He or She: Does gender affect various modes of instructional visual design?

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Abstract

Learning with onscreen visual instruction environments (multimedia learning, interactive learning, etc.) is a growing phenomenon and its effectiveness has been supported by previous research. Although previous research emphasized gender as an important factor influencing information processing, possible factors related to gender and multimedia learning have not been given sufficient attention. From this perspective, this article addresses gender comparisons when the static versus animated modes of presentation are used. To investigate possible gender interactions with different modes of visual presentations, researchers developed two different types of instructional modules (static and animated). A total of 120 students (60 males and 60 females) participated in the study after being matched on relevant criteria. A MANOVA revealed a significant interaction effect between gender and mode of presentation. Females, compared to males, scored higher in the static visual presentation, but males in the animated presentation performed better than females in each of three post-tests that assessed identification, terminology, and comprehension domains. The main effect of gender was insignificant. Possible implications of these results are explained.

Keywords

gender, multimedia instruction, cognitive load, instructional visualization

Introduction

In the present scenario, it is unimpugnable that technology has been prevailing in every aspect of our lives, and conjointly, advancement of technology leverages our way of teaching, learning, and instruction. Nowadays, most often we see that in a classroom environment, students learn from computer screens with the self-learning condition, indicating a technological revolution amidst teaching and learning. However, learning with an onscreen, visual-instruction environment, such as multimedia learning and interactive learning, is a growing phenomenon, and its effectiveness has been established by previous researchers (Halder, Saha & Das, 2014). Likewise, a theoretical advantage of multimedia instruction has been found in various aspects such as: affecting student motivation, development of collaborative spirit, and critical thinking (Dong & Li, 2011). Though effectiveness of multimedia technology is conspicuous, unfortunately, design of the multimedia presentation is still lacking intuition. However, recent theories have emphasized the cognitive architecture of human memory and have intended to develop scientific aspects of multimedia design. One well-established cognitive science of multimedia design principles was oriented by Mayer (2001) in his Cognitive Theory of Multimedia Learning

(CTML). The theoretical architecture of CTML mainly emphasizes the design of verbal and pictorial representation on multimedia based visuals, such as dual channel assumption. Likewise, Baddeley (1992) empirically established that in the memory system one can acquire and process limited amount of information, or limited capacity assumption. Researchers also emphasized sense making and deeper cognitive processing for meaningful learning, or active processing assumption.

The above mentioned assumptions have been given as guidelines for an instructional designer to use for the development of instructional material. But astonishingly as yet, gender difference in multimedia learning has not been taken seriously, even though research establishes gender as an important factor influencing information processing in interactive visual instruction (Halder, Saha and Das, 2015). From this orientation a major question arises in this article- "Does gender effect different modes of presentation (static vs. animation)?" This article dexterously takes instructional multimedia into consideration in order to explore the effect of gender.

Review of Literature

Multimedia Instruction and Cognitive Load

A well-defined multimedia learning instruction is "learning from words and pictures…The words can be printed (on-screen text) or spoken (narration). The pictures can be static (illustration, graphs, charts, photos, or maps), or dynamic (animation, video, or interactive illustration)" (Mayer and Moreno, 2003). In his book, *Multimedia Learning*, Mayer (2001) describes a model. "How the Mind Works" shows how pictures and words are processed in our working memory. Mayer (2001) also argued that in multimedia learning active processing requires five cognitive processes: selecting words, selecting images, organizing words, organizing images, and integrating those processes that place demands on the cognitive capacity of the information processing system.

Mayer (2001) terms these as "cognitive load" which is a major challenge for instructors and instructional designers. Referencing the terms germane load, extraneous load and intrinsic load as defined by Sweller, Van Merrienboer, and Paas (1998), Mayer (2001) describes three kinds of cognitive load which occur when processing information from verbal and picture code: essential processing, incidental processing and representational holding. Mayer (2001) proposed essential processing in this cognitive process for stressing the need to make sense of the presented material as linked to germane load. Incidental processing refers to cognitive processes where design of the learning task may affect cognitive load, corresponding to the term extraneous load. Representational holding refers to: "cognitive processes aimed at holding a mental representation in working memory over a period of time" which is equivalent to the term, intrinsic load. Like Sweller and Chandler (1994), Mayer (2001) also proposed different guidelines to overcome cognitive overload. Hence, the underlying generalization, of the above theoretical discussion, shows that cognitive overload is a major challenge to processing information effectively (Grimley, 2007).

Gender Differentiation and Mode of Presentation (Static vs. Animation)

Research on visual instruction has reported that different modes of presentation of instructional material have a significant effect in learning outcomes (Lin, 2011). It has been found that animated visuals expedite learning outcomes and comprehension levels of students more than the static visual level (Lin, 2011). Conjointly, it is also found that an animated visual can increase self-motivation, and helps improve students' learning performance (Lin & Dwyer, 2009). However, emphasizing on mode of presentation and characteristics of instructional material, Parette Jr., Hourcade and Blum, (2011) discussed two major contributions of animated visuals, as compared with static visualization. "Animation elicit the attention of the learner to important features of the lesson, and prompt the learner as appropriate to ensure correct responding" (p. 60). These findings may conclude that presentation features of an animated visual such as: color, sound, video, animation, etc. may influence learner attention. Nevertheless, plenty of researchers in the field of visual instruction have explored the effectiveness of animation as compared to a static one. In their research, Taylor, Pountney, and Malabar (2007), found that animation is more useful and effective than static versions. Though previous research has found a positive effect of an animated visual over a static image the effect of gender differentiation has been seriously ignored. The pivotal factor of the present study is an attempt to diminish this gender gap.

Gender Differences and Information Processing

An important theoretical assumption can be put forward by the selectivity model of Meyers-Levy (1989) which stated that people process information in various ways from the environment. Additionally, this theory emphasized that gender differentiation in information processing is a pivotal factor influencing learning and academic achievement. The selectivity model proposes that males and females select various cues from the environment when processing information (Meyers-Levy, 1989). However, the selectivity model proposed that males are highly selective in the way they process information and use various heuristic devices that serve as surrogates for more comprehensive processing of information (Meyers-Levy, 1989). It is also stated that males typically lead to a reliance on subsets of available cues, rather than a comprehensive processing of all available cues. However, males are focused on highly available cues, often singular cues that eclipse detailed and/or inconsistent cues (Meyers-Levy, 1989). Females process information more comprehensively because they consider more subtle cues, along with those that are more focal. According to this model, females attempt to assimilate all available cues by engaging in "effortful, comprehensive, itemized analysis of all available information" (Darley & Smith, 1995, p.43). Comprehensive processing of all available cues may not be possible due to restrictions imposed by the context of the task or limitations of basic human processing (Halder, et al., 2015). Hence, it is maintained that the goal of the female information processor is comprehensive analysis of all available information rather than the use of heuristic devices.

A number of research studies support the premise that women more comprehensively process information than do men in the same task context (Bonomo, 2010). Barber, Dodd and Kolyesnikova (2009) found a significant relationship between gender and the ways in which males and females accessed and utilized information. The findings of this study lend support to the gender differences in information processing, as proposed by Meyers-Levy (1989).

All these theoretical and empirical evidences are of great significance for teaching-learning in a classroom situation. It is important for teachers, educators, psychologists, and instructional designers to keep in mind these basic facts, and accordingly, frame the course and employ suitable teaching methods and strategies to diminish or narrow down the gender specific differences in achievement and learning as much as possible.

Objectives of the Study

- To find out the interaction effect of visual instruction between gender and various modes of presentation (static vs. animation).
- To investigate the impact of gender in various knowledge domains (factual, conceptual, rules and principle knowledge).

Methodology of the Study

Sample and Sampling Procedure

The present study was conducted on the 120 students (60 males and 60 females, mean age 14.26 years and SD= 2.75) from different higher secondary schools in Kolkata. The majority of them belonged to lower middle class families, and their age ranged from 13-15 (mean age 14.26 years and SD= 1.75). Purposive random sampling was followed.

Inclusion Criteria for Participant Selection

- Sufficient fluency in English for reading text comprehension according to their school record.
- Scored 10, (median standard score based on pilot study), or greater in computer proficiency tests developed by the researcher.

Design of the Study

This study employed a post-test only, 2x3 factorial-experimental design. The two independent variables were types of instructional visualizations (static and animated), and gender (male and female). The dependent variables were three criterions post-tests, (identification, terminology, and comprehension), and measuring different learning objectives of the students, (factual knowledge, conceptual knowledge, and rules and principle knowledge).

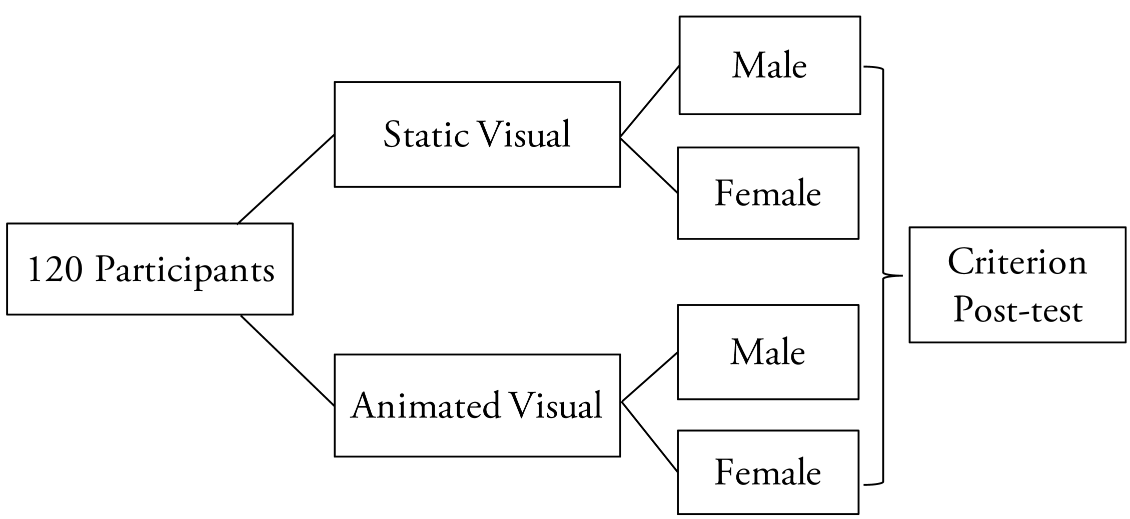

Figure 1. Graphical representation of design of research

Measurement Instrument

1. General Information Schedule: Comprised of student demographic information and socioeconomic status (parental education, income and occupation).

2. Computer Proficiency Test: Developed by the researchers to match experimental and control groups. The main objective of this test was to measure how efficiently participants were able to use different functions of the computer, especially mouse, keyboard, and computer screen. Reliability of this test was measured at .874.

3. Prior Knowledge Test (pre-test as covariate): Originally developed by Dwyer (1978), consisted of 36 multiple choice questions on human physiology. For the purpose of the study, this test was re-standardized and validated by Kuder-Richardson's estimation and by content validation. The objective of this test was to measure students' previous knowledge regarding human physiology. Reliability of the prior knowledge test was .89.

4. Criterion Measures Test (post-tests): The three criterion tests used in this study were developed by Dwyer (1978). Each test consisted of twenty multiple choice questions worth 1 point each.

5. Identification Test: The main objective of the identification test was to measure students' factual knowledge about content material used for the present study. Here, factual knowledge refers to specific disciplines such as: learning of the essential facts, terminology, details, and elements that students must know or be familiar with in order to understand the topic (the human heart) taught in this research. Reliability of the identification test was .86.

Example of an item: Arrow number five points to the ________________.

6. Terminology Test: The main objective of the terminology test was to measure the students' conceptual knowledge of the human heart. Here, conceptual knowledge refers the interrelationships among the basic elements within a larger structure that enable students to function together. Learning the classifications, categories, principles, and generalizations that students must know, or be familiar with in order to understand the topic taught (human heart). Reliability of the terminology test was .81.

Example of an item: _____ is (are) the thickest walled chamber(s) of the heart.

7. Comprehension Test: The main objective of the comprehension test was to measure students' rules and principles knowledge about the human heart. The rules and principles knowledge learning of students on the given module, refers to those cause and effect, or correlational relationships that are used to interpret events or circumstances. The learner is required to correctly identify and match those relationships. Reliability of the comprehension test was .80.

Example of an item: Which valve is most like the tricuspid in function?

Learning Material Used in the Study

Instructional Content Material

Instructional content material of this study was adapted from a color-coded, paper-based booklet developed by the researchers on the topic 'human heart' containing five units: 1) the heart's structure; 2) the veins and arteries; 3) the valves of the heart; 4) the blood flow through the heart; and 5) the phases of the heart cycle (Dwyer, 1978). This content was chosen as it allows the evaluation of different levels of learning objectives and was selected after a discussion with a subject expert.

Development of the Instructional Module in Different Modes

For the purpose of the study, two separate instructional modules were developed by the researchers:

Static mode of presentation. Under this condition, the above mentioned instructional content was framed in 20 different slides. Each frame introduced the structure and function of the human heart. The extreme left sides of each frame have text, and the right sides have a corresponding static graphical representation elaborating the text. Students need to read the text and compare it with the graphical image. In each frame, the user can hear audio that corresponds to the text (Figure 2).

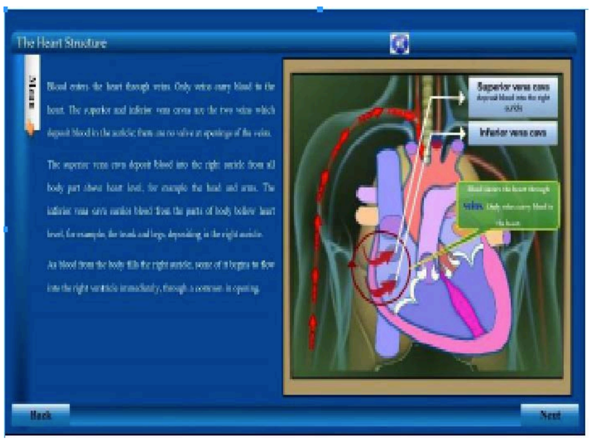

Figure 2. Static mode of presentation.

Animated mode of presentation. Akin to the static mode of presentation, in animation mode there was instructional content framing 20 different slides. Each frame introduced the learner to the structures and functions of the human heart presented in an animated video along with some particular buttons, (play, pause, and stop) (Figure 3).

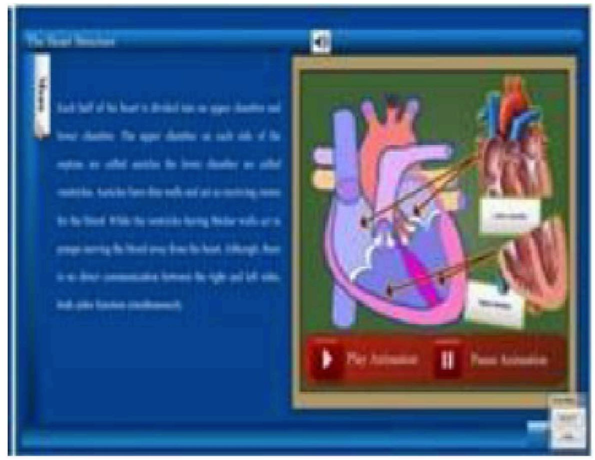

Figure 3. Animated mode of presentation.

Data Analysis and Interpretation

Preliminary Analysis: Prior Knowledge Test on Physiology

A variance of analysis (ANOVA) was conducted on the physiology test scores to determine if there was a significant difference among the treatment of groups on the prior knowledge test.

The result of the ANOVA analysis indicated that there were no significant differences among the treatment groups on the test, (*Table 1*) score F = 2.33, ρ= .13. The result indicated that the participants were approximately equal in their prior knowledge on the content material used in the study, therefore, any results of treatment effects would not be attributed to the differ-

Table 1
ANOVA result for tests of between-subjects' effects (prior knowledge test and three criterion tests)

Dependent Variable	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Identification Terminology Comprehension	82.30	3	6.33	2.33	0.13

ence in participants' prior knowledge.

Main Analysis

Results of MANOVA

As more than one dependent variable was used in conjunction with the independent variable, a multivariate analysis of variance (MANOVA) was conducted to analyze the main effect of gender and interaction effect between gender and different modes of visual instruction on students' learning of educational objectives (overall effect, factual, conceptual, and knowledge of rules and principles) through computer based instruction modes. SPSS for Windows was used for the analyses, and the criterion alpha level (0.05) was used for verifying statistical significance. The effect size may be interpreted according to the following guidelines provided by Cohen: (1988): $\eta\rho^2$= 0.01 is small, $\eta\rho^2$= 0.05 is medium, and $\eta\rho^2$= 0.13 is large. For MANOVA, the effect size was reported as $\eta\rho^2$ partial eta squared ($\eta\rho^2$), and is used as an estimate of variance in the dependent variables.

In *Table 2*, the multivariate analysis for the main effect of gender found no significant difference with Wilks' Λ value 0.99, F= 0.31, sig 0.81>0.5. However, an interesting result interaction between various visual instructions (static and animation) and gender was found to be significant with Wilks' Λ = 0.15, F = 6.69, ρ<.05.

The overall interaction between the mode of presentation and gender MANOVA Wilks' Λ value was statistically significant at the 0.05 alpha level, so Huck's recommendation regarding significant, subsequent exploratory analysis was conducted to further examine where the differences were located (Huck, 2004). The results of the exploratory follow-up analysis using MANOVA are presented in *Table 3*.

Subsequent univariate tests, or exploratory follow-up analysis using MANOVA, (*Table 3)*, indicated that different modes of presentation had a significant effect on three criterion tests (Identification test F = 5.21, ρ= .02 < 0.05, $\eta\rho^2$ = 0.04, Terminology test F = 6.00, ρ= 0.001 < 0.05, $\eta\rho^2$ = 0.04, Comprehension test F = 12.19, and ρ= 0.00 <0.05, $\eta\rho^2$ = 0.09). To further identify

Table 2

Represents analysis with all criterion tests (identification, terminology, and comprehension test) MANCOVA results using Pallai's Trace and Wilks' Lambda

Effect	**Tests**	**Value**	**F**	**Sig.**
Gender	Wilks	0.99	0.31	0.81
IV+ Gender	Wilks	0.15	6.69	0.00*
IV= Instructional Visualization (Static vs. Animation) *Mean difference significant at 0.05 level				

Table 3

Represents tests of between-subjects' effects

Effect	**Dependent Variable**	**F**	**Sig.**	$\eta\rho^2$
IV+ Gender	Identification	5.21	0.02*	0.04
	Terminology	6.00	0.01*	0.04
	Comprehension	12.19	0.00*	0.09
*Mean difference significant at 0.05 level				

Table 4
Adjusted means and standard errors for methods of instruction

Dependent Variable	Mode of Presentation	Gender	Mean	Std. Error
Identification	Static	Female	8.094	0.46
		Male	6.821	0.492
	Animation	Female	8.467	0.475
		Male	9.367	0.475
Terminology	Static	Female	7.313	0.483
		Male	6.464	0.517
	Animation	Female	8.4	0.499
		Male	10	0.499
Comprehension	Static	Female	8.813	0.478
		Male	7.429	0.511
	Animation	Female	9	0.494
		Male	11.067	0.494

Profile plot for interaction effect of various mode of presentation (Static vs. Animation) and gender on three criterion tests (Identification, Terminology, and Comprehension).

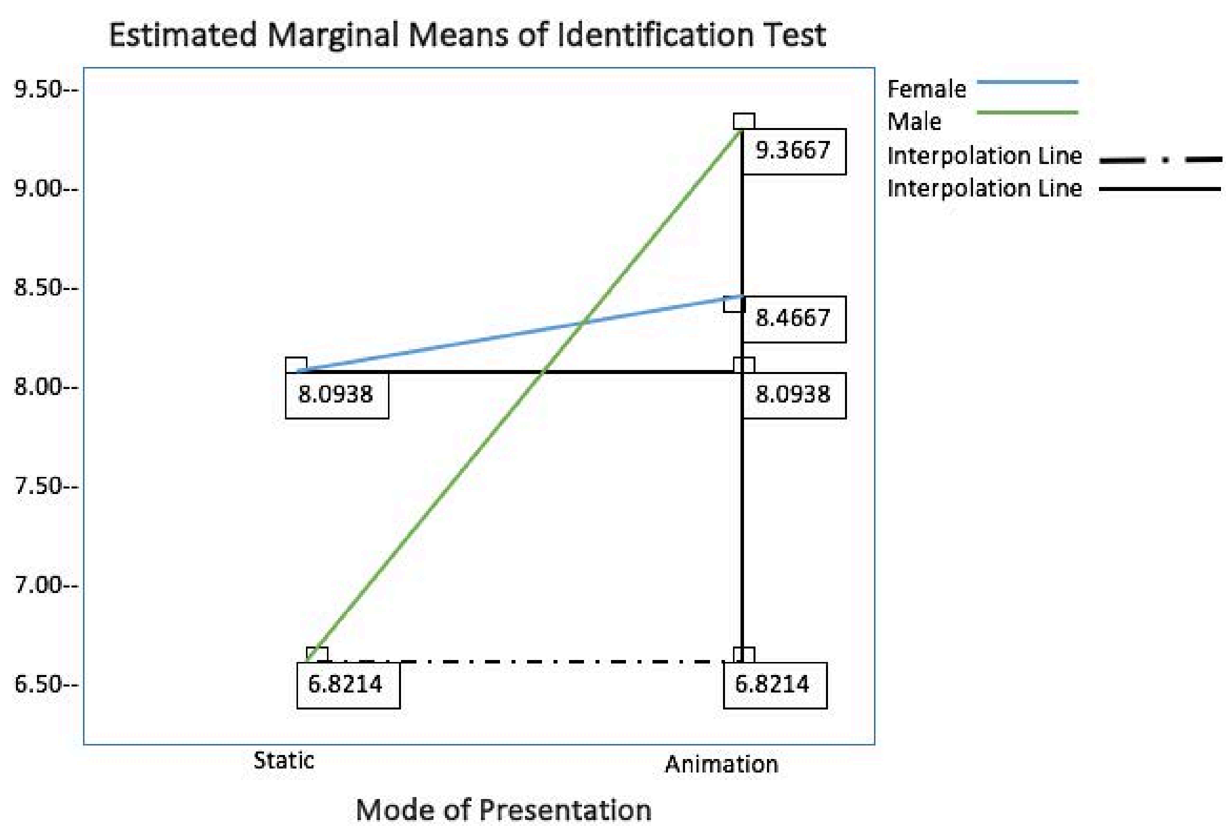

Figure 4: Interaction between various modes of presentation and gender in identification test

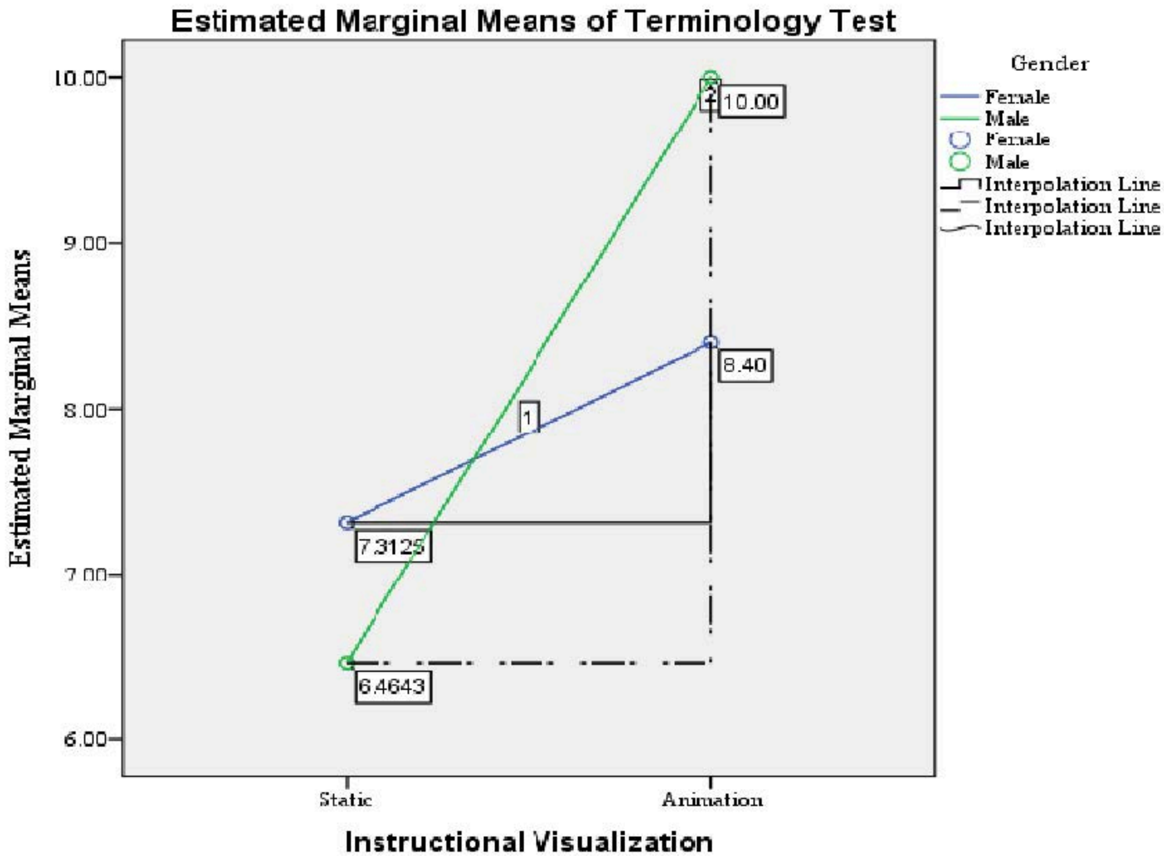

Figure 5: Interaction between various modes of presentation and gender in the terminology test

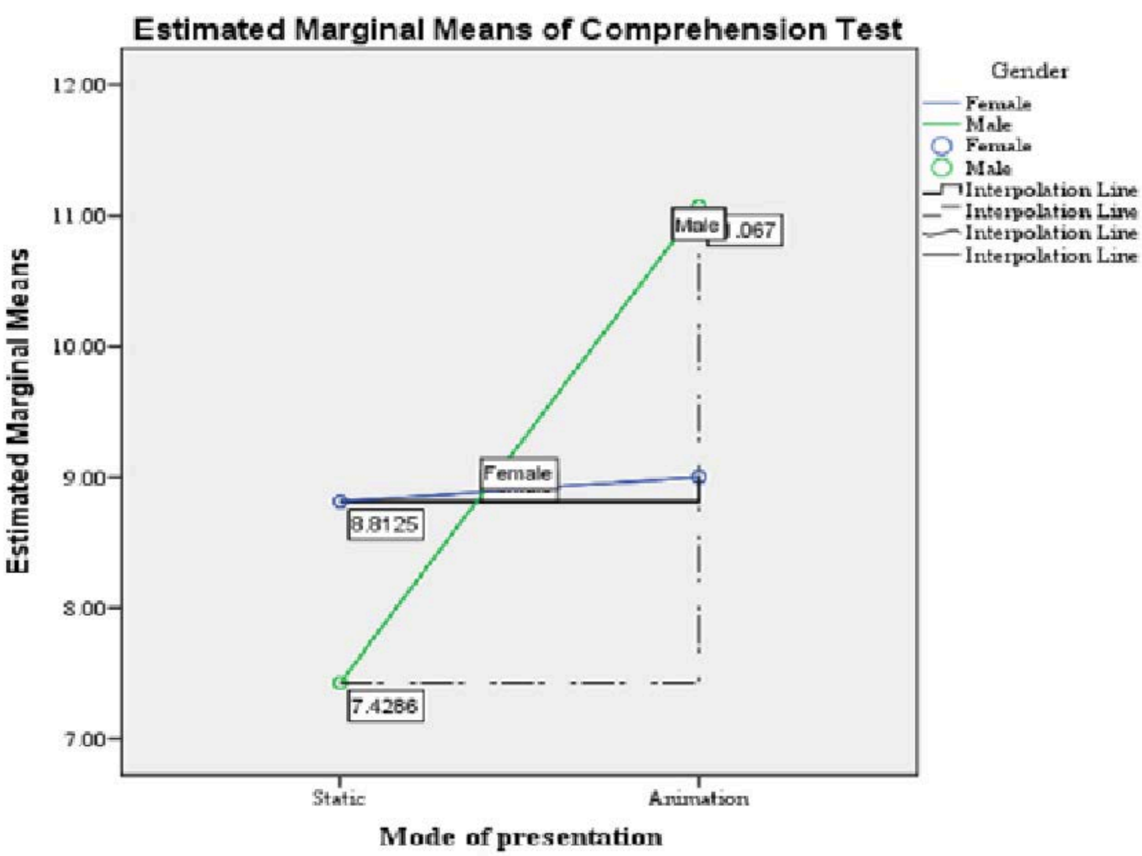

Figure 6: Interaction between various modes of presentation and gender in comprehension test

where the differences were, follow-up pairwise comparisons were examined.

Table 4 presents the adjusted means and standard errors for different modes of presentation and gender. From *Table 4*, we found that female student performance was superior (with a higher mean than male) in static visual instruction on three criterion tests, and male students performed better than females in the animation mode of instruction on three criterion tests.

Discussion

The results of the study unveiled that various modes of presentation, static and animated visual, effect gender differentiation. Alternatively, this empirical research result establishes the fact that main effect of gender in various knowledge domains, (factual, conceptual, and rules and principle), is not significant. The theoretical justification of multimedia instruction explains that animation put more demand on cognitive load than static image. Conjointly, this research result depicts superiority in performance of female participants over males in static visual strengthening; previous research found that females process static and verbal information more effectively than males (Halpern, 2004). Additionally, this result can also explain that a female participant needs less mental effort to process verbal information for freeing up cognitive resources for processing spatial information (Coward, Crooks, Flores & Dao, 2012). Nevertheless, the superiority of male participants in animated visual modes can explain the theoretical basis of Baddeley's (1992) working memory model that explains that male participants process more cognitive resources to understand visuospatial information (dynamic visual).

Significance and Practical Implication of the Study

In the present situation, it is a growing phenomenon to use various visual instructions as a mode of teaching-learning, but it is very important to know whether it really facilitates our various knowledge domains. If it does, which level(s) of knowledge does it facilitate, and how does it affect gender? The present study can be useful for the future designer to design learning material with gender in mind.

Furthermore, it is also important for instructional designers and educators to know the combined effectiveness of static and animated visualization when using both separately for males and females.

The results of this study shed light on the idea that visualization not only affects rote memorization, but also affects our factual and conceptual knowledge domain, which provides information to instructional designers and educators in the decision-making process of using visual instruction in Computer Based Instruction (CBI) environments.

Gender differentiation affects our national socio-cultural development which may be one of the major factors to account for the imbalance in social development. Researchers, teachers, instructional designers, and practitioners need to put more efforts into exploring the various aspects of the gender gap.

Teachers may use the results of this study for implementing new strategies. Also, it puts forth a further caution that generalization of multimedia learning principles, for all individuals, is not appropriate, and that factors leading to gender differentiation should be taken into consideration. A teacher trainer can also use these research findings for training new teachers. Instructional designers will get an overall picture of how various modes of presentations may affect gender differentiation. Most importantly, the Ministry of Human Resource Development can use these results for decision making in education.

Limitations of the Study

The results of the study definitely warrant a cautious interpretation due to a number of limitations.

a) The research is restricted only to standards IX and X of the Central Board of Secondary Education (CBSE).

b) The research is restricted to the students from English medium schools with computer facilities.

c) Only 120 students studying by the IX and X standards in CBSE comprised the final sample of this study.

d) The results are limited within the age-range and socio economic status considered in the study. ■

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