual explanation + several different illustrations
- Recommendation: Knowledge transfer
  - Let the learner transfer abstract knowledge to several concrete examples
  - Use examples of large variability
- Recommendation: Present full complexity
  - Do not isolate aspects of the knowledge too much
  - Introduce learners to complexity right from the beginning
- Recommendations are to some extent in contradiction to CTML!
Learning with Multiple External Representations

• Multiple External Representations (MER) of knowledge:
  – Diagrams, equations, tables, text, graphs, animations, sound, video, ...

• Perceptual variability helps in building abstractions
  – Cognitive Flexibility Theory (Spiro) and other research
  – Empirical studies prove that learners benefit from multiple representations

• Mixed results:
  – “Unfortunately, just as many studies have shown that learners can fail to benefit from these proposed advantages of MERs”
  – Main problem: Integration of information from more than one source
  – Similarities to Redundancy and Contiguity Principles of CTML

Shaaron Ainsworth 2006:
DeFT: a conceptual framework for considering learning with multiple representations.
DeFT = Design, Functions, Tasks
QUESTION

• Please think of concrete examples for *multiple representations* of learning material you have used already!
  – Text vs. pictures vs. video
  – Examples vs. conceptual explanations
  – Audio support or not

• **PLEASE STOP PLAYBACK AND TAKE A MOMENT TO THINK!**

• Does your personal experience tell you that multiple representations may be helpful for learning?
Design Parameters in DeFT

• Number of representations
  – Multiple (two or more) representations can assist learning
    » Individual representation simple enough to be understood
    » Excessive number rarely helps

• Information distribution in multiple representations
  – Completely complementary information
  – Completely redundant information
  – Partially overlapping information

• Form of representations employed

• Sequence
  – Parallel or sequential presentation of MERs
  – Learner options: Switch, advance, add representation

• Translation support (between MERs)
  – Existence of support
  – Level (semantic, syntactic)
Functional Taxonomy of Multiple Representations

FUNCTIONS

- Complementary Roles
  - Different Processes
  - Different Information

- Constrain Interpretation
  - Constrain by Familiarity
  - Constrain by Inherent Properties

- Construct Deeper Understanding
  - Abstraction
  - Extension

- Strategies
- Tasks
- Individual Differences
Complementary Functions (of MERs)

• Individual differences
  – Learners are able to choose the representation which fits their learning style best
  – “Limited evidence” exists

• Task adequacy
  – Test performance is facilitated “when the structure of information required by the problem matches the form provided by the representational notation” (Gilmore & Greene 1984)
    – Example: Control panel device
      » Learners using tables and diagrams are better in identifying faulty components
      » Learners using procedures are better in identifying mispositioned switches
  – For multiple tasks, multiple learning materials can be helpful

• Strategy
  – MERs encourage learners to try more than one strategy
Constraining Functions (of MERs)

• One representation constrains interpretation of another representation
  – Learning benefits from existence of multiple representations
• Constraining by familiarity
  – Example:
    » Graph representation of a physical law: Unfamiliar and complex
    » Accompanying animation/simulation: Constrains interpretation, i.e. makes more concrete what the meaning is
• Constraining by inherent properties:
  – Example: Graphical representations are implicitly over-specific
    » Text: “the knife is beside the fork”
    » Picture: knife has to be placed either left or right of the fork
    » Using several representations can help to find the right interpretation
Constructing Functions (of MERs)

- Support for deeper understanding
  - Learners integrate information from different representations
- Abstraction
  - Learners construct references across MERs
  - Stimulation and feedback tool for abstractions
- Extension
  - Learners can transfer isolated previous knowledge (bound to one representation) into a larger conceptual framework
  - E.g. knowing about velocity-time graphs, extending to acceleration measure
- Relation
  - Knowledge about the relationship between representations is helpful in itself
  - Example: Formula vs. graph