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Date of publication: February 25th, 2012

To cite this article: Cowards, F.L.; Crooks, S.M.; Flores, R. & Dao, D. (2012). Examining the Effect of Gender and Presentation Mode on Learning from a Multimedia Presentation. *Multidisciplinary Journal of Gender Studies, 1* (1), 48-69. doi: 10.4471/generos.2012.03

To link this article: http://dx.doi.org/10.4471/generos.2012.03

GÉNEROS. Multidisciplinary Journal of Gender Studies Vol. 1 No. 1 February 2012 pp. 48-69

Examining the Effect of Gender and Presentation Mode on Learning from a Multimedia Presentation

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Abstract

Visual presentation modes in multimedia learning include pictures, video, and animations. Research also reveals cognitive differences between males and females (Halpern, 2004). Which one of the presentation modes is more effective? Can one of these presentation modes be more effective for a specific gender? This study aimed to investigate the role of gender and presentation mode in multimedia learning. Participants were 72 university students randomly assigned to one of the two different versions of a computer-based multimedia program (narration with animation vs. narration with static images). A 2 × 2 factorial design is created by crossing gender and presentation mode (animation vs. static image). Dependent measures consisted of a transfer and a comprehension test. The results showed a significant modality by gender interaction on the comprehension test. Females performed better studying animations, whereas males performed better studying static pictures. The results are interpreted in light of multimedia learning principles and studies in the area of gender differences in learning. The important contribution of this study is the suggestion that individual differences such as gender should be considered in multimedia learning.

Keywords: multimedia learning, gender issues, animation design.

2012 Hipatia Press
ISSN 2014-3613
DOI: 10.4471/generos.2012.03

Hipatia Press
www.hipatiapress.com

Introduction

It is true that the technological boom has a strong impact on teaching and learning activities. Nowadays, most classrooms have high-speed Internet connections that allow both teachers and and students to easily access online media. Technological innovation has effectively contributed to the teaching and learning activities, and students perceive the advantages of multimedia learning. There are numerous studies that confirm this idea (Berk 2009; Myer, 2003). In their study, Neo & Neo (2009) concluded that multimedia learning increased students' motivation to learn and contributed to the development of students' critical thinking skills and collaborative spirit. Their study included fifty-three university students and one faculty member from Malaysia.

Similarly, Lai, Tsai, and Yu (2009) studied how the multimedia English learning (MEL) system enhanced students' awareness of phonetics and pronunciation when students learned English. Their study included third-grade students (67 girls and 53 boys) from an elementary school in Taiwan and used the multimedia English learning (MEL) system for two forty-minutes sessions per week during a twelve-week period. Their results indicated that the MEL system promoted the students' phonemic ability. As Berk (2009) stated, "Multimedia auditory/verbal and visual/pictorial stimuli increase memory, comprehension, understanding, and deeper learning" (p. 5). Additionally, Dong & Li (2011) believe that multimedia teaching brings both teachers and students many advantages. In their reflection on multimedia teaching, they mentioned that using multimedia, such as pictures, sounds, and animations makes teaching more lively, interesting, and vivid.

The advantages of using multimedia in learning are obvious, however, there are also concerns about how to use this type of technology in learning. With the advancement of technology, multimedia learning can include various presentation modes such as words, pictures, static images, and animations. The use of more than one presentation mode is supported by the multimedia effect, which states that two modalities are better than one (Mayer, 1997; Mayer, 1999). This is also consistent with Paivio's (1986) dual-coding theory, which states that the concepts that are coded in both visual and verbal channels will be more likely to be remembered. However, concerns about overloading the processing and memory system have been well documented (Kalyuga, 2000; Mayer, Heiser, & Lonn, 2001). In a review, Mayer & Moreno (2003) stated that cognitive load is a central consideration in multimedia design.

Even though learner characteristics and multimedia design principles have been studied extensively (Jonassen & Grabowski, 1993; Mayer & Sim, 1994; Moreno & Mayer, 1999; Mayer & Massa, 2003), few studies have considered how these two research areas may interact to affect learning (Riding & Grimley, 1999; Grimley, 2007; Flores, Coward, & Crooks, 2011). This study focused on the influence of one learner characteristic, gender, and examined if one of the presentation modes is superior to the other. Specifically, we wanted to examine the relationship between gender and two presentation modes, animation versus static images.

Multimedia Learning

Richard Mayer & Roxana Moreno (2003), as the leading researchers in this area, defined multimedia learning as "learning from words and pictures…. The words can be printed (e.g., on-screen text) or spoken (e.g., narration). The pictures can be static (e.g. illustration, graphs, charts, photos, or maps) or dynamic (e.g. animation, video, or interactive illustration)" (p. 43). According to Baddeley's (1992) model of working memory, working memory contains two sub-systems, one for processing pictorial/visual information and another for processing acoustic/verbal information. In addition, each system has limited capacity, meaning that only a limited amount of cognitive processing can take place in either the visual system or the verbal system at any given time. Therefore, presenting textual information visually (as on-screen text) in conjunction with illustrations is purported to overload the visual subsystem of the learner due to the need to process both pictorial and textual information within the same memory subsystem. Consequently, many researchers have explored the type of multimedia instructional design that is sensitive to cognitive load (Mayer, Heiser, & Lonn, 2001; Tabbers, Martens, & van Merrienboer, 2004).

Mayer (2001, 2009) extended cognitive load theory with his cognitive theory of multimedia learning. Based on the cognitive theory of multimedia learning, learning is activated through five steps " (a) selecting relevant words for processing in verbal working memory, (b) selecting relevant images for processing in visual working memory, (c) organizing selected words into a verbal mental model, (d) organizing selected images into visual mental model, and (e) integrating verbal and visual representations as well as prior knowledge" (p.54).

Mayer & Moreno (2003) summarized the research in this area and outlined nine principles to reduce cognitive load in multimedia learning:

1. Modality effect: There is better learning when words are presented as narration rather than on screen text. When employing a bimodal format, textual information should be presented auditorily and pictorial information should be presented visually (Moreno & Mayer, 1999 & Mayer, 2001).
2. Segmentation effect: There is better learning when material is presented in learner-controlled segments rather than as a continuous presentation.
3. Pretraining effect: There is better learning when pretrainning is provided. Pretraining involves " a specific sequencing strategy in which components are presented before a causal system is presented" (p. 47), so that students know the names and behaviors of the components ahead of the time.
4. Coherence effect: There is better learning when interesting but irrelevant material is excluded.
5. Signaling effect: There is better learning when multimedia presentation includes signals on how to process the learning materials.
6. Spatial contiguity effect: There is better learning when printed words and the corresponding visual images such as static images or animations are placed near each other.
7. Redundancy effect: There is better learning when words are presented as narration rather than as narration and on-screen text. This is to eliminate an unnecessarily duplication of essential and relevant materials.

8. Temporal contiguity effect: There is better learning when narrations and visual images such as static images or animations are presented simultaneously rather than successively.
9. Spatial ability effect: There is better learning when we individualize the design by matching high-quality multimedia design with high-spatial learner. It is noted that low-spatial learners may not be able to take advantages of simultaneous presentations because they must devote much more cognitive processes to hold mental images than a high-spatial learner.

The design of the presentations in the current study follow these principles to reduce cognitive load, but does one of the two presentation modes perform better than the other?

Animation versus Static

Animation has become a popular design feature in multimedia learning. Studies have shown that animated visuals facilitate students' learning and comprehension more than static images (Lin & Dwyer, 2010; Lin, 2011; Parette, Hourcade, & Blum, 2011). The findings in Lin & Dwyer (2010) and Lin (2011) showed the superior effectiveness of animated visuals over static visuals among undergraduate students. Animation motivates and improves students' learning performance. Similarly, in their research, Parette, Hourcade, & Blum (2011) found that using animation for teaching and learning activities has two main contributions: "to elicit the attention of the learner to important features of the lesson, and prompt the learner as appropriate to ensure correct responding" (p. 60). Specifically, they pointed out that PowerPoint applications like colors, pictures, animations, videos, and transitions make it easy for teachers to deliver knowledge to learners, especially, young learners and for learners to pay attention to the teaching (p.59). Another study using the subject of math found similar results. Taylor, Pountney, & Malabar (2007) conducted a study with undergraduate students majoring in Math to see if animated learning materials aid students' learning. Their research results showed that the students considered the animated learning materials "as being more useful than the equivalent static versions" (p. 259). The students perceived that animated animated learning materials facilitate their understanding of math concepts much faster than static images.

Animations have great appeal to students. However, research has shown mixed evidence regarding the effectiveness of animation over static images (Hoffler & Leutner, 2007; Walcutt, Gebrim & Nichonson, 2010). For example, Kim et al (2006), conducted a research on 101 fourth grade students and 107 sixth grade students from a public elementary school in Seoul, Korea. They argued that animation is not always effective in teaching and learning as many researchers usually believe. In their research, they did not find any evidence to show that animation is more beneficial to learning than static images.

Animation and Cognitive load

Some argue that processing animated information imposes higher cognitive load due to the temporal limits of working memory, so animated instructional presentations do not seem to improve efficiency over static ones (Höffler & Leutner, 2007). Recall the modality effect mentioned earlier; this effect refers to instructional situations in which learning from words and pictures is improved when written text is replaced with spoken text. Evidence has shown that the modality effect is linked to reduced mental effort and to improved performance on retention, transfer, and matching tests (Ginns, 2005). The modality effect has also been validated in other instructional formats, such as multimedia presentations, computer games, interactive simulations, and virtual reality (Mayer, 2009). Although the evidence in support of the modality effect is clear, its theoretical underpinnings have been questioned. Mayer's (2009) cognitive theory of multimedia learning provides a popular framework for explaining the modality effect, which sometimes is referred to as the cognitive-resources explanation (Schueler, Scheiter, Gerjets, & Rummer, 2008a). This explanation states that there is a greater extraneous load placed within the visual system when processing written text (rather than spoken text) and pictures. According to Mayer's cognitive theory of multimedia learning, written text interferes with the cognitive process of organization in the visual system. In other words, presenting written text with pictures (e.g., animation) can overload the capacity of the visual system by requiring both text (at least initially) and pictures to be processed concurrently within the same system. However, presenting spoken text with pictures (e.g., narration with animation) allows spoken text to be processed in the auditory system and pictures to be processed in the visual system, thereby using the dual channel system more efficiently.

Researchers have recently begun to question the cognitive-resources explanation of the modality effect on theoretical grounds (Rummer, Schweppe, Furstenberg, Seufert, & Brunken, 2010; Schmidt-Weigand, Kohnert, & Glowalla, 2010). This explanation we found also falls short on explaining if animation is a more effective learning tool than static images when it is accompanied with a narration. Based on this explanation, animation should function in the same manner as the static images. We found the perceptual-resources explanation on modality effect to be more useful in discussing this issue. The perceptual-resources explanation says that modality effects occur due to limitations at the sensory-perceptual level, rather than limitations at the cognitive-processing level (as in the cognitive-resources explanation). According to Mayer's cognitive theory of multimedia learning, the transiency and/or complexity of instructions strain memory resources more during selection in sensory memory than during organization in the visual channel. This explanation is related to the split-attention principle in multimedia learning, which refers to the need for instructional designers to avoid instructional formats that require learners to split their attention between multiple sources of information (Ayres & Sweller, 2005).

The perceptual-resources explanation suggests that if visual information is too transient (as with many animations), learners will have a difficult time simultaneously perceiving written words and related moving pictures. Similarly, if visual information is complex, learners must use limited visual-perceptual resources to search for visual referents to written words. In other words, the learning decrement in these situations occurs at the sensory-perceptual level rather than the cognitive-processing level. Specifically, the learning problem relates to difficulties in getting information into working memory, rather than processing or capacity limitations within working memory itself. Likewise, we suspect that if visual information is complex and the transient nature of animation requires higher level of cognitive load, students with better verbal processing will be able to free up resources in sensory-perceptual level to focus on visual information.

Does animation impose higher level of cognitive load than static images due to its transient nature? Additionally, does animation present a challenge similar to the seductive details in a presentation as mentioned in research done by Harp & Mayer (1997, 1998)? Harp & Mayer indicated that conceptually irrelevant features in multimedia learning, although might increase emotional interest in learning, could result in poorer performance on tests of retention and transfer.

Gender Differences

Research has suggested that males and females differ in regard to certain mental abilities (Berk, 2005; Halpern, 2004). One major finding in gender cognitive differences suggests that males perform better in spatial–ability tests (Collines & Kimura, 1997; McGee, 1979; Halpern, 2004), while females perform better in verbal ability tests (Herlitz, Nilsson, & Backman, 1997). Some studies indicated the differences are caused by genetic and hormonal influences. However, others have pointed to the importance of sociocultural factors, such as training or cognitive strategies causing the differences (Baenninger & Newcombe, 1989; Kimura, 1999; Richardson, 1994). In addition, Quaiser-Pohl & Lehamann (2002) concluded that spatial ability in females is much more vulnerable to experiential and attitudinal factors, than spatial ability for males. This implies that males may be hard wired with spatial ability, while females need the influence of sociocultural factors to develop this ability.

Bosco, Longoni, & Vecchi (2004) suggested that spatial ability gender differences depend on the type of task performed. For instance, Vecchi and Girelli (1998) found that males outperformed females inactive tasks (e.g. manipulating and transforming visuo-spatial information), but not in passive tasks (e.g. memorizing visuo-spatial information). They speculated that it might also due to the different strategies they used in the tasks (Bosco et al., 2004). Similarly, Ruggiero, Sergi, & Iachini (2008) indicated that males excel at tasks which require spatial inference (i.e. ability to work out new spatial information from memory) and mental rotation and that males only outperform females in tasks which require active processing and strategic control of metric information.

While males possess superior spatial ability, research indicates that females have superior verbal abilities (Maccoby & Jacklin, 1974; Halpern, 2004). Halpern (2004) concluded that "compared with men, women have more rapid access to phonological, sematic, and episodic information in long term memory, and obtain higher scores on tests of verbal learning and the production and comprehension of complex prose." (p. 136) Tan, Okuyan, Bayraktar, & Akgun (2002) found that females outperformed males on the verbal components of an IQ test. In another study, Lezak (1995) found that females outperformed males in tasks that involving verbal fluency, a large vocabulary, naming, speed of response, mental organization, and search strategies. Furthermore, international studies on reading literacy have shown that boys scored below girls from 34 countries (Mullis, Martin, Gonzalez, & Kennedy, 2003). In the United States, boys score lower than girls on reading and writing tests from the elementary school years through the high school years (Berk, 2005; Halpern, 2000). These studies indicate that females are generally more effective than males in processing verbal information. The reason behind these results (i.e. biological or environmental influence) is inconclusive and the review regarding this issue is beyond the scope of our study. However, the gender differences in these studies resulted in our assumptions that the male participants in our study would then perform like the novice readers, whereas the female participants would perform in a manner similar to the expert readers.

Previous research further indicates that gender may influence the effectiveness of certain multimedia designs, even if these designs are based on commonly accepted principles. For example, Riding & Grimley (1999) compared the performance of 11-year-old boys and girls studying from either dual mode (pictures with corresponding speech) or single mode (pictures with corresponding text) presentations. Results from their study suggested that boys perform best from dual mode presentations, while girls performed best from single mode presentations. Similarly, in a study with undergraduate students, Flores, Coward, & Crooks (2011) found that males benefitted from a dual mode presentation of text (text with redundant speech), whereas females benefit from a single mode presentation (text only). These studies seem to confirm that females do have advantages over verbal tasks and are able to process verbal information much more effectively and efficiently than males. It is also seems reasonable that during multimedia learning females may need to expend less mental effort toward processing verbal information, thereby, freeing up cognitive resources for processing spatial information.

While previous studies may not explain why males and females differ in certain mental abilities, they do point to the importance of considering gender in the design of multimedia learning systems. If males are better at processing pictures and females are better at processing words, should this influence the design and effectiveness of multimedia instruction? Will males be favored with one certain design and females with another?

In this study, following the multimedia learning principles, the textual information was presented auditorily, and we used two presentation modes (narration with animation vs. narration with static image) to explore the following three questions:

1. Is the animation presentation mode superior to the static image presentation mode?
2. Does gender impact multimedia learning?
3. What is the relationship between gender and two presentation modes, animation versus static images?

Method

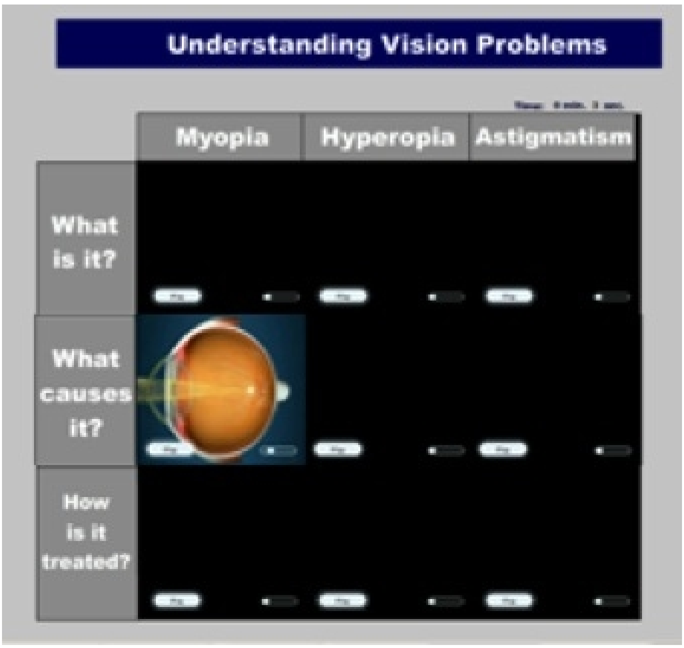
This study investigated the effects of gender and presentation mode on learning from a computer-based matrix graphic organizer. A 2 × 2 factorial design was created by crossing two presentation modes (narration with animation vs. narration with static image) and gender. Seventy-two university students (42 women and 30 men, mean age = 19.58) from a large southwestern university volunteered to participate in the study. Students were randomly assigned to one of the two presentation mode conditions. Dependent measures included a transfer test and a comprehension test.

Materials

The experimental materials consisted of a computer-presented 3 x 3 matrix describing three common vision problems (myopia, hyperopia, and astigmatism), their causes, and how they are treated.

The two experimental conditions (narration with animation vs. narration with static image) presented the same content at the same pace and both include a narration of the text. The difference between the conditions lay in the visual presentation mode. Students in the animation condition received animated sequences illustrating various dynamic processes associated with vision problems discussed in the text. Students in the static condition viewed static illustration of the same dynamic processes. For example, the animation condition would see an animated sequence of light entering the eye and focusing in front of the retina while the static condition would be presented with an image of light focusing in front of the retina due to the eye's shape (see Figure 1).

Figure 1. Sample screen from the static condition



Procedures

This experiment was conducted in a computer lab with 15 to 18 participants in each experimental session. Students were instructed to study the matrix and to use the row and column headings to help make connections between the information within the matrix. Participants had complete control over the sequence in which they visited each cell. Both experimental conditions (narration with animation & narration with static image) presented the same content at the same pace. They were allotted 7.5 minutes. After 7.5 minutes and a one-minute rest period, a comprehension test and a transfer test were administered.

Criterion Measures

Dependent measures included a comprehension test and a transfer test. The comprehension test consisted of 12 multiple-choice items, designed to assess the participants' ability to recognize basic facts from the material. The transfer test, on the other hand, was viewed as requiring more higher-order thinking than the comprehension measure. This assessment consisted of 10 multiple-choice items requiring individuals to use information provided in multiple cells and the matrix structure more fully.

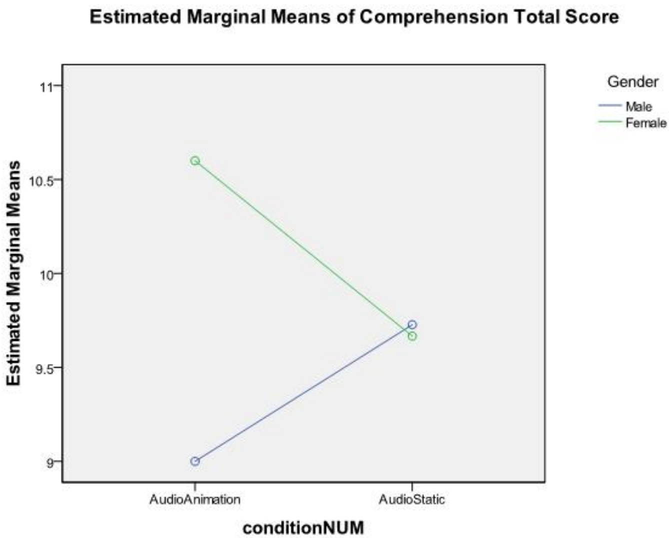
Results

All statistical tests were conducted using an alpha of .05. Estimates of effect size are reported using partial eta squared.

A 2 (narration with animation vs. narration with static image) × 2 (gender) ANOVA was conducted on the comprehension test scores. The main effect of gender was statistically significant, $F(1, 74) = 4.59$, $p < .05$, partial $\eta 2 = .06$. There was also a gender by presentation mode interaction, $F(1, 74) = 5.34$, $p < .05$, partial $\eta 2 = .7$ (see Figure 2). The main effect of presentation mode was not significant. The main effect of gender is ignored due to the significant gender by presentation mode interaction. The interaction suggests that female students comprehend material better than males when instruction includes animation, whereas no gender differences occur when instruction includes static images.

The ANOVA was not significant for either presentation mode or gender on the transfer test, nor was there a significant interaction for these variables.

Figure 2: Interaction between presentation mode and gender



Discussion

The results of this study answered our original research questions in the following way: (a) The animation presentation mode is not superior to the static image presentation mode, (b) Gender does play a role in multimedia learning, (c) Female students comprehend material better than males when instruction includes animation, whereas no gender differences occur when instruction includes static images. These findings are consistent with the perceptual-resources explanation of the modality effect. The perceptual-resources explanation asserts that modality effects occur in multimedia learning because the concurrent presentation of written text and pictures overburdens perceptual memory while the concurrent presentation of spoken text and pictures does not. Both of our conditions (narration with animation vs. narration with static image) follows that design principles and the results of our study indicated both have the same effect in students' learning.

In addition, the perceptual-resource explanation of the modality effect is concerned with overload in perceptual memory. The task of processing animation would demand more cognitive load than static images. Our study suggests that females in general are more effective in processing verbal information than males (Maccoby & Jacklin, 1974; Halpern, 2004; Tallberg et al., 2008), and need less mental effort toward processing verbal information, thereby, freeing up cognitive resources for processing spatial information. Consequently, they are more effective in processing dynamic images (i.e., animations) than males because they have more cognitive resources to devote to understanding visuospatial information.

Using cognitive principles of multimedia learning (e.g., modality principle) to create effective learning environments for students is important. It is also important to know if a given principle applies to all learners, and if not, how the principle should be modified to suit different learners. This study adds to the literature by showing that gender is another factor to consider in conjunction with expertise and modality in multimedia learning. Even though the exact nature of difference between male and females is not yet clear, it is of practical importance. It hints at an essential gender difference in information processing which also involves style. It further cautions the generalization of multimedia learning principles to all individuals. The current educational outcomes in the United States suggest great differences in achievement between boys and girls (Berk, 2005; Halpern, 2000). It would be beneficial for educator to learn more about gender interactions and their effects on multimedia learning.

Four limitations of the current study and some directions for future research should be noted. First, student performance was only measured immediately after the experiment; the extent to which the results apply to delayed performance is unknown. Future studies should investigate the robustness of the current findings by testing student performance under delayed conditions. Second, we did not find statistical significance on the transfer test performance but on the comprehension test, which does not always lend itself to multifaceted assessment approaches. Future research should explore how gender affects the transfer of learning with more comprehensive instructional programs. Thirdly, students' reading levels were not formally assessed. Based on the literature, we anticipated that males would act as novice readers, whereas females were expected to act as expert readers. While the literature has shown this to be true for the general population, this generalization may not have been true with our sample. Finally, The small sample size in the present study may have contributed to our non-significant findings on some criterion measures.

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