The Effects of Level-of-Interactivity and Gender on Learners' Achievement and Attitude in an E-learning Course on Computer Graphics

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Abstract: - The interactivity of e-learning may affect how learners responding to the learning content. This study examined the effects of level-of-interactivity and gender on learners' achievement and attitudes under the condition of learning computer graphics on-line. One hundred and twenty one e-learners participated in this study and the effective sample size for the present study was ninety two. The effects of level-of-interactivity of e-learning courseware and gender on e-learners' performance and attitudes were analyzed with learners' prior-knowledge as a covariate to eliminate the effect caused by learners' various degrees of background knowledge in computers and the Internet. The analysis on e-learning performance revealed a significant interactivity-gender interaction and indicated that (a) when receiving the high-interactivity e-learning, male and female learners performed equally, but when receiving the low-interactivity e-learning, the male learners outperformed the female learners; (b) from the gender aspect, the male learners performed equally under the high-interactivity e-learning and the low-interactivity e-learning, the female learners, however, performed better when receiving the high-interactivity e-learning. The analysis on participants' attitudes revealed that (a) e-learners were satisfied with the design of e-learning and showed positive attitudes toward the learning guidance, prior-knowledge connection and practice, and (b) the high prior-knowledge learners approach e-learning more positive than the low prior-knowledge learners. It was concluded that the employment of interactivity should suit to the learning needs and individual difference of the learners in order to be effective.

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

1 Introduction

Recently, the rapid growth of Internet technology has changed the nature of interaction especially for online learning environments. There are increasing concerns toward interaction issues of e-learning. Accordingly, empirical studies on interactivity have dramatically increased with the emergence of new communication technologies. Today 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].

Although with the perceived benefits of human to human communications in on-line environments, the importance of human to computer interactions may be apportioned and diminished. However, Sims suggested that interactions between learners and learners or learners and content cannot be assumed to be automatically facilitated by the computer based medium. Instead, interactivity is a critical component of any computer facilitated learning and requires constant maintenance regardless of the medium of delivery [4]. Although the role of interactivity in effective learning is widely accepted, it is not obvious exactly what interactivity is and what types of interactivity can be most effective to engage learners. The multi-facets of interaction in online environments require further efforts and evidences in order to build up a comprehensive body of knowledge. Therefore, this study intend to investigate the effect of level-of-interactivity of e-learning courseware on e-learners' achievement and attitudes in the field of computer skills learning.

2 Interactivity for on-line learning

Interaction is a two-way communication process. Norman [6] suggested that the interactive process is a repeated looping of decision sequence of a learner's action and the environment's reaction. Kiousis [7] 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. Therefore, interactivity consists of three factors, including the technological structure of the media employed, the characteristics of communication settings, and individuals' perceptions [8]. Reichert and Hartmann [9] indicated that there are two types of interactions in on-line environments which are often confused. First, from a social viewpoint, human-human interaction through technology is referred to as computer mediated communication, such as interactions taken place in chat rooms and discussions forums. This type of interaction is supported by general purpose communication tools. The second type is human-computer interaction and referred to as interactivity, such as tutorial courseware and educational simulations. The human-computer interaction can not be provided by technology itself, but rather requires specific purposeful instructional design efforts during the development process. Furthermore, based on the instructional quality of the interaction, Schwier and Misanchuk [10] identified three levels of interaction, including reactive, proactive, and mutual interactions. 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].

From the learner's perspective, Moore [11] identified three types of interaction involved in the process of learning, including learner-content interaction, learner-learner interaction, and learner-instructor interaction. Each type of interaction can have different effects on learners' achievement and attitude. From the perspective of knowledge acquisition, it can be argued that the most important interaction occurs between the learner and the content material [9]. However, based on the quality of interaction, the learner-content interaction can range from low to high levels of interaction. In low level of interaction, there is less interactivity, engagement, and cognitive processing. In contrast, high level of interaction brings forth more interactivity, elaboration, and cognitive processing. Therefore, the effectiveness of learning can be enhanced through high level of interaction.

The quality of interaction is a function of the learner's response and the computer's feedback [12]. 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. In other words, interactivity also means the learner's active participation in the learning process. Therefore, interactivity is necessary and fundamental in the knowledge acquisition process and also the key to successful on-line learning [2], [3]. Through high level of interaction, students will be able to develop into independent learners [5]. Although web-based learning can provide all types of interaction through various means [11], in reality, most web-based learning materials only provide low level hyperlink interactivity. This low level of interaction can not promote learners' learning and motivation. 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 Evaluation of Interaction

Interaction is one of the key variables involved in successful online learning [5]. The assessment methods can be a useful tool for identifying the nature of the interaction occurring in online environments. Previous studies [13], [14] suggested two distinct approaches for assessing interaction, including the micro-level approach which examines the information acquired in the process of interaction and the macro-level approach which examines the flow or patterns of interaction. Sims [4] suggested a framework consisting of who (the learner), what (the content), how (the pedagogy), and when and where (the context) for implementing appropriate interactive strategies in the on-line learning process. Likewise, Hannafin [15] argued that there are two perspectives on interaction, quantitative and qualitative. A quantitative view of interaction refers to external factors such as response frequency or interval, or the number of questions embedded in an instructional module. A qualitative view of interaction mainly emphasizes the learner's role in mediating interaction. The major concern of Hannafin's assertion is how to foster cognitive engagement of the learner by means of the purposeful processing of lesson content. Furthermore, Schulmeister [16] defined six levels of increasing human-computer interaction, Level one means no interaction at all, but only a display of information, Level two lets learners navigate through the information, Level three provides multiple forms of the content, Level four allows the learner to modify the forms of representation, Level five provides the learner to manipulate the content, and Level six allows the learners to create and manipulate objects and monitor what the system reacts. Reichert and Hartmann [9] also suggested that the criteria of good interactive educational software should offer a broad range of tasks on different cognitive levels along with higher level of interactivity.

In addition, Song [17] proposed a multi-level assessment framework to analyze various aspects of interaction in online environments. According to the framework, the unit of analysis at the micro level is the individual message. Through the content analysis of individual messages, the nature of the shared information (message) can be uncovered. As a result of the micro-analysis, each individual message was divided into two main dimensions: cognitive and social. Then, the dimensions can be divided into more specific sub-dimensions according to the nature of the interaction. Due to the fact that individual messages are inter-related to each other, the related messages can form a multiple message combining those individual messages. Therefore, macro-analysis was employed to sketch out the whole picture of an interaction and served as a mean to analyze the interaction more deeply.

Based on the notion that highly interactive e-learning systems must be considered for complex tasks that require some level of decision making real-time, the U.S. Department of Defense (DOD) developed definitions for four major levels of e-learning interactivity to correspond with various levels of learning (fact, rule, procedure, discrimination, and problem solving), as well as identified the resulting skills expected at the end of the training session [18]. These *levels of interactivity* provide a basic set of standards to help define the appropriate level for e-learning systems. Each level is indicated by certain core criteria including nature of content, job descriptions, technology infrastructures and even budget constraints. Level I: Passive, the learner may read text on the screen as well as view graphics, illustrations and charts and acts merely as a receiver of information. There may be multiple choice exercises, pop-ups, rollovers or simple animations. Unfortunately, the passive e-learning systems represent the majority of online learning being used today. However, they are still appropriate when the training session needs to distribute information quickly. Level II: Limited Interaction, the learner makes simple responses to instructional cues embedded in scenario-based multiple choice and column matching related to the text and graphic presentation. Level III: Complex Interaction, the learner makes multiple, varied responses to cues embedded in complex interactions. In addition, scenario-based branching logic is introduced. Learners experience some kind of jeopardy for incorrect responses, and their progress is determined by their decisions. Finally, Level IV: Real-time Interaction creates a training session that involves a life-like set of complex cues and responses in this last level. The learner is engaged in a simulation that exactly mirrors the real-world situation.

Although analyses of interactivity have provided perspectives for assessing interactivity through taxonomies [3], [9], [10], [11], [16] and dimensions [17]. Even so, what a best framework is for assessing interaction remains inconclusive. Interactivity is important but there appears to be no consensus on what interactivity actually represents or involves. Therefore, further research is required to better understand what the concept is and shift the emphasis away from the level of interface interactivity to a consideration of cognitive interactivity. Therefore, the purpose of this study was to examine the effects of types of level-of-interactivity, which were grounded on instructional design theories and aimed to facilitate learners' cognitive learning needs.

4 Individual differences

Individual differences among learners presented a pervasive and profound problem to educators. 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 [19], [20]. 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 [21], algebra [22], geometry [23], and computers [24]. Experts and novices in a domain typically did not differ with respect to general strategies or working-memory size, but did differ significantly in both the quantity and the quality of domain-specific knowledge they possessed [22]. Sternberg [25] suggested that the ability of the more able people to organize their knowledge in a domain in ways allows them to access and use this knowledge efficient and effectively. Weinert, Helmke and Schneider [26] found that domain-specific knowledge can explain learning achievement better than intelligence, and the differences between individuals' prior knowledge can be reduced by instruction. Furthermore, in classes with intensive individualized support, perceived ability was a much less important determinant of math achievement than it was in classes where teachers gave students little individual support. Previous studies have shown that the most reliable predictions of computing attitude and achievement are based on the amount of prior computing knowledge [27], [28], [29].

Waern [30] suggested that the way learners construct mental models depends upon whether or not an individual possesses prior knowledge about the system. The bottom-up approach is commonly used by novice learners who work from the bottom by connecting pieces of information. The top-down approach is usually used by experienced learners who construct mental models based on what they already know. Researchers even suggested that domain-specific expertise can compensate for students' low aptitude on learning domain-related cognitive processing tasks [31]. Glaser [32] also argued that high aptitude learners appear to be skillful thinkers because of the level of their content knowledge as well as their abstract reasoning skills. Therefore, it is important to consider learners' prior knowledge along with learners' performance in computer skills learning.

Previous computer science education studies have indicated a disproportionate low number of females in the computer science domain [33], [34], [35]. The U.S. Department of Education [36] 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. Singh, Darlington, and Allen [37] also found that women's numbers in computer related majors have continued to decline in recent years. The phenomenon of gender differences and similarities has implications for education. Hyde and Linn [38] concluded that emphasis on gender differences in the popular literature has the effect to reinforce the stereotype that girls lack mathematical and scientific aptitude. Hyde and Linn [38] also suggested that gender is a poor indicator of whether one will choose mathematics or sciences as an undergraduate major. A better predictor would be mathematics achievement in previous secondary school or high school. It was suggested that teachers should address variability in aggression and activity level for all learners and try to neutralize traditional stereotypes about girls' lack of ability and interest in mathematics and science. As a result, teachers can avoid discouraging girls from entering the science related fields and continue to focus on the relative progress of all learners so that no one will fall behind. Besides, Hyde [39] further suggested that gender acts as a stimulus are important directions for future studies and this approach could effect a major change in the way in which psychologists conceptualize the concept of gender. 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.

5 Methods

5.1 Research design

A quasi-experimental design was employed to examine the effect of level-of-interactivity of e-learning courseware on e-learners' achievement and attitudes 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 learning guidance, 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 in computers and the Internet, Analysis of Covariance (ANCOVA) was conducted on learners' performance with learners' prior knowledge in computers as a covariate. Likewise, Multiple Analysis of Covariance (MANCOVA) was conducted on learners' attitudes toward the received e-learning with learners' prior knowledge of computers as a covariate. The significance level was .05 for the present study.

5.2 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 present study. 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

5.3 The interactive learning materials

An e-learning courseware was employed to provide a 3-hour tutorial with practice sessions on the topic of measuring geometric shapes in the computer graphics course to the learners. The common format of the employed e-learning courseware was implemented using Flash multimedia and followed the principle of the nine instructional events [40] 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. Therefore, the pre-set learning goals were assured to be achieved by the learners successfully.

Two versions of the e-learning courseware were developed based on the common format of the e-learning courseware with two levels of interactivity implemented in the learning guidance, prior-knowledge connection, and practice sessions. As shown in Table 2, the low-interactivity version employed interactive navigational functions with page-browsing learning guidance, keyword-highlight prior-knowledge connection support, and fill-in-blank practice. In contrast, the high-interactivity version employed higher level of interactivity designs such as learner-control-browsing for learning guidance, 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 difference of the level-of-interactivity reasonably. The designs of levels of interactivity of the e-learning courseware are shown in Figure1, Figure 2, Figure 3, and Figure 4.

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

Interactivity Design	Low-interactivity	High-interactivity
Learning guidance	Page-browsing	Learner-control
Prior-knowledge connection	Keyword-highlight	Keyword-hyperlink
Practice	Fill-in-blank practice	Interactive practice

5.4 Instruments

A prior knowledge test, an achievement test and an on-line questionnaire were employed for data collection in the present study. The prior knowledge test consisted of 16 items to assess participants' fundamental skills in computers and the Internet. The prior knowledge test scores were used as the covariate in the analyses in order to eliminate the effect of participants' various levels of prior knowledge on the e-learning performance and attitudes. The internal consistent reliability was .89 as measured by Cronbach's α.

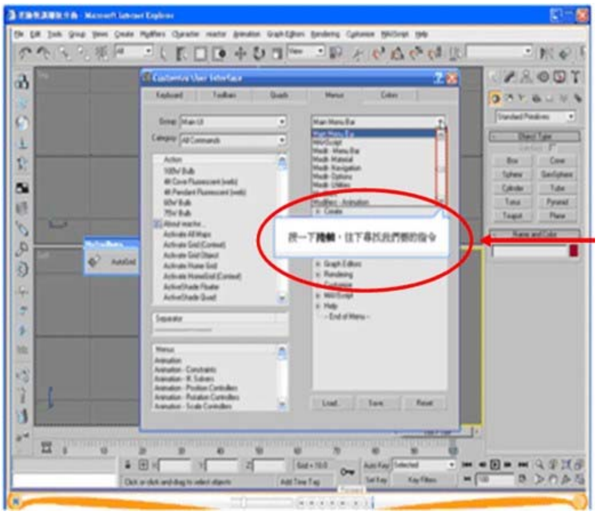

Fig. 1 The high-interactivity version employed learner-control-browsing for content presentation

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

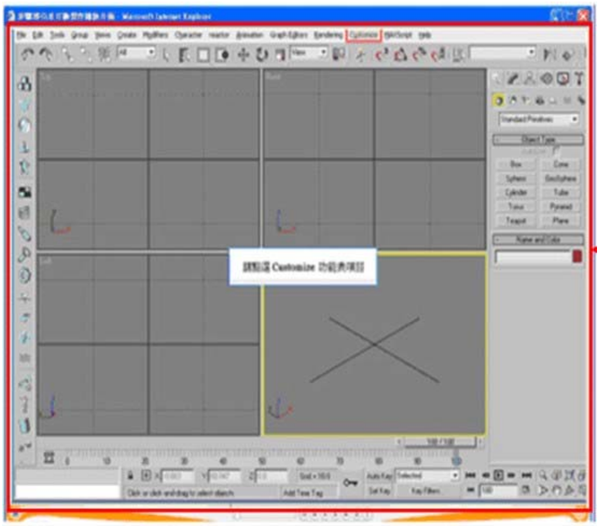

Fig. 3 The high-interactivity version employed interactive practice

Fig. 4 The low-interactivity version employed fill-in-blank for practice

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-in-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.

An on-line questionnaire was developed based on the instructional strategies employed for the levels of interactivity design and conducted immediately after the achievement test. The attitude questionnaire employed a 5-point Likert-type scale to collect participants' perception of the learning guidance, prior-knowledge connection, and practice with 1 to 5 standing for "strongly disagree", "disagree", "neutral", "agree", and "strongly agree", respectively. There were three items for each component measure of the attitude questionnaire. Totally, the attitude questionnaire consisted of 9 items. For ensuring the validity, the instrument was developed and revised by peer experts. The internal consistent reliability coefficients of the component measures of learning guidance, prior-knowledge connection, and practice were .87, .95, and .92, respectively, as measured by Cronbach's α. The overall reliability of the attitude questionnaire was .95 (Cronbach's α).

6 Findings

The adjusted group means of participants' performance are shown in Table 3. The overall mean score for all participants was 14.65. The mean score of males was 15.18 and higher than the mean score of females (mean=14.00). For the level-of-interactivity groups, the mean score of the high-interactivity group was 15.44 and was higher than the mean score of the low-interactivity group (mean=13.83). Furthermore, the standard deviation of the high-interactivity group (SD=3.02) was lower than the low-interactivity group (SD=4.33). This indicated that participants performed more stable when receiving the high-interactivity e-learning than receiving the low-interactivity e-learning. As for the interactivity-gender groups, the low-interactivity-female group scored the lowest (mean=12.25) among four groups.

Table 3 Summary of group means of e-learning performance

Interactivity	Gender	Mean	SD	N
Hi-interactivity	Male	15.14	3.00	27
	Female	15.84	3.04	20
	Total	15.44	3.02	47
Low-interactivity	Male	15.22	4.42	24
	Female	**12.25**	4.22	21
	Total	13.83	4.33	45
Total	Male	15.18	3.67	51
	Female	14.00	3.64	41
	Total	14.65	3.66	92

Two-way ANCOVA was conducted to examine the effect of level-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 ($F_{(3,\ 88)}$=.027, p=.870). The ANCOVA assumption that the error variance of the dependent variable is equal across groups was sustained. The summary of ANCOVA analysis is shown in Table 4, the effects of interactivity-gender interaction was significant on e-learners' performance ($F_{(1,\ 87)}$=4.117, p=.046). Therefore, the simple main effects of level-of-interactivity and gender need to be further examined to explore the nature of the two-way interaction.

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

Source	SS	df	MS	F	Sig
Prior-knowledge	10.117	1	10.117	1.112	.295
Interactivity	88.833	1	88.833	9.760	.002
Gender	17.538	1	17.538	1.927	.169
Interactivity×Gender	38.393	1	38.393	4.117	**.046**
Error	212.957	87	2.448		

6.1 The analysis of the simple main effect of gender

One-way ANCOVA analyses were conducted to examine the simple main effect of gender on participants' e-learning performance with prior-knowledge as a covariate for the high-interactivity group and the low-interactivity group, respectively. The summary of the simple main effect of gender for the high-interactivity group is shown in Table 5. The simple main effect of gender was not significant ($F_{(1,\ 44)}$=1.637, p=.207). The result indicated that males (mean=15.14) and females (mean=15.84) performed equally when receiving the high-interactivity e-learning. That is to say, female learners performed as well as males when learning from a highly interactive courseware.

Likewise, the summary of the simple main effect of gender for the low-interactivity group is shown in Table 6. For the low-interactivity group, the simple main effect of gender was not significant The simple main effect of gender on e-learning performance was significant ($F_{(1,\ 42)}$=4.414, p=.042). The result indicated that males (mean=15.22) outperformed females (mean=12.25) when receiving the low-interactivity e-learning. In other words, females performed poorly when receiving a low-interactivity e-learning, but the male learners performed equally no matter the levels of interactivity of received e-learning.

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

Source	SS	df	MS	F	Sig
Prior-knowledge	.600	1	.600	.571	.454
Gender	1.721	1	1.721	1.637	.207
Error	46.274	44	1.052		

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

Source	SS	df	MS	F	Sig
Prior-knowledge	10.555	1	10.555	.580	.450
Gender	80.300	1	80.300	4.414	**.042**
Error	764.017	42	8.191		

6.2 The analysis of the simple main effect of interactivity

Similarly, one-way ANCOVA analyses were conducted to examine the simple main effect of level-of-interactivity on participants' e-learning performance with prior-knowledge as a covariate for the gender groups, respectively. As shown in Table 7, for the male group, the simple main effect of level-of-interactivity was not significant ($F_{(1,\ 48)}$=.008, p=.930). The result indicated that the level-of-interactivity did not affect the male learners' e-learning performance. They performed equally no matter the levels of interactivity of the received e-learning.

As for the female group, as shown in Table 8, the simple main effect of level-of-interactivity was significant ($F_{(1, 38)}$=13.790, p=.001). In other words, the female learners performed better in the high-interactivity e-learning (mean=15.84) than in the low-interactivity e-learning (mean=12.25). The result indicated that high-interactivity design will compensate for the female learners' gender deficiency and help them to achieve better performance.

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

Source	SS	df	MS	F	Sig
Prior-knowledge	.771	1	.771	.081	.777
Interactivity	.074	1	.074	.008	.930
Error	456.636	48	9.513		

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

Source	SS	df	MS	F	Sig
Prior-knowledge	27.163	1	27.163	3.064	.088
Interactivity	122.251	1	122.251	13.790	**.001**
Error	336.876	38	8.865		

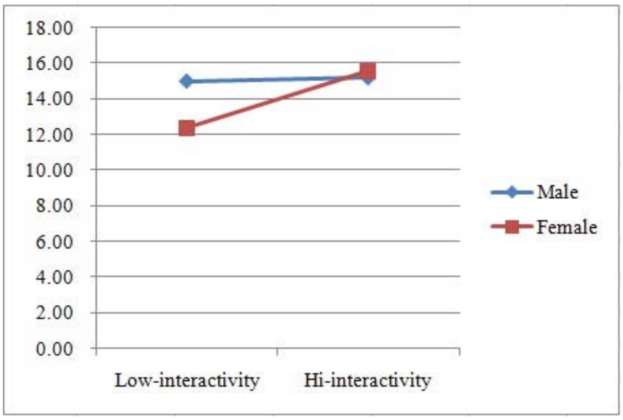

Fig. 5 The interactivity-gender interaction on e-learning performance

The nature of the interactivity-gender interaction is shown in Figure 5. From the interactivity aspect, male and female learners performed equally in the high-interactivity e-learning, but males outperformed females in the low-interactivity e-learning. As for the gender aspect, male learners performed equally no matter the levels of interactivity of the received e-learning, female learners, however, performed better in the high-interactivity e-learning. Therefore, the nature of the interactivity-gender interaction suggested that the high-interactivity of e-learning courseware compensated for the female learners' gender deficiency and helped them achieve better e-learning performance. In other words, a higher level of interactivity e-learning is a better choice to enhance the female learners to learn computers kills on-line.

6.3 The analysis of learners' attitudes toward e-learning

Two-way MANCOVA was conducted to examine the effects of level-of-interactivity and gender on participants' attitudes toward the received e-learning with prior-knowledge as a covariate. The adjusted group means of participants' attitudes for the interactivity groups and the gender groups are shown in Table 9 and Table 10, respectively. The overall mean score for all participants was 4.04 measured by a 5-point Likert-type scale and indicated that participants possessed positive attitudes toward the received e-learning. As shown in Table 9, the mean scores of the interactivity groups in all attitude aspects are around 4 in the 5-pont scale and revealed that both of the high-interactivity group and the low-interactivity group possessed positive attitudes toward the learning guidance, prior-knowledge connection, and practice of the e-learning courseware. Similarly, as shown in Table 10, the mean scores of the gender groups are also around 4 and indicated both males and females held positive attitudes toward the learning guidance, prior-knowledge connection, and practice of the e-learning courseware. The positive attitudes of the gender groups and interactivity groups indicated that the two versions of e-learning courseware are appropriately designed and could suit the needs of various learners.

Table 9 The group means of participants' attitudes for the interactivity groups

Attitude aspect	Courseware	Mean	SD	N
Learning guidance	Hi-interactivity	4.11	.42	47
	Low-interactivity	3.82	.69	45
Prior-knowledge connection	Hi-interactivity	4.07	.54	47
	Low-interactivity	3.89	.75	45
Practice	Hi-interactivity	4.10	.42	47
	Low-interactivity	4.24	.61	45
	Total	4.04	.57	92

Table 10 The group means of participants' attitudes for the gender groups

Attitude aspect	Gender	Mean	SD	N
Learning guidance	Male	3.99	.59	51
	Female	3.94	.54	41
Prior-knowledge connection	Male	3.94	.69	51
	Female	4.02	.63	41
Practice	Male	4.13	.57	51
	Female	4.21	.46	41
	Total	4.04	.57	92

MANCOVA analysis was conducted on participants' attitudes toward the learning guidance, prior-knowledge connection, and practice of the received e-learning. Box's Test of equality of covariance matrices was not significant (Box's M = 15.719, F = .762, p = .747). The homogeneity assumption was sustained. As measured by Wilks' Lambdas, the interactivity-gender interaction was not significant (Wilks' Lambda = .970, p= .450, η^2 = .030), the main effect of gender was not significant (Wilks' Lambda = .973, p = .513, η^2 = .027), but the level-of-interactivity was significant (Wilks' Lambda = .786, p < .001, η^2 = .214). The significant Wilks' Lambda of level-of-interactivity indicated that at least one aspect of participants' attitudes toward the received e-learning was affected by the level-of-interactivity.

The MANCOVA summary is shown in Table 11, the interactivity-gender interaction and the main effect of gender were not significant in all attitude aspects, the main effect of interactivity was not significant in the prior-knowledge connection and the practice aspects but was significant in the learning guidance aspect. In other words, under the condition of eliminating the effect of prior-knowledge, participants' attitudes toward the received e-learning were not affected by gender, and participants' attitudes in aspects of prior-knowledge connection and practice were not affected by level-of-interactivity. However, the high-interactivity group perceives the learning guidance more positive (mean=4.11) than the low-interactivity group did (mean=3.82). In other words, participants perceived the received e-learning positively as measured in the aspects of learning guidance, prior-knowledge connection, and practice. This confirmed that both of the two versions of the employed e-learning courseware were appropriately designed and met most learners' learning needs. Furthermore, higher level of interactivity brought forth more positive attitude toward the learning guidance aspect of e-learning in the learners.

Due to the significant covariate effects of prior-knowledge on participants' attitudes toward the learning guidance, prior-knowledge connection, and practice of e-learning, the group means of prior-knowledge are further examined. As shown in Table 12, the high prior-knowledge group (the top 40%) possessed more positive attitudes toward the learning guidance, prior-knowledge connection, and practice of the e-learning courseware than the low prior-knowledge group (the last 40%) did. In other words, participants with higher prior-knowledge perceived the e-learning more positively, and this could result in positive impacts on those participants' learning computer skills on-line. Possessing high prior-knowledge could bring about better performance and positive attitude has been supported by previous studies [27], [28], [29], [30], [31], [32]. Therefore, it is important to facilitate learners to build up proper knowledge structure and foundations in the early stages of learning, thus learners will be able to successfully progress throughout the on-line learning process.

Table 11 MANCOVA Summary of interactivity and gender on participants' attitudes

Source	Dependent variable	SS	df	MS	F	Sig
Prior-knowledge	Guidance	3.379	1	3.379	9.577	.003
	Connection	2.671	1	2.671	6.626	.012
	Practice	2.585	1	2.585	10.504	.002
Interactivity	Guidance	1.794	1	1.794	5.084	**.027**
	Connection	.703	1	.703	1.744	.190
	Practice	.516	1	.516	2.096	.151
Gender	Guidance	.087	1	.087	.353	.554
	Connection	.078	1	.078	.224	.637
	Practice	.091	1	.091	.405	.526
Interactivity×Gender	Guidance	.016	1	.016	.066	.798
	Connection	.231	1	.231	.665	.417
	Practice	.067	1	.067	.297	.587
Error	Guidance	21.371	87	.246		
	Connection	30.152	87	.347		
	Practice	19.588	87	.225		

Table 12 The group means of participants' attitudes for the prior-knowledge groups

Attitude aspect	Prior-knowledge	Mean	SD	N
Learning guidance	Low	3.92	.70	36
	High	4.15	.50	38
Prior-knowledge connection	Low	3.87	.62	36
	High	4.16	.60	38
Practice	Low	4.06	.66	36
	High	4.32	.52	38

7 Conclusion

Interaction is the key to successful learning. High level of interaction facilitates learners to acquire the learning content based on individual needs, correct misconceptions, and develop into independent learners efficiently. In the present study, interactivity was implemented in two levels in e-learning to provide learner-content interaction for the learners to learn computer skills on-line. The scope of the interactivity examined in this study was, therefore, limited to the human-machine interaction, especially the cognitive interaction for learners to comprehend and apply the learning content. In the present study the level of interactivity did not matter for the male learners to learning computer graphics on-line, however, the female learners performed better in the higher interactive e-learning. This may imply that the male learners' gender characteristics may compensate for the lower interactivity, or the instructional design of the low-interactivity version courseware was sufficient in supporting those learners to achieve the learning goals. In contrast, probably due to the female learners' gender characteristics, the low-interactivity e-learning was incapable of supporting success in e-learning. Therefore, it is reasonable to infer that the high interactive e-learning could compensate for the female learners' gender deficiency and bring about better e-learning performance in learning computer graphics.

Although, interactivity brings forth higher learning quality for the learners, Reichert and Hartmann [9] indicated that only few computer based learning environments satisfy the demand for a high degree of interactivity. 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 focus on fundamental concepts and skills of a domain and address various cognitive levels in order to possess long-lived value and, therefore, maintain at a reasonable level of cost-effectiveness for the development of e-leaning becomes a critical subsequent issue for on-line learning.

Furthermore, appropriate designed learning guidance will facilitate e-learners to comprehend the learning content and generate better application and performance. In the present study, high level of interactivity brought about more positive attitude toward learning guidance in the learners. However, e-learners seemed not to favor the interactive practice over the fill-in-blank practice. The reason could be contributed to the format of the outcome assessment as well as the characteristics of the domain knowledge. The topic of the employed e-learning was measuring the area of geometric shapes. The measurement required the learners to carry out calculations on the area of a given geometric shape. The interactive practice probably will enhance learners' comprehension and application of the construction of the geometric shapes. However, the calculation of the area takes a more implicit cognitive effort and probably just fit in the fill-in-blank format of assessment. Therefore, the use of interactivity should suit the learning task in order to be effective in facilitating learners' performance or attitude.

To sum up, interactivity has become a synonym of quality e-learning today. Engaging e-learners in the learning process by means of high-degree interactivity is the pre-requisite for achieving expected learning goals. Making learning more engaging relies on considerate design of learning activities as well as deliberate considerations of individual differences. Therefore, e-learners can involve in the learning process actively and truly benefit from the learning activities.

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