Using Multi-Monitor Technology to Construct a Simultaneous Authoring and Synchronized Mathematical Teaching Aided System

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Abstract: The progress of computer technology has enabled an explosion in the visual ways of teaching presentation. In recent years, most educators present their instructional materials by using projectors primarily rather than chalkboards. Multimedia instructional presentation is the best approach for learners to construct meaningful knowledge and to build referential connections of mental representations. However, most teaching presentations today bind with a single monitor system which is difficult to present multiple documents or multimedia formats simultaneously if necessary. Another problem is that most authoring and presenting software supports multiple monitors poorly. Besides, the synchronization of multiple documents among multiple monitors during teaching presentation is worthy to be concerned. Therefore, the purpose of this research is to use a multi-monitor technology to construct a teaching aided system that supports and controls existing authoring software applications such as Microsoft PowerPoint, Microsoft Word, Microsoft Excel, Adobe Acrobat, etc. In multimedia presentation, the aided system also provides several multimedia formats: HTML, image and video. Based on the Cognitive Theory of Multimedia Learning, this aided system is realized to combine and support verbal and pictorial forms. Such as a scenario of mathematical teaching, educators can easily dispose the geometric interpretations and the algebraic expressions to help learners who build the referential connections of mental representations on two different monitors by using this aided system. In the scenario, the geometric interpretations displayed on one monitor represent the pictorial form, and the algebraic expressions displayed on the other monitor represent the verbal form. In addition, during multiple monitor presentation, this teaching aided system performs to be an event controller, and provides a synchronized control mechanism, such events as “Go to Next Page”, ”Go to Previous Page”, etc. The system can trigger directly most events.

1. Introduction

In traditional teaching, chalkboards are the most widely used medium in the instructional presentations in the classroom, especially in mathematical teaching [1] [2]. As with chalkboard, it’s inefficient to teach mathematical materials using handwriting during the lecture and it’s difficult to present animations or video in the classroom. In recent years, the progress of computer technology is encouraging the trend of teaching presentation via using projectors and laptops. Due to the limited capacity of human mind, the educators are not easy to remember all the presenting materials. Hence, instructional materials are almost prepared in advance by using authoring tools, such as Microsoft PowerPoint, Microsoft Word, Microsoft Excel, Adobe Acrobat, etc. Therefore, the performance of the teaching presentation can be greatly improved and controlled.

Computers are frequently used to display and edit large documents. As a result, information complexity creates this situation. Many documents being opened will generate many overlapping windows and large Windows taskbar buttons. While minimizing or restoring these windows which may be distracting some users, users may choose wrong windows. It is difficulty to present multiple documents or multimedia formats simultaneously with only a single display monitor.

An appropriate approach to solve the co-presentation problem is to use multiple channel distributed over multiple monitors or projectors. A teaching environment of using multiple monitors can effectively promote the teaching qualities and also improves knowledge construction of building mental representation for learners. An effective authoring and presenting support tool is an important component of the teaching aided system. It is built by using multi-monitor technology for the scenarios of mathematical teaching.

Our system is dedicated to c-Learning (classroom learning), that is, we design a system to let teachers can efficiently handle their classrooms. Our research reveals a significant technology to implement the theory of multimedia learning such that the future classroom can be possibly fulfilled. Especially, the spatial and temporal principles of multimedia learning are applied into our system and then the referential connection between figures and text (equations) can be achieved in front of our students, that is, teachers can easily present their mathematical teaching with this new science education technology. Also, teachers can interactively lead students to discuss and compare the figure and equation of skew lines.

2. Cognitive Theory of Multimedia Learning

Multimedia learning provides multiple modalities of information for learners, including speech, printed text, static graphics, animation and video. Richard E. Mayer defined multimedia as the presentation of material using both words and pictures [3]. The Cognitive Theory of Multimedia Learning, proposed by Mayer, provides empirical guidelines that help instructional designer to promote the meaningful learning. The theory is based on the following assumptions: *dual channel, limited capacity,* and *active processing*. These assumptions are summarized as follows [4].

Dual Channels Working memory separates information into two qualitatively different channels – one for visual form and one for auditory form [5] [6].

Limited Capacity Each channel of working memory has a limited capacity for processing information at one time [6] [7].

Active Processing Human constructs meaningful learning by selecting incoming information, organizing selected information and integrating selected information with other existing knowledge [8] [9].

Figure 2.1 shows the cognitive model of this theory [3]. A multimedia learning pipe from outside world to inside mind could be separated into four parts: Multimedia Presentation, Sensory Memory, Working Memory, and Long-Term Memory. Words and pictures represent the teaching materials designed by instructional designers. Mayer defined words as the material presenting in verbal form, such as using speech or printed text; and pictures as the material presenting in pictorial form, such as using static graphics or dynamic graphics. Sensory Memory provides as for verbal form or pictorial form to be kept as visual images or auditory images for a short time period. The arrow from Multimedia Presentation to Sensory Memory represents the word or picture to be registered in the eyes or ears.

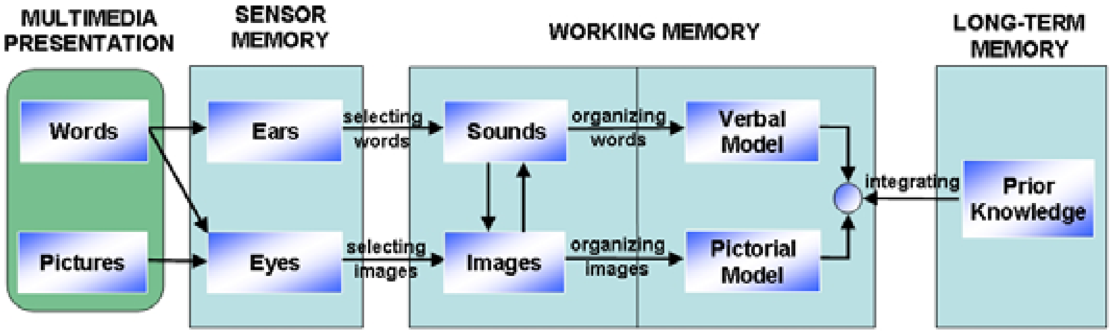

Figure 2.1 Cognitive Theory of Multimedia Learning

Mayer also presented seven principles which should be used in ways that are consistent with the Cognitive Theory of Multimedia Learning [3]. These principles are presented as instructions for how to design multimedia presentations. The seven principles are: Multimedia Principle, Spatial Contiguity Principle, Temporal Contiguity Principle, Coherence Principle, Modality Principle, Redundancy Principle and the Individual Differences Principle. According to the Spatial Contiguity Principle and Temporal Contiguity Principle [3], learners have the opportunity to build mental connections between verbal and pictorial representations while corresponding words and pictures are presented simultaneously.

Spatial Contiguity Principle While corresponding words and pictures are near each other on the page or screen, learners have the chance to hold them both in working memory simultaneously.

Temporal Contiguity Principle While corresponding words and pictures are presented simultaneously, learners have the chance to build mental connections between verbal and visual representations.

3. The Environment and Processes of Multimedia Learning

Many learners simply memorize formulas and participate in rote practice during mathematics problem solving. As a result of learners do not build the referential connections of mental representations while educators teach the mathematical formula, it's difficult for them to make sense of these formulas if they are altered in any way. We dispose the geometric interpretations and the algebraic expressions on two different monitors. According to the Cognitive Theory of Multimedia Learning [3], the synchronization mechanism of the teaching aided system plays an important role to help learners build the referential connections. By doing so, learners can infer the formula easily rather than memorize it. Figure 3.1 demonstrates the environment of multimedia learning.

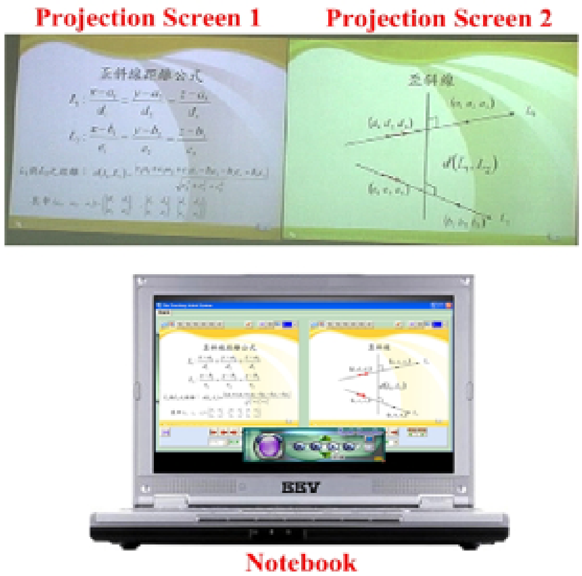

Figure 3.1 The environment of multimedia learning

In Figure 3.1, we use the Synchronized Event Controller to present two Microsoft PowerPoint documents simultaneously. The algebraic expressions displayed on projection screen 1 are in accord with the verbal form defined by the Cognitive Theory of Multimedia Learning; the geometric interpretations displayed on projection screen 2 are in accord with the pictorial form. The content of this mathematical teaching is to measure the distance between two skew lines. We separate the presented materials into three portions: spoken words, pictures, and on-screen words. We will specify how these presented materials are processed from start to finish according to the model of multimedia learning.

Figure 3.2 shows the path for processing of spoken words [3]. When educators explain the concepts of the algebraic expressions by narration (as indicated by the Words box under Multimedia Presentation), the sounds come into learner's ears (as indicated by the Ears box under Sensory Memory). The active processing stated in Section 2.4 can take place. From the Ears box to the Sounds box under Working Memory, the Sensor Memory selects parts of the incoming sounds in the learner's word sound base. The spoken words in the word sound base are raw materials. The Working Memory constructs internal connections to organize spoken words to verbal model. Eventually, the learner may use his prior knowledge of Long-Term Memory to help integrate the transition and may connect words with pictures.

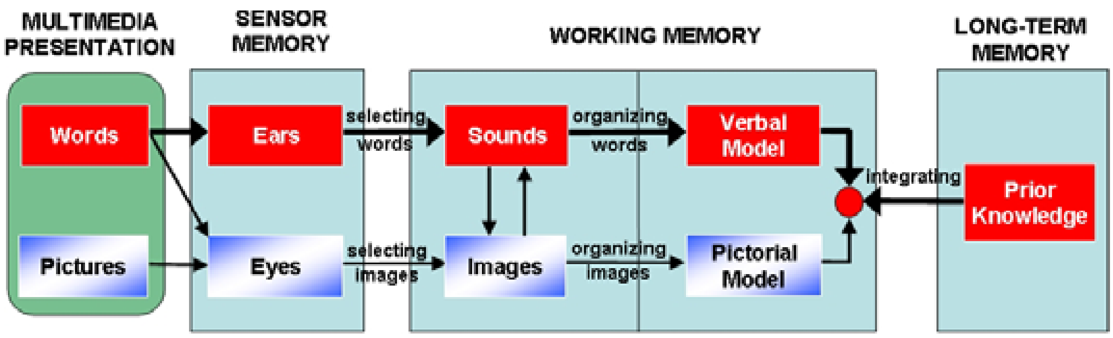

Figure 3.2 Processing of spoken words

When learner takes notice of the geometric interpretations, he processes the pictures mentally as show in Figure 3.3 [3]. We don't focus on how the path is traversed since the path for processing of pictures is entirely opposite to the path for processing of spoken words. We place emphasis on the mental model under Working Memory. While learner pays attention to the geometric interpretations, the Pictorial Model will be constructed and integrated with prior knowledge.

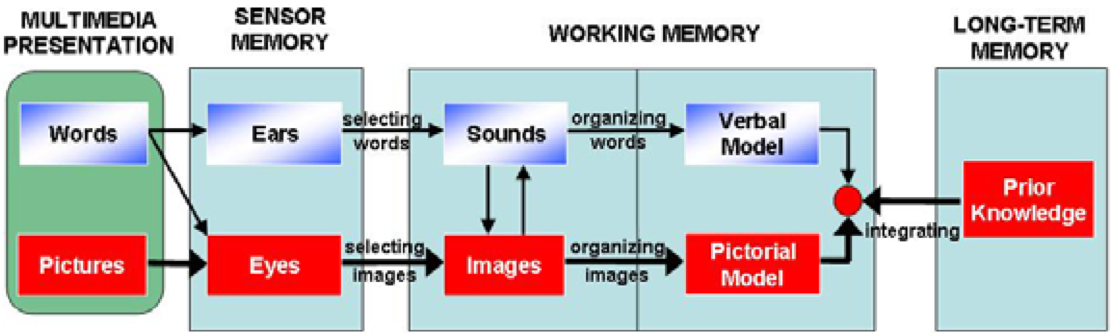

Figure 3.3 Processing of pictures

Figure 3.4 shows the path for processing of on-screen words [3]. The arrow from Words to Eyes represents that the learner looks at the algebraic expressions. Then he may pay attention to some of the incoming words and select them into working memory as indicated by the Images box. From Images box to Sounds box, the learner may mentally pronounce the on-screen words, and the words will be transfer into the word sound base. Once the words are represented in the verbal model, they are processed like the spoken words, as described above.

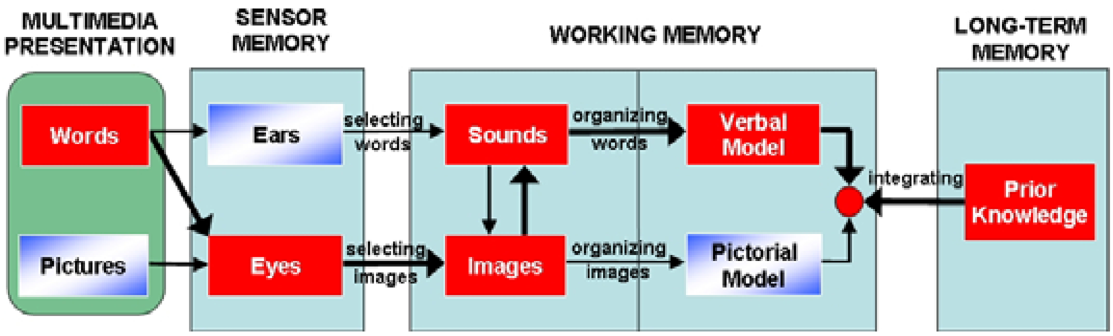

Figure 3.4 Processing of on-screen words

4. The Scenario of Mathematical Teaching

We will give a scenario of measuring the distance between two skew lines and simply explain how to infer the formula. Basing on the Spatial Contiguity Principle, the algebraic expressions were disposed on one monitor and the corresponding geometric interpretations were disposed on another monitor. We place them side by side rather than place the significant picture on next page. Due to the Temporal Contiguity Principle, we use the synchronization mechanism of the teaching aided system to present these relative words and pictures synchronously. By doing so, we can help learners build mental connections between verbal and pictorial representations.

Skew lines are defined as two or more lines which have no intersections but are not parallel. Skew lines can exist only in three or more dimensions. Figure 4.1 shows the algebraic expressions of two skew lines and the corresponding geometric interpretations. The formula of the distance between two skew lines is also displayed for learners. It's an arduous task for learners to memorize such a complicated formula. Therefore, we need to help learners develop the ability of math problem solving to use visual representation automatically and comprehend the concepts of the formula step by step.

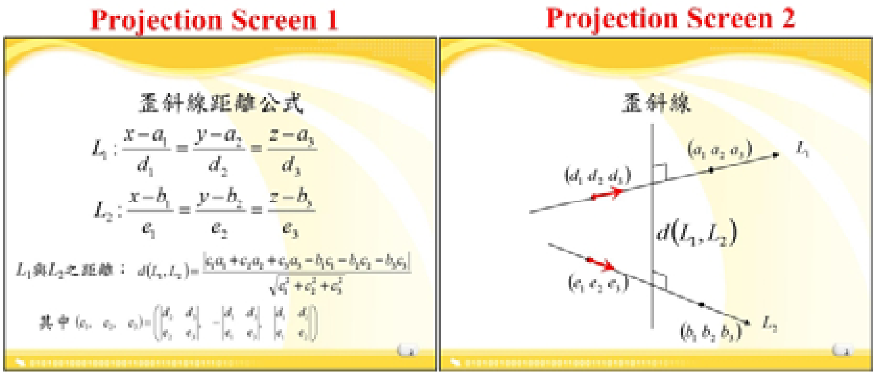

Figure 4.1 The formula of the distance between two skew lines

Educators have to infer the concepts of the formula and explain them with verbal and pictorial form. The first step is to calculate the direction vector which is orthogonal to the two skew lines as show in Figure 4.2. The concept of this step can be drawn out from the learner's long-term memory since they have learned before.

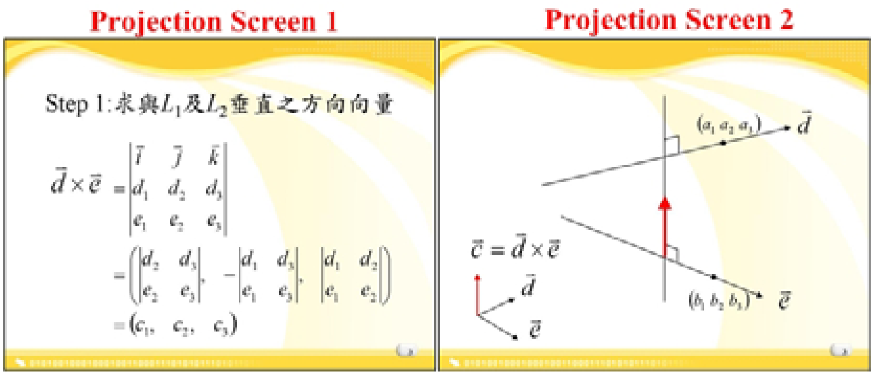

Figure 4.2 The first step of the formula

The second step is to build a plane contained a point of one skew line, and the normal vector of this plane must be equaled to the direction vector we calculated from the first step. In order to help learners build the referential connections, educators not only need to specify the algebraic expressions, but also have to explain these equations with the geometric interpretations, as show in Figure 4.3.

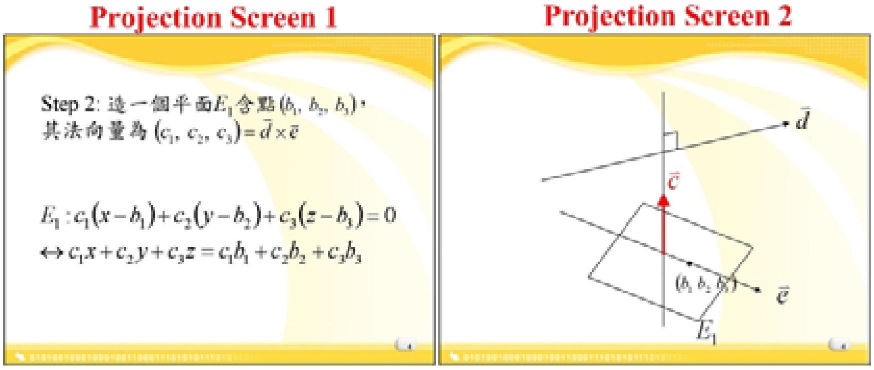

Figure 4.3 The second step of the formula

The final step is to get a point of another skew line, and to calculate the distance between the point and the plane. The concept of this step is also a prior knowledge under learner's long-term memory. Due to these steps, learners can construct the meaningful knowledge and build referential connections of mental representations.

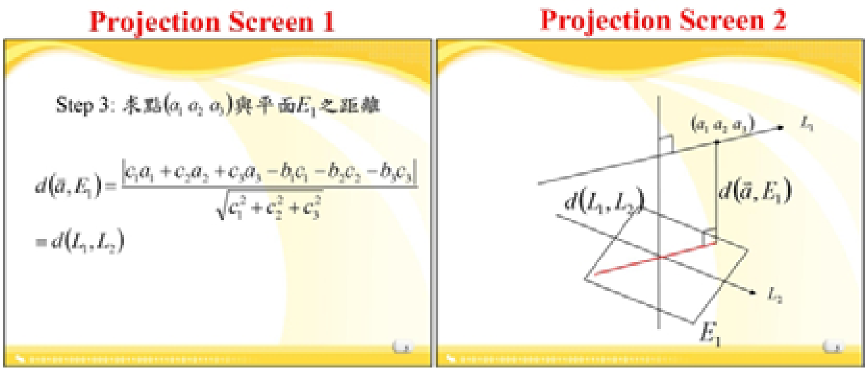

Figure 4.4 The final step of the formula

5. Conclusions and Future Researches

Due to the multiple modalities of instructional materials, educators require various authoring tools that support multiple formats. The teaching aided system supports four existing and in common use authoring tools: Microsoft PowerPoint, Microsoft Word, Microsoft Excel and Adobe Acrobat. In multi-monitor presentation, educators can handle seven major tools: Microsoft PowerPoint, Microsoft Word, Microsoft Excel, Adobe Acrobat, Web Browser, Picture Viewer and Video Viewer. Educators can concentrate on the thumbnails of projection screens without turning around to glance at those projection screens which are behind them.

Due to the Cognitive Theory of Multimedia Learning, the aided system supports verbal and pictorial form corresponding to these multimedia formats while in presenting. According to the Spatial Contiguity Principle and the Temporal Contiguity Principle, we place the algebraic expressions and the related geometric interpretations side by side and present them synchronously. Therefore, we can help learners build mental connections between verbal and pictorial representations.

We have not yet done the formal experiment for this teaching aided system. It's necessary for us to invite several educators to teach in the class by using this aided system. We need to design the teaching scenario which contains the experimental group and the control group. Learners have to write down the explanation they had learned and to generate as many solutions as possible to a series of problem-solving transfer questions.

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