行政院國家科學委員會專題研究計畫 成果報告

女性學習者在合作學習情境下學習風格、電腦焦慮、及性別異質分組對資訊科學學習之影響
研究成果報告(精簡版)

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報 告 附 件 ：出席國際會議研究心得報告及發表論文

公 開 資 訊 ：本計畫可公開查詢

中 華 民 國 98 年 01 月 08 日

行政院國家科學委員會補助專題研究計畫 ■ 成 果 報 告
□期中進度報告

女性學習者在合作學習情境下學習風格、電腦焦慮、及性別異質分組對資訊科學學習之影響

The effects of learning style, computer anxiety, and gender stereotype on females' performance in learning computers

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■出席國際學術會議心得報告及發表之論文各一份
□國際合作研究計畫國外研究報告書一份

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執行單位：國立台灣師範大學資訊教育研究所

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壹、報告內容

I. INTRODUCTION

In the digital era, information fluency has become one of the most important capabilities for students [1]. Information fluency implied that students should be able to apply existing knowledge to generate new ideas, develop innovative products, or make use of technology as cognitive or productivity tools. From perspective of social constructivism, the function of individual differences on skills, aptitudes and learning preferences could have impact for the application of technology in classroom settings. Learners' learning styles affect the preferences of information process and prior knowledge affect the propositional network of the long-term memory. Previous studies have confirmed that matching types of instruction with learners' stronger learning styles could enhance learners' information and communication technology (ICT) skills and motivation [2], [3], [4]. Kolb also suggested that compensation can help learners overcome weakness in their cognitive styles and develop a more integrated approach to learning [5]. However, how can learning activities make effect to compensate for learners' weaker learning style remains an unsolved issue?

Based on the enhancement/compensation perspective, the present study employed a collaborative project-based learning to help learners become aware of their learning preference, reflect on their learning progress, and promote their performance in ICT learning. Therefore, the effects of learning style and gender on secondary school learners' collaborative project performance in an ICT course can be examined thoroughly.

II. LITERATURE AND RELATED WORKS

The emerging technologies contribute learners to communicate, work collaboratively and develop creativity products effectively. In the digital age, information is commonly delivered by multiple-representations. How to cultivate learners to select informed information, develop innovative products and evaluate learning product based on critical thinking skills as common issues of educators? To achieve these goals, teachers who plan and design technology-supported learning environments and experiences for their students must be considerate of information-processing variables, background variables, learning objectives, the attributions of technology, and the assessment of content comprehension and appropriateness of technology used.

In junior high technology course, learners play as active, silence or passive participants. Individual differences, such as prior knowledge, learning style and gender can have impact on skills, aptitudes and learning preferences for the application of technology in educational practice. Prior knowledge consists of propositional networks in the long-term memory and is a prerequisite to the learning of new skills. Learning styles are the mental processes and instructional settings a learner apply learning strategies to perform specific tasks [6]. It has been concluded that the verbalizers learn best from textual representation, and that the imaginers learn best form graphical representation. Literatures have confirmed that matching learners' stronger learning styles with instructional strategies will result in enhanced performance, higher level of satisfaction and motivation in the learners [2], [3], [4]. Furthermore, it was suggested that gender differences influenced learners' computer performance and computer attitudes since males got higher scores in technology-based courses, performed better in the practical tasks, showed more interests in using and learning about computers, and attributed any success in technology is ability [7], [8], [9]. Conversely, females were reported to be fear of using computers, had lower confidence in computer aptitudes, but performed better in academic tests, attracted to computer courses that emphasize social issues and computer applications [7], [9], [10], [11]. Similarly, some studies suggested that females benefit from their tame gender characteristics to achieve higher

performance [4]. And female attributed their success to work hard instead of ability [9]. To sum up, research findings on gender differences and learning preferences remain inconclusive. The expected positive impact on learning performance and attitudes relies on considerate design that matches learners' individual needs and characteristics. Therefore, Kolb suggested that compensation designs can help learners overcome weakness in their cognitive styles and develop a more integrated approach to learning [5].

The role of technology in learning as thinking tools, communication media, environment, partner and scaffold [14] that learners use technology as vehicle for interacting with each other, sharing ideas, applying their insights to real-life problem, and by the way of expert guidance or collaboration with peer extending learners' ability. Integrating pedagogy, content and technology into educational practice, learners used ICT to represent comprehended knowledge based on their learning preference in peer tutoring context. The helper could consolidation acquired knowledge by demonstrating project. Meanwhile, the helped learners could aware their learning preference and compensation acquired knowledge by modeling project. Therefore, combining peer assessment with collaborative project could promote learners' self-awareness, reflective and meta-cognition understanding about their learning process in technology-supported learning environment [12], [15]. Literature reviewed also confirmed that students held positive attitudes toward the use of peer assessment activities, and male students had more positive attitudes toward online peer assessment than female [15].

III. METHODS

The present study examined the effects of individual differences on secondary school learners' project performance, learning progress and attitude in an ICT course. A 5-week group-based collaborative multimedia project was employed. An example-theory-practice learning approach and peer assessment were implemented in the collaborative project to facilitate participant's multimedia skills learning and production performance. The participants were 139 secondary school learners, 72 male and 67 female 8th graders aged from 15 to 16, who were taking the information technology courses taught by the same teacher. Participants' learning style was identified based on the perspective of Verbal-Imaginal information processing.

A collaborative ICT project was implemented in the present study in order to enhance the stronger learning style and/or compensate the weaker learning style by peer learning. It consisted of five sessions including creative scenario, background design, photo design, context design, project demonstrate and conclusions. The process and content of the collaborative learning process is shown as Table 1.

Table 1 Collaborative learning process

Sessions	Topics	Project Activity	Time
1	Description of group activity	Each group consisted of 3-4 learners by heterogeneity Description of task goals and criteria of peer assessment	10
	Project phase 1 - Creative scenario	Discuss the project scenario Record learning progress in worksheet	15
2	Project phase 2 – Background design	Collaborative project task 2 Record learning progress in worksheet **Online peer assessment** (scored. attribution)	30 15
3	Project phase 3 – Photo design	**Peer feedback** **Revised** project task 2 by peer feedback Collaborative project task 3 Record learning progress in worksheet	10 35
4	Project phase 4 – Context design	Collaborative project task 4 Record learning progress in worksheet **Online peer assessment** (scored. attribution)	30 15
5	Project phase 5 – Demonstration	**Peer feedback** **Revised** project task 3,4 by peer feedback Collaborative project task 5 Record learning progress in worksheet **Online peer assessment** (scored. attribution)	10 20 15
6	Conclusions	**Peer feedback** Announcement final project score of each group and individuals	10

Learners' self-assessment and peer assessment were conducted between sessions in order to promote the

comprehension of knowledge and compensate for inability in knowledge construction, knowledge clarification, knowledge consolidation and knowledge application. The effect of peer learning is shown as Figure1. Learners construct content knowledge by peer learning. During peer assessment, they discuss the peer production based on pre-defined criteria to clarify comprehended knowledge and negotiate feedback to consolidate knowledge.

IV. FINDINGS

Multivariate analyses of variance (MANOVA) were performed to investigate the effects of learning style and gender on participants' project comprehension and application performance, and attitude. ANOVA were performed to investigate the effects of learning style and gender on participants' learning progress. Spearman rank-order correlation was conducted to evaluate the consistency between peer assessment and expert assessment. The significance level was set to .05 for the study.

The mean scores of learning style and gender on project comprehension and application performance are shown in Table 2. The imaginal learning style group scored higher than the verbal group and the female group scored higher than the male group both in the performance test (comprehension performance) and project products (application performance).

Table 2 The mean scores of learning style and gender groups on comprehension and application performance

Independent Variables	Aspects	M	SD	N
1.Comprehension Performance				
Learning Styles	Verbal	60.87	20.763	52
	Imaginal	**70.85**	16.720	53
	Total	65.91	18.722	105
Gender	Male	61.40	21.666	57
	Female	**71.25**	14.822	48
	Total	65.90	19.399	105
2.Application Performance				
Learning Styles	Verbal	19.33	6.336	52
	Imaginal	**21.32**	5.424	53
	Total	20.33	5.88	105
Gender	Male	18.79	7.333	57
	Female	**22.17**	2.816	48
	Total	20.33	5.950	105

The MANOVA summary of learning styles and gender on comprehension and application performance is shown as Table 3. All of the 2-way interactions of learning style and gender were not significant. The main effects of learning style was significant in the comprehension performance ($F_{(1,101)}$ =4.738, p = .032), but not significant in application performance($F_{(1,101)}$ =1.023, p = .314). Meanwhile, the main effects of gender were significant in the comprehension ($F_{(1,101)}$ =4.084, p = .046) and application ($F_{(1,101)}$ =6.916, p = .010) performance. The results indicated that learning style and gender affected participants' project performance significantly. In other words, on the project comprehension performance, the imaginers (M =70.85) and female (M =71.25) outperformed the verbalizers (M =60.87) and male (M =61.40). On the project application performance, the female (M =22.17) outperformed the male (M =18.79). There is no significant difference between verbalizers and imaginers in project application performance.

Table 3 ANOVA summary of learning styles and gender on comprehension and application performance

Source of Variation	Aspects	SS	df	MS	F	Sig.
Learning Styles×Gender	Comprehension	135.568	1	135.568	.392	.533
	Application	.933	1	.933	.028	.867
Learning Styles	Comprehension	1638.026	1	1638.026	4.738	**.032**
	Application	33.903	1	33.903	1.023	.314
Gender	Comprehension	1412.046	1	1412.046	4.084	**.046**
	Application	229.230	1	229.230	6.916	**.010**
Error	Comprehension	34918.403	101	345.727		
	Application	3347.754	101	33.146		

Spearman rank-order correlation was conducted to evaluate the consistency between peer assessment and expert

assessment. The correlation coefficients for the 3 phases of peer assessment and overall coefficient were significant (phase 1: r = .674; phase 2: r = .668; phase 3: r = .665; total: r = .751). The results indicated that the reliability between peer assessment and expert assessment was consist and acceptable.

The mean scores of learning style and gender on learning progress are shown in Table 4. The imaginal learning style group scored higher than the verbal group and the female group scored higher than the male group in the monitoring of learning progress.

Table 4 The mean scores of learning styles and gender groups on learning progress

Independent Variables	Aspects	M	SD	N
Learning Styles	Verbal	6.92	2.300	52
	Imaginal	**7.36**	1.962	53
	Total	7.14	2.129	105
Gender	Male	6.58	2.521	57
	Female	**7.81**	1.299	48
	Total	7.14	2.137	105

The ANOVA summary of learning styles and gender on learning progress is shown as Table 5. All of the 2-way interactions of learning style and gender were not significant. The main effects of gender was significant in learning progress ($F_{(1,101)}$ =8.028, p = .006), but the main effects of learning style was not significant ($F_{(1,101)}$ =.107, p = .744). The results indicated that gender difference affected learning progress. In other words, the female (M =7.81) got better learning progress than the male (M=6.58).

Table 5 The ANOVA summary of learning styles and gender on learning progress

Source of Variation	SS	df	MS	F	Sig.
Learning Styles×Gender	.339	1	.339	.079	.779
Learning Styles	.460	1	.460	.107	.744
Gender	34.537	1	34.537	8.028	**.006**
Error	434.482	101	4.302		

Table 6 The attitude mean scores of learning style and gender groups

Independent Variables	Aspects	M	SD	N
1.Perception toward Enhancement				
Learning Styles	Verbal	10.04	2.856	52
	Imaginal	10.09	3.499	53
	Total	10.07	3.181	105
Gender	Male	9.74	3.538	57
	Female	10.46	2.681	48
	Total	10.07	3.181	105
2.Perception toward Compensation				
Learning Styles	Verbal	10.12	3.123	52
	Imaginal	10.23	3.309	53
	Total	10.18	3.217	105
Gender	Male	9.33	3.313	57
	Female	11.17	2.785	48
	Total	10.17	3.203	105
3.Perception toward Motivation				
Learning Styles	Verbal	9.81	2.870	52
	Imaginal	10.57	2.832	53
	Total	10.19	2.851	105
Gender	Male	9.68	3.036	57
	Female	10.79	2.543	48
	Total	10.19	2.863	105

The attitude mean scores of learning style and gender groups are shown in Table 6. Participants showed positive attitudes toward the enhancement, compensation, and motivation. As for participants' perception toward the assertion that learning style enhances learning, the imaginer (M =10.09) scored higher than the verbalizer (M =10.04) and the female group (M =10.46) scored slightly higher than the male group (M =9.74). On perception toward compensation aspect, the verbalizer (M =10.12) scored higher than the imaginer (M =10.23) and the female group (M =11.17) scored higher than the male group (M =9.33). Furthermore, on the motivation aspect, the imaginer (M =10.57) scored higher than the verbalizer (M =9.81) and the female group (M =10.79) also scored higher than the male group (M =9.68). The difference of participants' attitudes between groups was further examined by means of MANOVA analysis.

The MANOVA summary of learning style and gender on attitude is shown in Table 7. All of the 2-way interactions were not significant. The main effects of gender on perception of compensation ($F_{(1,101)}$ =7.919, p = .081) was significant and indicated that female learners (M =11.17) perceived higher level of compensation effect of learning style than the male(M =9.33). The results indicated that participants' held the same positive toward enhancement, compensation, and motivation no matter the stronger learning style their possessed. Similarly, male and female learners revealed the same positive perceptions of enhancement and motivation. In addition, male and female learners both perceived the compensation aspect positively, but female learners possessed higher degree attitude toward the compensation aspect than males.

Table 7 The MANOVA summary of learning style and gender on attitude aspects

Source of Variation	Aspect	SS	df	MS	F	Sig.
Learning Styles×Gender	Enhancement	.075	1	.075	.007	.932
	Compensation	5.762	1	5.762	.600	.440
	Motivation	8.332	1	8.332	1.045	.309
Learning Styles	Enhancement	.512	1	.512	.050	.824
	Compensation	4.655	1	4.655	.485	.488
	Motivation	4.820	1	4.820	.604	.439
Gender	Enhancement	14.032	1	14.032	1.365	.245
	Compensation	93.330	1	93.330	9.719	**.002**
	Motivation	24.723	1	24.723	3.100	.081
Error	Enhancement	1038.417	101	10.281		
	Compensation	969.886	101	9.603		
	Motivation	805.616	101	7.976		

V. Findings

The findings of this study can be summarized as follows. For the learning performance, gender difference and the effect of learning style was found. The effect of gender difference on learning performance was opposite to Chen [7] and Demirbas and Demirkan [8] that female learners got higher scores in technology-based course. As for the attitude aspect, female and male learners almost got the same perception toward learning activity. However, an interesting phenomenon that the female learners revealed higher degree perception of compensation effect was found. These signified that female perceived more helpful and conceptual understanding from collaborative peer discussion, and get more in-depth comprehension from peer tutoring. By thus, female got higher comprehension performance and application performance, and monitored better on learning progress.

After learning, the imaginers outperformed the verbalizers on comprehension performance. That is to say, the imaginers benefited more from the given learning activity than the verbalizers. Therefore, the enhancement effect can be concluded for the imaginers. The effect can be inferred as contributed by the collaborative learning process that facilitate individuals to communicate and tutor each other, monitor learning progress, notice about necessary adjustment in employed strategies. Besides, the abstract characteristic of the ICT domain knowledge usually requires learners to construct multi-representations in they mind in order to comprehend the given content. Thus, the imaginal learners could get more proficient in constructing multi-representations than the verbal learners. According to the perspective of multimedia learning theory, the "enhancement" result of the present study is consistent with the perspective of "matching learning styles with instructional presentational strategies is significant in enhancing learners' learning performance". For verbal learners, they also benefited from collaborative project to compensate their inability by peer tutor. These revealed on learners' application performance that after the process of collaborative project work, record learning progress, self/peer assessment, peer feedback and modify project product, the verbaliers achieved the same skill level and learning progress with the imaginers. This result verified the perspective of compensation that "matching weaker learning styles with learning strategies to compensate learners' inability and promote learners aware their learning preference by peer assessment.

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貳、 計畫成果自評

本計劃針對女性學習者資訊科學技能學習，順利完成國中電腦課程、高職資處科程式語言課程、及科技大學網路程式設計專題之實驗教學研究，成果豐碩。由於本研究完成三個學習階段之實驗教學活動，比預期只針對國民中學階段女性學習者資訊科學學習之探討更能展現由不同教育階段之發展歷程中，女性學習者在資訊科學學習之進展與異同。因此，本研究實證探討所獲得之成果更具提供教育實務參考之價值。再者，由於本研究所獲致三個學習階段之實驗數據非常豐富，雖然並非短時間內即可全部分析完成；但是，本研究相關成果已發表 1 篇國內研討論論文、3 篇國際研討論論文、2 篇國際期刊論文、並有 2 篇論文已通過 SSCI 期刊 special issue 初審並將於 2009 年 2 月投稿第二階段審查。因此，本計劃成果堪稱豐碩。

研討會論文：

Wang, L. C. & Chen, M. P. (2008). The effects of experiential gaming on learning to program. *Proceedings of Technology Enhanced Learning 2008 (TELearn 2008)*. Hanoi, Vietnam, Dec. 4-6, 2008. (NSC 96-2629-S-003-001)

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期刊論文：

Wang, L. C. & *Chen, M. P. (2008). Enhancing ICT skills learning through peer learning: Perspectives of learning style and gender. *International Journal of Education and Information Technology, 2*(1), 18-23. (ISSN: 1109-9577) (NSC 96-2629-S-003-001)

Chen, M. P. (2008). The effects of level-of-interactivity and gender on learners' achievement and attitude in an e-learning course on computer graphics. *WSEAS Transactions on Advances in Engineering Education, 5*(4), 220-231. (ISSN: 1790-1779) (NSC 96-2629-S-003-001)

出席國際學術會議心得報告

計畫編號	NSC 96－2629－S－003－001
計畫名稱	女性學習者在合作學習情境下學習風格、電腦焦慮、及性別異質分組對資訊科學學習之影響 The effects of learning style, computer anxiety, and gender stereotype on females' performance in learning computers
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出國時間地點	日期：2008 年 4 月 6~8 日 地點：Hangzhou, China
會議名稱	International Conference on Applied Computer and Applied Computational Science (ACACOS '08)
發表論文	Does interactivity matter for females to learn computer skills on-line

工作記要：

ACACOS'08 (International Conference on Applied Computer and Applied Computational Science)是由 WSEAS 所主辦的國際研討會。總部位於希臘的 WSEAS (The World Scientific and Engineering Academy and Society)是一個以科學及工程為主軸的學術社群組織，其分支機構遍佈全球各大地區，其目的在於運用新電腦科技與計算方法來促進科學及工程應用與發展。ACACOS 先前之研討會分別於 Rethymno, Greece (2001, 2002), Malta (2003), New York (2004), Hangzhou, China (2006, 2007)等地舉行。此次會議也在大陸杭州舉辦，會議場地附近之交通往返十分便利。

ACACOS'08 與 IMCAS'08 (Instrumentation, Measurement, Circuits and Systems), ROCOM'08 (Robotics, Control and Manufacturing Technology)及 MUSP '08 (Multimedia Systems & Signal Processing)共同舉行，總計有 865 篇論文投稿，錄取 412 篇，論文錄取率約

47.63%。ACACOS'08 論文約 140 篇，多數是探討數位科技於學習應用之相關研究議題。此次參加 ACACOS'08 主要目的是發表 96 年度性別科技計畫之研究成果，分別針對女性學習者以數位學習方式學習資訊科技技能之數位教材互動性之影響、以及電腦技能學習之學習風格適性學習之研究成果進行論文發表；並與美國、墨西哥、羅馬尼亞、及日本等多國研究者交換研究心得。在討論中也了解到各國由於文化不同，其男女性對於科學學習之興趣也有很大之差異。WSEAS 每年在世界各國都舉辦許多科學及工程國際性研討會，吸引各國人士與會交流研究經驗，其成功經營的經驗值得國內學術研究成果推廣之參考。

與羅馬尼亞、美國研究者之合照

與墨西哥、日本研究者之合照

Does Interactivity Matter for Females to Learn Computer Skills On-line

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Abstract: - The purpose of this study was to investigate the effect of level-of-interactivity of e-learning courseware on e-learners' achievement while learning computer graphics skills on-line. One hundred and twenty one e-learners participated in this study. The effects of interactivity and gender on e-learners' performance were examined. A significant interactivity-gender interaction was found on participants' e-learning performance. The results indicated that (a) under the high-interactivity mode, male and female learners performed equally, but while under the low-interactivity mode, male outperformed female learners; (b) male learners performed equally under the high-interactivity mode and the low-interactivity mode, female learners, however, performed better while under the high-interactivity mode. It was concluded that e-learning courseware with high of interactivity will compensate for female learners' gender differences and best fit their learning needs.

Key-Words: - E-learning, Interactivity, Instructional design, Gender difference

1 Introduction

In recent years, the rapid growth of Internet technology has changed the nature of interaction especially for online learning environments. As a result, there are increasing concerns towards interaction issues of e-learning. Accordingly, the use of interactivity as a variable in empirical studies has dramatically increased with the emergence of new communication technologies such as the Internet. Nowadays, interactivity has become a synonym of quality learning. Engaging learners in the learning process is the pre-requisite for effective e-learning. However, making learning more engaging relies on considerate design of learning activities that allow learners to participate and involve in the learning process. In other words, the design of learning activities must be able to incorporate interactivity into learning process to make learning become engaging and effective. Therefore, interactivity is not just necessary and fundamental in the knowledge acquisition process but also an intrinsic factor for successful and effective online learning [1], [2], [3], [4], [5], [6].

2 Interactivity for on-line learning

Interaction is a two-way communication process. Norman suggested that the interactive process is a repeated looping of decision sequence of a learner's action and the environment's reaction [7]. Kiousis asserted that interactivity is the degree to which a communication technology can create a mediated environment in which participants can participate in reciprocal message exchanges in the forms of one-to-one, one-to-many, and many-to-many communication and both synchronously and asynchronously [8]. Therefore, interactivity consists of three factors, including the technological structure of the media employed, the characteristics of communication settings, and individuals' perceptions [9]. Furthermore, based on the instructional quality of the interaction, Schwier and Misanchuk identified three levels of interaction, including reactive, proactive, and mutual interactions [10]. A reactive interaction is a response to a given question. Proactive interaction involves learner construction and generation activities during the learning process. And in a mutual interactive environment, the learner and system are mutually adaptive in reactions with each other. The relationships among the three levels of interaction are hierarchical in terms of quality of interaction. The quality of a mutual-level interaction is higher than that of a proactive-level interaction, and the quality of a proactive-level interaction is higher than that of a reactive-level interaction. In other words, higher levels of interaction provide greater opportunity for mental engagement and learner involvement than the lower ones in the learning process [10].

The quality of interaction is a function of the learner's response and the computer's feedback [11].

If the response matches the learner's needs, then it is meaningful to the learner. Therefore, interactive learning has to be more than just clicking on and bringing up pop-up menus. Instead, it has to mean more than pointing and clicking and be involving and personal to the learner. However, whether a specific implemented strategy can enhance the interactivity of on-line learning needs to be further examined. Therefore, it is necessary to explore more strategies and examine the effects in increasing the level of interaction of web-based learning in order to attract and engage learners more actively.

3 Individual differences

The individual predispositions somehow condition learners' readiness to benefit from the provided instructional environment. Learners had to fit the instructional environment as given; some benefited more, some less and some not at all. In the field of computer skills learning, prior knowledge has been suggested to dominate learners' performance. Individual differences in background and prior experience have been found to affect the performance and attitude of users of computers [12], [13]. Prior knowledge is either a necessary or at least a facilitating factor in the acquisition of new knowledge in the same content domain. Individuals who have greater knowledge will learn more quickly and more effectively. The domain-specific expertise has been found to be the most important difference between novices and experts in various knowledge domains, such as physics [14], algebra [15], geometry [16], and computers [17]. Previous studies have shown that the most reliable predictions of computing attitude and achievement are based on the amount of prior computing knowledge [18], [19]. Therefore, it is important to examine learners' prior knowledge along with learners' performance in learning computer skills.

Previous computer science education studies have indicated a disproportionate low number of females in the computer science domain [20], [21]. The U.S. Department of Education also found that there was no difference for male and female high school students in the enrolment of computer-related courses, but their preferences in types of courses showed significant different between groups [22]. Singh, Darlington, and Allen also indicated that women's numbers in computer related majors have continued to decline in recent years [23]. The phenomenon of gender differences and similarities has implications for education. Therefore, it is worthy to examine how girls and boys benefit from a specific type of computer-based learning activity, so that educators can deliver instruction and deploy instructional resources adapting to learners' needs.

4 Methods

4.1 Research design

A quasi-experimental design was employed to examine the effect of level-of-interactivity of e-learning courseware on e-learners' achievement in a 3-hour computer graphics e-learning course. Two versions of e-learning courseware were employed to provide e-learners with different levels of interactivity, the high-interactivity courseware and the low-interactivity courseware. The levels of interactivity were distinguished by the instructional strategies implemented in the content presentation, prior-knowledge connection, and practice sessions of the e-learning courseware. Learners are allowed to finish the on-line course in a 2-week period based on personal needs and time available. Due to the pervasive noticed gender differences in the field of computer education, female learners' performance and attitudes were also examined with contrast to the males in the present study. For eliminating the dominant effect of prior-knowledge, Analysis of Covariance (ANCOVA) was conducted on learners' performance with learners' self-reported level of computer skills as a covariate. The significance level was .05 for the present study.

4.2 Participants

There were one hundred and twenty one e-learners who are taking the computer graphics e-learning course participated in this study. Participants were randomly assigned to either the high-interactivity group or the low-interactivity group. For considering the fidelity of learners' involvement in the e-learning course, only those who had participated in the learning activities for more than 90 minutes were identified as the effective sample for the analysis. The numbers of participants for each group are shown in Table 1.

Table 1 The numbers of participants for each group

	High-interactivity	Low-interactivity	Total
Male	27	24	51
Female	20	21	41
Total	47	45	92

4.3 The interactive learning materials

An e-learning courseware was employed to provide a 3-hour tutorial with practice sessions on the computer

graphics concepts and hands-on practice of measuring geometric shapes to the learners. The common format of the employed e-learning courseware was designed using Flash multimedia and followed the principle of nine instructional events and provided learners with learning events of (1) gaining attention, (2) informing the learner of the objective, (3) stimulating recall of prerequisite learning, (4) presenting stimulus materials, (5) providing learning guidance, (6) eliciting performance, (7) providing feedback, (8) assessing performance, and (9) enhancing retention and transfer [24]. Therefore, the pre-set learning goals can be achieved successfully by the learners.

Two versions of the e-learning courseware were developed based on the common format of the tutorial courseware with different levels of interactivity implemented in the content presentation, prior-knowledge connection, and practice sessions. As shown in Table 2, the low-interactivity version employed interactive navigational functions with page-browsing content presentation, keyword-highlight prior-knowledge connection, and fill-the-blank practice. In contrast, the high-interactivity version employed higher levels of interactivity design such as learner-control-browsing for content presentation, keyword-hyperlink for prior-knowledge connection, and interactive practice, but equipped with the same interactive navigational functions as the low-interactivity version did. Therefore, the research can infer learners' difference in performance and attitudes back to the level-of-interactivity reasonably. The design of levels of interactivity of the e-learning courseware is shown in Figure1, Figure 2, and Figure 3.

Table 2 The design of levels of interactivity of the e-learning courseware

	Low-interactivity	High-interactivity
Content presentation	Page-browsing	Learner-control browsing
Prior-knowledge connection	Keyword-highlight	Keyword-hyperlink
Practice	Fill-the-blank practice	Interactive practice

4.3 Instruments

An achievement test was developed and conducted to collect participants' performance in the computer graphics e-learning course. The achievement test was developed by the domain expert and revised by the researcher. The achievement test consisted of 20 fill-the-blank items and was conducted in the form of paper/pencil test immediately after the given 2-week learning period in the learner center where e-learners come to a monthly face-to-face course session. The internal consistent reliability was .71 as measured by Cronbach's α.

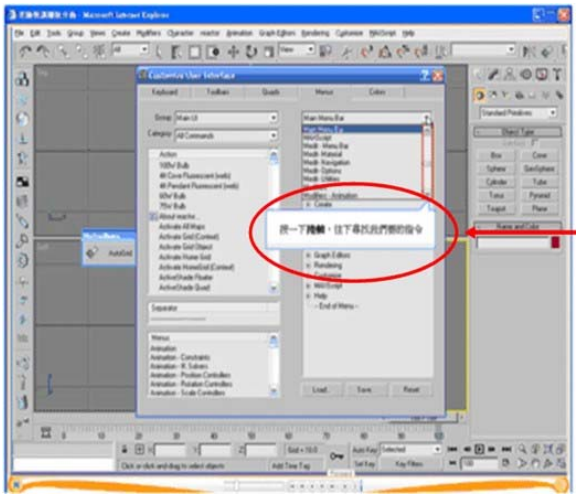

Fig 1. The high-interactivity version employed learner-control-browsing for content presentation

Fig 2. The high-interactivity version employed keyword-hyperlink for prior-knowledge connection support

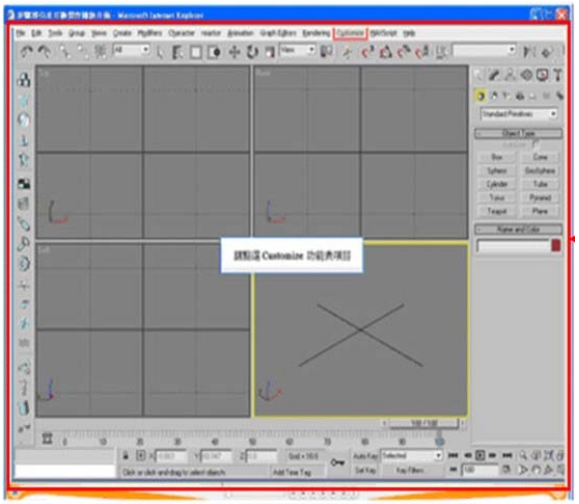

Fig 3. The high-interactivity version employed interactive practice

5 Findings

The group means of participants' e-learning performance are shown in Table 3. The overall mean score for all participants was 14.58. The mean score of males was 15.10 and was slightly higher than the mean score of females (mean=13.96). For the level-of-interactivity groups, the mean score of the high-interactivity group was 15.36 and was higher than the mean score of the low-interactivity group (mean=13.78). As for the interactivity-gender groups, the low-interactivity female group scored the lowest among four groups.

Table 3 Summary of group means of e-learning performance

Gender	Interactivity	Mean	SD	N
Male	Hi-interactivity	15.18	3.00	27
	Low-interactivity	15.00	4.42	24
	Total	15.10	3.70	51
Female	Hi-interactivity	15.60	3.04	20
	Low-interactivity	12.38	4.22	21
	Total	13.96	3.64	41
Total	Hi-interactivity	15.36	3.04	47
	Low-interactivity	13.78	4.48	45
	Total	14.58	3.76	92

Two-way ANCOVA was conducted to examine the effect of interactivity and gender on participants' performance in learning computer graphics on-line with prior-knowledge as a covariate. First, Levene's test of equality was not significant ($F_{(3,88)}$ = .775, p = .551). The null hypothesis that the error variance of the dependent variable is equal across groups was sustained. The ANCOVA summary is shown in Table 4, the effects of interactivity-gender interaction was significant on participants' e-learning performance ($F_{(1,87)}$=5.329, p=.023). Therefore, the simple main effects of level-of-interactivity and gender need to be further examined to explore the nature of the interaction.

Table 4 ANCOVA Summary of interactivity and gender on e-learning performance

Source	SS	df	MS	F	Sig
Prior-knowledge	.250	1	.250	.102	.750
Interactivity	6.604	1	6.604	2.698	.104
Gender	15.977	1	15.977	6.527	.012
Interactivity×Gender	13.045	1	13.045	5.329	**.023**
Error	212.957	87	2.448		

5.1 The simple main effect analysis on interactivity

One-way ANCOVA analyses were conducted to examine the simple main effect of gender and level-of-interactivity on participants' e-learning performance, respectively, with prior-knowledge as a covariate. First, the ANCOVA summary for the high-interactivity group is shown in Table 5. For the high-interactivity group, the simple main effect of gender on e-learning performance was not significant ($F_{(1,44)}$=3.425, p=.071). The result indicated that males (mean=15.18) and females (mean=15.60) performed equally while learning from the high-interactivity e-learning courseware. That is to say, female learners performed as well as males when learning from a highly interactive courseware.

Likewise, the ANCOVA summary for the low-interactivity group is shown in Table 6. For the low-interactivity group, the simple main effect of gender on e-learning performance was not significant The simple main effect of gender on e-learning performance was significant ($F_{(1,42)}$=4.674, p=.036). The result indicated that males (mean=15.00) outperformed females (mean=12.38) while learning from the low-interactivity courseware. In other words, females performed poorly when learning from a low-interactivity courseware, but male learners performed equally no matter the levels of interactivity.

Table 5 Summary of simple main effect analysis for the high-interactivity group

Source	SS	df	MS	F	Sig
Prior-knowledge	.773	1	.773	.319	.575
Gender	.795	1	.795	3.425	**.071**
Error	10.218	44	.232		

Table 6 Summary of simple main effect analysis for the low-interactivity group

Source	SS	df	MS	F	Sig
Prior-knowledge	3.071	1	3.071	.651	.424
Gender	22.051	1	22.051	4.674	**.036**
Error	198.167	42	4.718		

5.2 The simple main effect analysis on gender

Similarly, one-way ANCOVA was conducted to examine the simple main effect of level-of-interactivity on participants' e-learning performance with prior-knowledge as a covariate. As shown in Table 7, the ANCOVA summary for the male group revealed that the simple main effect of level-of-interactivity was not significant ($F_{(1,48)}$=.319, p=.575). The result indicated that the level-of-interactivity did not affect male learners' e-learning performance. They performed equally no matter the levels of interactivity of e-learning courseware.

In contrast, as shown in Table 8, the ANCOVA summary for the female group indicated that the simple main effect of level-of-interactivity was

significant ($F_{(1, 38)}$=11.576, p=.002). In other words, that female learners performed better in the high-interactivity e-learning (mean=15.60) than in the low-interactivity e-learning (mean=12.38).

Table 7 Summary of simple main effect analysis for the male group

Source	SS	df	MS	F	Sig
Prior-knowledge	2.610	1	2.610	1.081	.304
Interactivity	.773	1	.773	.319	.575
Error	115.908	48	2.415		

Table 8 Summary of simple main effect analysis for the female group

Source	SS	df	MS	F	Sig
Prior-knowledge	2.212	1	2.212	.911	.346
Interactivity	28.096	1	28.096	11.576	**.002**
Error	92.227	38	2.427		

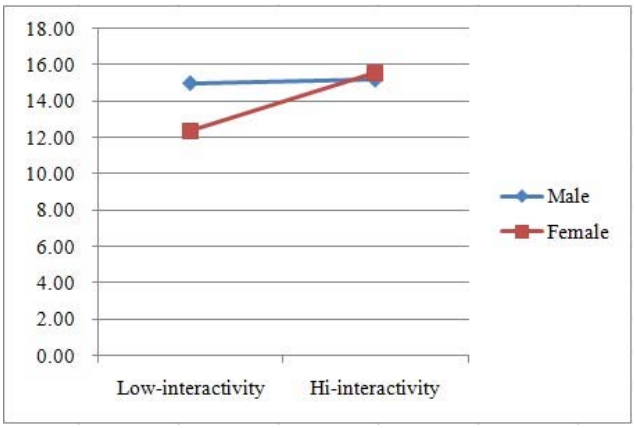

Fig 4. The interactivity-gender interaction on e-learning performance

To sum up, the results of the simple main effect analyses for the significant interactivity-gender interaction on participants' e-learning performance is shown in Figure 4 and indicated that (a) under the high-interactivity mode, male and female learners performed equally, but while under the low-interactivity mode, males outperformed female learners; (b) male learners performed equally no matter the levels of interactivity of e-learning courseware, female learners, however, performed better while under the high-interactivity mode. As shown in Figure 4, it can be inferred that the high-interactivity of e-learning courseware will compensate for female learners' individual difference and help them achieve better performance. Therefore, the implication is that the development of courseware for female learners to learning computers kills on-line should employed higher level of interactivity in the design in order to enhance female learners' performance.

6 Conclusion

Interactivity is the key to successful on-line learning for learners. Through high level of interaction, learners will be able to acquire the learning content based on individual needs, correct misconceptions, and develop into independent learners more efficiently. In the present study, levels of interactivity were implemented in e-learning courseware to provide levels of learner-content interaction for the learners to learn computer skills on-line. In other words, the scope of interactivity examined in the study was only limited to the human-machine interaction, especially the cognitive interaction for learners to comprehend the learning content.

In the present study the male learners performed equally in the high-interactive courseware and the low-interactive courseware. In other words, lower interactivity of the courseware did not affect male learners' performance. This may imply that male learners possessed certain characteristics to compensate for the lower interactivity of the courseware, or the instructional design of the low-interactivity version courseware was sufficient in supporting those learners to achieve the learning goals. In contrast, for the female learners, probably due to female learners' gender characteristics, the low-interactivity version courseware was insufficient in supporting success in the e-learning with comparison to the high-interactivity version. Therefore, it can be reasonably inferred that the high-interactivity of e-learning courseware could compensate for female learners' gender characteristics and bring about better performance. This implies that the design and development of e-learning courseware should incorporate higher level of interactivity to bypass learners' gender characteristics and facilitate learning effectiveness, especially for learning computers from the Internet.

Although, interactivity brings forth higher learning quality for the learners, Reichert and Hartmann indicated that only few computer based learning environments satisfy the demand for a high degree of interactivity [25]. Educational software needs to correspond to the modern multimedia technologies to attract and motivate the learners. Most of the time, the employed leading technologies dramatically increase the cost of the development. How to design e-learning courseware to focus on fundamental concepts and skills of a domain and address various cognitive levels in order to possess long-lived value and, therefore, maintain the cost-effectiveness at a reasonable level has become a subsequent issue for on-line learning.

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