

## **Evaluation of Multimedia Representation Tools In Mathematics**

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### **Introduction**

The purpose of this study is to develop a hybrid evaluation guideline for representation tools, especially in k-12 mathematics learning context. Incorporating aspects of learning and performance support, instructional design, usability, and cognitive load theory, the proposal guideline can be utilized for both design and evaluation. Existing e-learning evaluation models and guidelines were reviewed to identify specific features and components that can be applied to evaluate multimedia representation tools. Application of the guideline will be demonstrated using one of the multimedia mathematics representation tools developed by the Mathematics Education and Educational Technology programs at Purdue University.

### **Evaluating e-learning, instructional design, performance support, usability and cognitive load**

Evaluation can be defined as the process of making judgments regarding the appropriateness of some person, program, process, or product for a specific purpose (Shrock & Coscarelli, 2000). As several different forms of e-learning are used in instructional situation, e-Learning is defined as an instruction delivered on a computer by way of CD-ROM, Internet, or intranet with learning objectives, instructional methods and media elements to build new knowledge and skills (Clark and Mayer, 2003). Evaluating e-learning quality would occur as part of intervention design, development and implementation depending on the context. In a research context, it is necessary to determine if an e-learning course meets quality standards for validating the effectiveness of the course, which is accomplished in part by correlating quality indicators with learning outcomes.

Several researchers have proposed checklists or guidelines for e-learning as well as multimedia from various points of view: Horton's (2001) ten criteria for evaluation and scoring mechanism of e-learning; Merrill's (2001) five star rating for evaluating tutorial or experiential (simulation) courseware; Reeves's (1997) fourteen pedagogical dimensions of computer-based education (CBE); Nielson's (1994) heuristic usability evaluation; Schaffer and Overcast's (2001) solution design decision aid for designing online learning environment; and Clark and Mayer's (2003) e-learning course development and evaluation guidelines based on cognitive load theory (CLT).

### **Multimedia representation tools in mathematics**

Constructivism has taken a strong hold in many areas of education today and there is a variety of recommendations from numerous researchers attempting to articulate constructivist theory (Driscoll, 2000). Jonassen (2004) presents a cohesive set of principles for Constructivist-Learning Environments (CLEs), and describes different types of tools used in a CLE to support learning. The problem/task representation tool is one of these tools that can support a learner's knowledge construction through problem-solving activities especially in mathematics and science courses.

In mathematics, manipulative materials including multimedia representation tools are designed to elicit and express abstract ideas and often developed with authoring tools using animation and graphics. Recent studies conducted in mathematics instruction in k-8 grades found that the use of manipulative materials supported the development of connection between concrete and abstract thinking by attaching meaning and importance to mathematical experiences (Sowell, 1989; Suydam and Higgins, 1977).

A multimedia representation tool can be categorized as an e-learning program because it includes some of the features of e-learning as described by Clark and Mayer. However, it can be differentiated from other e-learning programs by its purpose, context and characteristics. Instead of including a certain sequence of instruction, practice and feedback or a test, it includes a manipulatable tool presenting a concept or visualizing a model which can be used in different problem-solving situations depending on the learning context. Due to the differences in characteristics, it is difficult to apply current e-learning evaluation models directly to evaluate these cognitive tools.

### **Proposed guideline for multimedia representation tools**

Six guideline categories, including learning and performance support, instructional design, technical issues, usability, motivation, and cognitive load are selected. Existing guidelines or applicable checklist are adapted or consolidated into each category as follows:

- *Learning and performance support:* Schaffer and Overcast's suggestions for designing online learning environment and

Gery's (1991) concept of designing Electronic Performance Support System (EPSS) are combined to check the appropriateness and flexibility of the tool for supporting the performance of learners and teachers.

- *Instruction design*: Horton's instructional design and content guidelines are combined with his checklists regarding the goal and purpose of the tool and its possibilities of utilization in teacher-guided instruction. The concept of Merrill's 5 star rating is also emphasized in this category.
- *Technical issue and motivation*: both are modified from applicable check points of Horton's guideline.
- *Usability*: Horton's guideline of using text of media, navigation and control are combined with Nielson's usability principles.
- *Cognitive load*: the checkpoints are mainly based on Mayer's (2001) seven multimedia design principles. It is also combined with the principles of using animation as an aid to multimedia learning (Mayer and Moreno, 2002), Horton's graphic and multimedia (media) guideline, and Nelson's aesthetic and minimalist usability design principles.

The application of this guideline will be demonstrated using one of the representation tools from the Digital Learning Environment (DLE) project for elementary and middle school students entitled Making Arithmetic Tools Hands-on (MATH) for Kids. The 'Fraction animation tool' was developed in Macromedia Flash. The goal of the tool is to get 4<sup>th</sup> to 6<sup>th</sup> graders be familiar with fraction addition and subtraction by utilizing four different representations of symbolic, written, divided squares, divided circles, counters, and arrows

### **Discussion and Conclusion**

The evaluation guideline will be validated through continued testing over the next six months. The results of these validation efforts will be reported in this presentation. Specifically, the guideline will be further validated for use with other types of cognitive and performance support tools. The evaluation guideline presented can be utilized by teachers to evaluate tools and products considered for use in teaching and learning activities; and also can be used for the developers or designers as a formative evaluation guideline during the development process.

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