Gender differences in visual presentation e-learning

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ABSTRACT: E-learning has been widely used in this society in line with the rapid growth of technology, and it is the best way to accomplish lifelong learning. A number of studies have suggested that there is a difference in males' and females' achievement and attitudes relating to computer use. Due to the gender differences in learners' achievement and attitudes according to computer use, this study investigated the gender differences in visual presentation e-learning based on an engineering drawing course. Through literature review, expert panel discussion and experimental design, the one-group pre-test/post-test experimental teaching was conducted within an eight week (three hours per week) period. Before and after the experimental teaching, the vocational high school students' learning achievement and learning attitudes were investigated. Data were analysed by using descriptive statistics, a paired-samples *t*-test, an independent-samples *t*-test and analysis of covariance (ANCOVA). The findings could lead to improved understanding of the gender differences in visual presentation learning.

INTRODUCTION

Information technologies and high-speed networking brought learners a new paradigm of learning in the e-learning environment [1]. The implementation of modern information technologies in engineering graphics education provides a good foundation for the acquisition of knowledge and skills which are necessary in engineering practice [2]. Under the development of high-technology, multimedia learning environments allow for the presentation of information in different semiotic codes, which can be processed in different sensory modalities [3]. Moreover, visualisations can be understood as graphical representations of data and concepts [4], and it helps students to receive representative information and to obtain knowledge [5]. Additionally, visual representation attracts attention and maintains motivation [6]. However, researchers have mostly focused on learning success in multimedia learning and few studies have focused on gender effects [7], not to mention a paucity of literature on gender differences among school subjects [8]. Thus, this article attempts to explore the gender differences in visual presentation e-learning on the subject of engineering drawing. The specific research questions to be addressed are as follows:

1. To what extent do learners' prior knowledge and pre-learning attitudes relate to their learning achievement and learning attitudes after the visual presentation e-learning on engineering drawing?
2. How learners' learning achievement and learning attitudes reflect in different genders in this subject?

LITERATURE REVIEW

Engineering Drawing

Engineering drawing is a practical course and acts as a technology foundation course for almost all of engineering knowledge [9]. It is a type of technical drawing conveying all information required for the manufacturing of certain components according to international norms [4]. In other words, engineering drawing is a means of graphical communication [10]. Additional evidence in support of the importance in engineering drawing is provided by Weng and Hsu [11]. Generally, an engineering drawing contains multiple orthographic projections rendering the item from the front, sides, top and/or bottom. These are useful for determining the outer shape [4]. In engineering drawing, the spatial ability is supposed to be involved, and the concept of spatial ability is used for the abilities related to the use of space, and the two major components are spatial relations and spatial visualisation [10]. Computers have been part of the automation technology educational arena since the early 1980s [12]. Furthermore, along with the evolution of computers, course content has moved on from being pure manual drawing to a combination of manual drawing and computer-aided drawing [13]. In order to take full advantage of the computational tools, e.g. CAD, students should have a prior knowledge of elementary concepts of geometry [2].

Visual Presentation

Multimedia learning occurs when a learner builds a mental representation from words and pictures that have been presented [14]. Furthermore, in a multimedia-based learning environment, information is received via numerous channels [15]. The instructional designer's role is to create environments in which the learner is exposed to large amounts of information, such as computer-based multimedia programs, and the computer-based visualisation tool provides learners a deeper understanding related to the basis for meaning making [16]. In recent years, dynamic visualisations, such as animations, have become a ubiquitous component of computer-based instruction and information delivery; however, learning from animations could impose some specific demands onto learners' processing that may interfere with learning [17]. For schools to remain globally competitive, it is essential for them to change the traditional way of delivering education in order to respond to the rapidly changing conditions in technology and society [18]. Nowadays, the pedagogical use of computer simulations has grown dramatically and shows little sign of abating [19]; nonetheless, educational research has emphasised verbal learning while interest in visual learning has lagged behind historically [6]. Thus, training students to create visualisations using computer-based drawing and painting tools, students may be instructed to use computers as a study tool to intentionally organise and integrate content ideas [20].

Gender Differences

Considering the increasing availability of computers, research effort has been devoted to foster equal e-learning for all willing users, and with the increasing personal access to computing devices and Internet services, the younger generations' early exposure to information and communication technology [21]. Gender differences have surfaced in inconsistent ways in autobiographical memory studies [22], and it was also found to be a factor that could have an impact on training outcomes using various methods of training in spatial visualisation skill [23]. Moreover, Mäntylä suggest that multitasking involves spatiotemporal task coordination and that gender differences in multiple-task performance reflect differences in spatial ability [24]. Therefore, many scholarly studies have focused on gender differences and their impact on e-learning.

Some studies showed that gender is an effective factor on learner control [25], and it is a factor that may have an impact on training outcomes using different methods of training in spatial visualisation skill [23]. Nevertheless, some studies suggested that gender has no impact on learning [26], and no previous studies have explored gender differences with respect to learning approaches and academic performance in different school subjects [8], not to mention about the application in visual presentation e-learning on engineering drawing. Under the circumstances, Smith and Miller suggested that future research is needed to clarify whether approaches to learning are related to gender and area of study [27].

METHOD

Research Design and Subjects

The purpose of the study is to investigate the gender differences in learners' learning attitudes and learning achievement according to the use of visual presentation e-learning material. In order to achieve the goals, a literature review was used to construct the research frame. Next, the subjects of this study consisted of 40 students selected from the engineering design course offered at a national vocational high school in Taiwan. In order to consider both genders, and because the subjects cannot be completely randomly sampled, the investigators adopted a one-group pre-test/post-test experimental design to carry out the empirical teaching experiment. The experimental teaching was conducted within an eight week (three hours per week) period. The pre-tests indicated how the participants did prior to the experimental teaching, and the effect was taken to be the difference between the pre-test and post-test scores. On the other hand, the pre-tests and post-tests were given in all subjects to obtain their learning attitudes and learning achievement.

Learning Material

The visual presentation e-learning material was constructed through a literature review and focus group interviews. It included basic engineering drawing knowledge and skills, and the material was divided into several teaching units. In addition, the ADDIE model (Analysis, Design, Development, Implementation and Evaluation) is a framework that lists generic process that instructional designers and training developers use. Therefore, in this study, the material was developed according to the ADDIE model, and the appropriateness of the material was modified and verified through pre-teaching process.

Instruments

Research instruments were developed and used for measuring the students' learning attitudes (Engineering Drawing Learning Attitudes Scale) and learning achievement (Engineering Drawing Learning Achievement Test). The development of these instruments proceeded in several stages and established satisfactory reliability and validity. First of all, the instruments were tested in a pilot test, and results from the pilot tests were analysed by items analysis, factor analysis and expert panel to explore the reliability, conceptual validity and content validity for understanding the appropriateness, feasibility, content validity and reliability.

The learning attitudes scale is composed of 17 questions and the learning achievement test was developed on the basis of engineering drawing. The internal consistency reliability in terms of Cronbach's alpha was excellent ($\alpha = 0.944$). The total variance explained was 68.027%, and the subscales' reliabilities were established as satisfactorily reliable and valid (Cognition of the importance of technology: $\alpha = 0.752$; Interest in learning about technology: $\alpha = 0.872$; Performance of technology-related actions: $\alpha = 0.698$; Technology career planning: $\alpha = 0.942$).

The learning achievement test is comprised of 21 multiple-choices questions, and the test was re-designed following pilot studies conducted with students from the same department who took the same course before. The acceptable range of the item difficulty index was from 0.38 to 0.80, the item discrimination index was from 0.44 to 0.64, and the KR_{20} reliability coefficient of this test was calculated as 0.708. Therefore, the learning achievement test was considered as having good difficulty and discrimination indices respectively.

Data Analysis

The quantitative analysis of the scales was conducted by using the SPSS for Windows through the following four statistical methods:

1. Descriptive statistics were used to investigate the discipline of quantitatively describing the main features of the collection of data in this study.
2. A paired-samples *t*-test was applied to test differences between pre-test and post-test for both gender groups on the learning achievement and attitudes of visual presentation e-learning.
3. An independent *t*-test was used to investigate the differences between the means of both gender groups on the learning achievement and attitudes of visual presentation e-learning.
4. Analysis of covariance (ANCOVA) was also applied to provide a way of statistically controlling the linear effect of pre-tests, and it is typically used to adjust or control for differences of between the genders. On the other hand, the pre-test scores of engineering drawing were used as covariates in this pre-test/post-test experimental design.

RESEARCH FINDINGS

Descriptive Statistics

Descriptive statistics were computed to summarise the participants' responses to the learning attitudes and learning achievement. A total of 40 students enrolled in this study. Table 1 illustrates the means, standard deviations (SD) and standard errors (SE).

Table 1: Results of descriptive statistics.

Variables	Tests	Gender	n	Mean	SD	SE
Learning attitudes	Pre-test	Male	22	2.98	0.494	0.105
		Female	18	2.85	0.661	0.156
	Post-test	Male	22	2.99	0.416	0.089
		Female	18	2.66	0.418	0.099
Learning achievement	Pre-test	Male	22	7.909	3.650	0.778
		Female	18	8.500	5.469	1.289
	Post-test	Male	22	17.590	4.747	1.012
		Female	18	14.333	5.099	1.201

Paired-samples *T*-Test

Table 2 shows the results of paired-samples *t*-test analysis, and the results showed a significant difference in the learning achievement ($t = -7.532$, $p = 0.000$), but there was no significant difference in learning attitudes ($t = 0.758$, $p = 0.453$). In short, the learners' attitudes had not been changed after the experimental teaching, but their learning achievement had been improved after learning. Stated in another way, the visual presentation e-learning had a positive effect in this experimental design.

Table 2: The result of paired-samples *t*-test analysis.

Variables	Tests	n	Mean	SD	95% CI for Mean Difference	r	*t*
Learning attitudes	Pre-test	40	2.921	0.571	[-0.132, 0.290]	0.174	0.758
	Post-test		2.841	0.445			
Learning achievement	Pre-test	40	8.1750	4.50577	[-10.085,-5.815]	-0.096	-7.532***
	Post-test		16.1250	5.11502			

*** $p < 0.001$

Independent-samples *T*-Test

The independent *t*-test was used to detect the differences between gender groups on learning attitudes and learning achievement. Table 2 shows that there were significant differences between male and female students in the post-tests of learning attitudes ($t = 2.528$, $p = 0.016$) and learning achievement ($t = 2.088$, $p = 0.044$).

In contrast, there were no significant differences in the pre-tests (learning attitudes: $t = 0.686$, $p = 0.016$; learning achievement: $t = -0.408$, $p = 0.685$). The results showed that the male students had higher learning achievement and learning attitudes than the female students did after the visual presentation e-learning.

Table 3: The result of independent-samples *t*-test analysis.

Test	Variables	Gender	Mean	SD	n	95% CI for Mean Difference	*t*
Pre-test	Learning attitudes	Male	2.98	0.494	22	[-0.245 , 0.495]	0.686
		Female	2.85	0.661	18		
	Learning achievement	Male	7.909	3.65030	22	[-3.521, 2.339]	-0.408
		Female	8.500	5.46916	18		
Post-test	Learning attitudes	Male	2.99	0.416	22	[0.067, 0.603]	2.528**
		Female	2.66	0.418	18		
	Learning achievement	Male	17.591	4.748	22	[0.100, 6.415]	2.088***
		Female	14.333	5.099	18		

** $p < 0.01$. , *** $p < 0.001$.

Analysis of Covariance (ANCOVA)

An ANCOVA was also applied in this study, and the students' pre-test scores were used as the covariate to exclude the impact of the prior knowledge and attitude on their engineering drawing learning.

It was confirmed that both gender groups were homogeneous [28]; in other words, the variance of male group is equal to the variance of female group. The results also showed that the regression coefficients between males and females were homogeneous.

As shown in Table 4, the post-test scores of learning attitudes between male and female was significant difference (F = 5.795, $p = 0.021$*) after the impact of the pre-test scores was excluded.

Table 4: The result of ANCOVA analysis on learning attitudes.

Gender	Learning attitudes			
	Observed mean	Adjusted mean	SD	n
Male	2.992	2.987	0.418	18
Female	2.657	2.665	0.416	22

Source	SS	df	MS	F
Pre-test	0.135	1	0.135	0.775
Gender	1.014	1	1.014	5.795*
Error	6.473	37	0.175	

* $p < 0.05$

Table 5 shows that the post-test scores of learning achievement between male and female were significantly different (F = 4.357, $p = 0.044$*) after the impact of the pre-test scores was excluded. In other words, the post-test scores were significantly different due to the gender differences. In short, after the experimental teaching, male and female students performed differently and it meant there were gender differences in visual presentation e-learning.

Table 5: The result of ANCOVA analysis on learning achievement.

Gender	Learning Achievement			
	Observed Mean	Adjusted Mean	SD	n
Male	17.591	17.610	4.748	18
Female	14.333	14.310	5.099	22

Source	SS	df	MS	F
Pretest	4.004	1	4.004	0.163
Gender	107.320	1	107.320	4.357*
Error	911.314	37	24.630	

* $p < 0.05$

DISCUSSION AND CONCLUSIONS

The purpose of this study was to investigate the gender differences in visual presentation e-learning based on the engineering drawing course. Several research questions were addressed in this study.

1. Visual presentation e-learning had a positive effect on students' learning achievement:

The data provided in this article indicate that the visual presentation e-learning for engineering drawing learners has had a significantly positive effect on the learning achievement. The finding is consistent with Lee and Yeap's study that good technology helps students to learn effectively [18], and with Yarden and Yarden's findings [29]. The value of concrete representations in education has been frequently noted [19], and the advancement of spatial and sketching abilities is a very important learning outcome for many entry level engineering graphics courses [30]. There are now many computer-based tools that are well suited for visualisation instruction and remediation relative to specific engineering specialities [31], and it is a promising way to help students interpret complex visualisations and integrate information [32]. On the other hand, students' study interests decide their study attitude and enthusiasm in the mechanical drawing course [33]. Learners' attitudes and multimedia instruction are major factors to affect learners' attitudes toward e-learning as an effective learning tool [34]. These studies have been critically important in laying the groundwork for understanding how engineering drawing learners use visual presentation e-learning. In conclusion, these aforementioned studies raised the possibility that similar effects might occur in other subjects, and the practicality of the visual presentation e-learning on engineering drawing is demonstrated through a bigger sample size. Future researchers might be able to increase their understanding of practices.

2. This study appears to support the superiority of male students' engineering drawing learning attitudes and learning achievement over those of female students:

This article analyses gender differences in visual presentation e-learning on engineering drawing. The estimations performed confirm that there were significant differences between male and female students in terms of their attitudes and achievement with visual presentation e-learning. However, in earlier studies, Wilson, Smart and Watson found no disparity between genders of students' approaches to learning psychology [35]. Moreover, Lagerspetz, Björkqvist and Peltonen proposed that the gender differences in mathematics performance were small [36]. In contrast, Gneezy, Niederle and Rustichini's study showed that there was a significant gender gap in performance in tournaments [37].

Also, the demographic factor of gender contributes to the overall training outcomes [23]. Additionally, Miller presented results that indicated that gender is one of the factors influencing the development of spatial ability [38], and the spatial ability is not only an important skill for engineers, but also for a wide variety of other disciplines [31]. In fact, gender differences in spatial aptitude may be caused by several socio-cultural factors [23]. The more likely explanation rests in the nature of the genders, and significant gender differences might have already existed when students entered college [39]. For the most part, the literature is replete with studies suggesting that the gender differences exist in social science. The authors of this study suggest that visual presentation e-learning on engineering drawing should consider gender differences, and this study could lead to a better understanding of gender differences in visual presentation e-learning.

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