Exploring the Effects of Game-based Instructional Design on 3D Animation: A Perspective of Technology Acceptance

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Abstract: - The purpose of this study was to investigate the effects of individual differences on learners' performances of three-dimensional animation through game-based instructional design. Participants were 78 college juniors enrolled in a 3D animation course, an 18-week course designed for enhancing students' animation skills. A *t*-test was conducted to analyze the independent variables by self-regulation, perceived parents' expectancy, perceived teachers' expectancy, and perceived initiative on project performance as the dependent variables. An online questionnaire was conducted at the end of the semester to obtain learners' perceptions of the system. The results showed that (a) students with higher self-regulation and stronger parents' expectancy outperformed the lower-group on project performance, (b) there were no significant differences on learners' acceptance grouped by gender and perceived parents' expectancy, (c) students with stronger teachers' expectancy demonstrated higher acceptance on perceived ease to use, perceived usefulness, and perceived willingness to use, and (d) students with higher perceived initiative showed more positive attitude in willingness to use the system.

Key-Words: - 3D animation, Game-based learning, Individual differences, Virtual reality, Self-regulation

1 Introduction

In recent years, e-learning system has become a promising technology for educational purposes. These revolutions are rapidly reaching into maturity, and their deployment provides a fully probability for the new patterns of work, life, and play in both academic and professional environments [1]. Several studies have noted that e-learning allows learners to take lessons in their own pace, expend times in their own choosing, and in sequence that they prefer [2], [3]. Moreover, e-learning system now can combine with ubiquitous computing and mobile technologies to provide much broader scope for innovative learning experiences that can take place in a variety of outdoor and indoor settings [4]. Thus, through the novel technologies and the network connectivity, e-learning enables learners to interact simultaneously with both the physical world and digital information for a new way of thinking and operating [5].

This paper thus examined the effects of using the game-based instructional design on 3D animation skills learning based on the pedagogical concepts of "goals expectancy" and "virtual simulations". The aim of the present study was to understand the influences of the individual differences on learners' acceptance of game-based learning in a web-based environment so as to provide implications for theoretical and practical practice. Based on the results from project reports and questionnaires, learners' attitudes toward the game-based e-learning as well as several emerging individual features were examined and discussed.

2 Literature

This section explores the theoretical viewpoint and in game-based learning. First, we express the game-based learning as the primary foundation for instructional guidelines. Then, we describe the conceptions and applications of self-regulation and parents' expectancy. Finally, students' attitudes, such as the effects of perceived-initiative on the learning effectiveness, are discussed respectively.

2.1 Game-based Learning

Game based learning (GBL) is a specific term of instructional strategies or activities that deals with the applications that have defined learning outcomes. As an emergent learning process, game-based learning is designed to incorporate the subject matter in the gameplay and to help the player to

retain and apply the subject matter to the real world [6], [7]. Game-based learning usually uses video-game technology, scoring strategy, interactive interface, flexibility course, and real-time feedback to engage learners into their learning [8]. It not only makes learning more meaningful but also creates a mental model which is response to participants' motivation [9], [10].

With the rapidly development of information and communication technology, computer and simulation games have become the most popular leisure activities in our daily life. Many educational scholars claim that computer game is the natural and necessary element of student's learning and it should be integrated into the instructional design as well as learning environments [6], [7]. They also believe that playing computer games applies the concept to "learning by playing", which helps students overcome the boredom of learning in the classroom [11], [12]. However, there are still some weaknesses and drawbacks in the implementation of game-based learning: (a) Game-based learning needs a lot of preparations and efforts; (b) the subjects and contents usually are pre-defined and fixed. More specifically, the workload of these tasks is very large and the completion of the application may not really meet the demand [13]. On the other hand, e-learning systems are usually designed to support alternative methods for traditional instruction in order to improve the quality of student learning and to reduce the costs of instruction [14]. Hence, the game-based e-learning has been proposed. As Clark and Mayer [15] noted in their review of e-learning, well-designed system can help generate the contents of entertaining scenario that correspond to the learning subject. Stated another way, game-based e-learning system should make the preparations of learning applications with less efforts and better efficiency [16].

2.2 Self-regulation in E-Learning

In recent years, e-learning has become the most popular and widely implemented approach for learning. In addition, the ubiquitous computing and network technologies which allow learning to take place anytime and anywhere and hence provide various innovative learning experiences. However, more flexibility means more responsibility. Learners are expected to be more self-aware and to have more self-control over their learning by actively participating in e-learning situation. Unfortunately, most students who favor in e-learning environment not only have a poor knowledge base of effective strategies but also fail to select, evaluate, and adjust faulty strategies when they are not working effectively [17]. Thus, how to facilitate learners' active learning and provide strategies for self-discipline on their e-learning process has become an essential issue.

Self-regulation is defined as self-generated thoughts, feelings, and actions for attaining academic goals [18]. Researchers criticized that self-regulation refers specifically to the processes of self-awareness, self-monitoring, self-judgment and self-reactive [19]. Many researchers have verified that the procedures of self-regulation could be learned as a strategy to help students to handle their learning and to perform the learning tasks efficiently [20]. Therefore, one of the purposes of this study was to further explore the effects of self-regulation in an e-learning environment.

2.3 Parents' Expectancy in Learning

Expectancy is defined as "a belief about a future state of affairs", and an interpersonal expectancy is a belief about the future behavior of another person [21]. In most theories of achievement motivation, achievement goals and goal expectancy are critical factors of goal-oriented activities. Goal expectancy consists of children's expectation that their level of performance will result in goal attainment [22]. However, the expectancy of parents and teachers seem only work by establishing appropriate goal expectancy and frustration tolerance in their children.

A number of studies have investigated that Chinese parents' attitudes do have an influence on children's behavior [23]. Stevenson's comparative study of Chinese and American children shows that Chinese children have higher cognitive abilities than American children [24]. Interestingly, when we compare the Chinese culture with Western culture, Chinese educational system seems to place more emphasis on the active participation of parents and teachers. Besides, the instructions children receive are more intensive and involve more tutoring. Thus, reasonable inference is that Chinese parents' expectancy is the critical determinants of children's mental development. It is therefore worthy to explore whether parents' expectancy affects the learning outcomes of the 3D animation learning by game-based instructional design.

2.4 Acceptance toward Game-based Design

The role of game-based e-learning technologies continues to expand for both virtual reality and

game engine of learning activities. Many studies examining this trend have focused on technology issues [25], [26], student achievements [27], or collaborative design [28], [29]. However, previous studies did not address learners' attitudes, which are also important contributing factors to the design of better game-based learning activities.

Zimbardo and Leippe [30] defined attitudes as an evaluative disposition toward some object based upon cognitions, affective reactions, behavioral intentions, and past behaviors. Various disciplines have considered the issue of learners' attitudes and perceptions of game-based learning technologies in educational environments, such as class interaction, class satisfaction, perceived initiative, computer proficiency, perceived performance, perceived usefulness, perceived ease-to-use, and willingness to use [31]. Waycott and Kukulska-Hulme [32] firmly suggested that prior experience on resemblance technologies is an influential factor to affect learners' acceptance of novel technologies.

Although individual characteristics vary among learners, the majority of the studies mentioned above agreed that learners hold positive attitudes toward the new technologies. Therefore, this study intended to develop simulations for learning 3D animation and examined the effects of individual difference factors on learners' attitudes toward game-based e-learning.

3 Methodology

3.1 Participants and Scenario

The present study investigated the effects of self-regulation and individual differences, such as learner's perceived parents' expectancy and initiative, on project performances in an 18-week 3D animation course on a game-based e-learning system. Base on the game-based learning theory, an instructional design with the learning goal setting was implemented in the 3D and virtual reality software, named Virtools. The detail of syllabus is shown in Table 1. The purpose of this instructional design was to facilitate participant's animation skills and production performance. The participants were 78 juniors, 54 male (69.2%) and 24 female (30.8%), enrolled in the 3D animation course.

A 3D project was assigned to the students for the assessment of learners' performance on the 3D animation skills. Students had to finish the learning tasks on schedule. The project environment, scenario and example of game-based learning goal are shown as figure 1, 2, 3, and 4.

Table 1: The syllabus of the experiment course in present study

Session	Topics	Instructional Design
Preparation works	Teaching Animation and System Design	Gathering the course material and data and preparing education implementation examples.
1th Week	Introduction to Teaching System	e.g. examples, animations and tutorial description
2th-3th Week	Integrated 3DS MAX Elements	Import objects and characters into Virtools scene; try to do arrangements for game design.
4th-5th Week	Character and Object Modeling	e.g. camera, light, animation, and so on.
6th-8th Week	Game Process Design	e.g. scene script, object script, and character script.
9th Week	Midterm Exam	Midterm result is announced via webpage to emphasize the learning results.
10th-11th Week	Sound and Particles System	Deal with sound effects and particles system.
12th-13th Week	Collision and Video	Simulate three-dimensional collision characteristic and combine with video content
14th-18th Week	Team Project Assignment	Announce term project requirement and grading policy regarding project.
14th-17th Week	Path Constraint Animate on Mouse and Keyboard	e.g. object moving rule, keyboard function, mouse control, and character perspective.
18th Week	Final Exam and Suggestions	Project presentation, peer exchanges advices and tips.

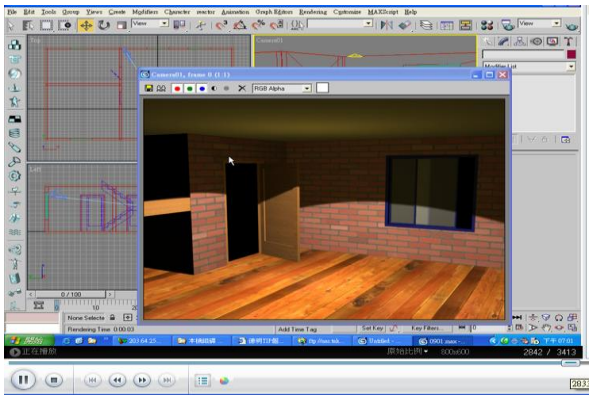

Fig-1: The game-based learning tools in this study

Fig-2: The game-based learning tasks in this study

Fig-3: Example of game-based learning environment

Fig-4: Scenario (racing track) of the learning game

3.2 System Architecture

A web-based integrated system was developed for enhancing learners' animation skills and knowledge sharing. The system consists of multimedia material download and upload server, game design platform, and web-based discussion forums. The multimedia material download and upload server provides the instructional animations, videos, audios, images, and components management. Examples and tutorials are also provided through the multimedia server. Learners can access them via hyperlinks of discussion forums or directly download from ftp service. The game design platform allows learners to browse instructional data and follow the guidelines to design Virtools games step by step. Some quizzes were conducted between sessions in order to promote the comprehension of animation commands and to elaborate individual cognition for knowledge construction. The system architecture of the web-based interaction learning system is shown in figure 5.

Meanwhile, the online discussion forums were employed to facilitate students to communicate among the project participants, including instructor, material designers, subject experts and students. According to the learning community theories, the discussion forums play a part in sharing and co-constructing experiences of learning process. And the feedbacks from community are utilized to make a comment or criticism in a metaphor way. Thus, the procedure of discussion is monitored by learners for necessary modifications toward their expectancy and learning goals.

Furthermore, the discussion forums also let learners to keep learning in "self-regulation". Self-regulated learning refers to the process of analyzing and making judgments about what has happened. Based on the researchers' claim [19], self-regulation includes the processes of self-awareness, self-monitoring, self-judgment and self-reactive. In this study, learners can issue their creations, problems and progress through the forums to discuss with each other later. Alternatively, learners can create their own learning profiles in the integrated system. Through reviewing the profiles, learners are aware of and are able to control their learning by actively performing reflective thinking.

3.3 Research Design and Questionnaire

A *t*-test was conducted to analyze the independent variables by self-regulation, perceived teachers' expectancy, perceived parents' expectancy and

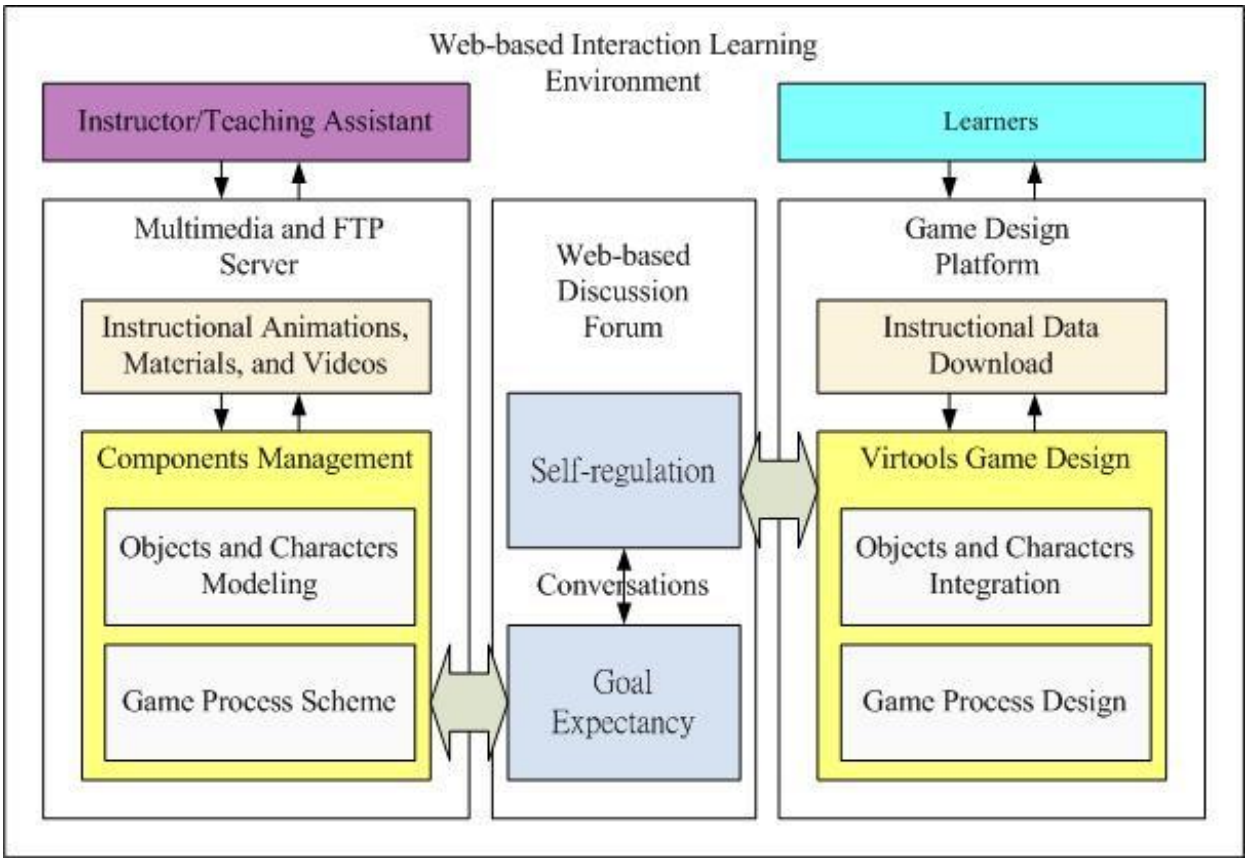

Fig-5: The system architecture of web-based integrated learning system

perceived initiative on project performance as the dependent variables. The high-low group procedure was employed to identify the top fifty percent participants as the high-group and the others as the low-group based on the data collected from the investigation. The significance level (Alpha) was set to .05 for the data analysis.

Three research instruments utilized in this study were a revision of MSLQ (motivated strategies for learning questionnaire [32]), a revision of college student perceived initiative scale [33], and an online attitude questionnaire developed by the researchers. These instruments are described as follows.

The MSLQ, based on a general cognitive view of motivation and learning strategies, consists of three aspects of subscales, including the motivation, the learning strategies, and the metacognitive strategies subscales. The motivation section has 31 items that assess students' goals and value beliefs for a course. The learning strategies section includes 31 items regarding students' use of different cognitive and metacognitive strategies and 19 items concerning students' management of different learning resources. In this study, we chose 6 items from the subscale of metacognitive as the measurement of learners' self-regulated strategies. The original reliability of the scale was .943 (Cronbach's alpha). In present study, the reliability of the revision of self-regulated subscale was .872 (Cronbach's alpha).

The educational expectancy scale surveyed learners' stronger or weaker mentality as reflection on their own learning, which consisted of 18 items with 6 items for each subscale, including learners' perceived expectancy of their parents, their teachers, and perceived initiative of their own. For each item, the students answered on a 5-point Likert-type scale ranging from 5 points, representing "strongly agree," to 1 point, representing "strongly disagree." The scale was developed by Lin & Huang [33] specifically for the students of vocational college. The original reliability of the scale was .859 (Cronbach's alpha). In present study, the reliabilities of each subscale were listed in Table 2.

For the learners' attitudes, a revision of online questionnaire developed by Davis, Bagozzi and Warshaw [34] was administered immediately after the last learning session to examine learners' perceived usefulness, perceived ease-to-use, and willingness-to-use toward the game-based learning system. Learners were asked to rate themselves on a 5-point Likert-type scale with response options ranged from 1 (strongly disagree) to 5 (strongly agree).The reliabilities of the attitude questionnaire and its component measures are also shown in Table

2. Base on the reliability coefficients, it was concluded that the questionnaire and its component measures were reliable.

Table 2: A summary of reliability of present study

Research Instruments	Items	Chronbach's α
Independent variable		
Self-regulation	6	.782
Expectancy of parents	6	.875
Expectancy of teachers	6	.919
Perceived Initiative	6	.807
Dependent variable		
Perceived usefulness	3	.887
Perceived ease-to-use	3	.897
Willingness-to-use	3	.857

4 Result and Discussion

The purpose of this study was to examine the effects of individual differences on learners' project performances and their acceptance of game-based learning design. The dependent variables were the performance of term project assessed by two instructors. The Spearman rank correlation coefficient indicated that there was no significant difference (p = .564) between the two scores. The mean scores, standard deviation and skewness of the study variables are shown in Table 3. We can see that the distributions for all variables were well within the range of the normal distribution, except for the project performance, which scores were quite peaked and slightly skewed toward the higher values of the records.

Table 3: Descriptive statistics of the variables in study

Measures	Descriptive Statistics			N
	M	SD	Skew	
Independent variable				
Sel-regulation	3.408	.777	.191	78
Expectancy of parents	3.095	.913	.475	78
Expectancy of teachers	3.882	.869	-.353	78
Perceived Initiative	3.468	.793	.125	78
Dependent variable				
Project performance	82.71	9.07	-1.006	78
Perceived usefulness	4.156	.547	-.082	78
Perceived ease-to-use	3.750	.692	-.210	78
Willingness-to-use	4.021	.570	.042	78

As can be seen from Table 3, participants in this study demonstrated positive attitudes toward the perceived usefulness, perceived ease-to-use, and willingness-to-use on 3D animation skill learning with game-based instructional design with the mean scores of 4.156, 3.750 and 4.021, respectively. Next, the effects of individual difference factors on learners' attitudes toward game-based e-learning were examined using *t*-test analysis.

4.1 Students with Higher Self-regulation and Stronger Parents' Expectancy Performed Better

The mean scores, standard deviation and *t*-test results of the independent variables— self-regulation, expectancy of parents, expectancy of teachers, and perceived initiative are shown in Table 4. The differences of the effects between high group and low group of self-regulation (t = 2.025, p=.046) and expectancy of parents (t = 2.532, p=.013) were significant. The mean values of self-regulation indicated that the high-group (M=84.64, SD=7.904) scored higher than the low-group (M=80.06, SD=10.076). Similarly, the mean values of expectancy of parents showed that the high-group (M=85.16, SD=8.629) scored higher than the low-group (M=79.53, SD=11.016).

Table 4: The *t*-test summary of independent variables on the project performance

Attitudes	N	Descriptive Statistics			*p*
		M	SD	*t*	
Self-regulation					
High	38	84.64	7.904	2.025	.046
Low	40	80.06	10.076		
Expectancy of Parents					
High	36	85.16	8.629	2.532	.013
Low	42	79.53	11.016		
Expectancy of Teachers					
High	39	82.17	10.763	-.556	.580
Low	39	83.47	9.105		
Perceived Initiative					
High	40	84.03	10.287	1.190	.238
Low	38	81.32	9.787		

These data indicated that the learners with high self-regulation performed better than the lower ones significantly when the project achievement was facilitated by game-based instructional design and e-learning system. The result of self-regulation on learning performance was similar to the studies of Zimmerman [17] and Kao, Lin, and Sun [20] in that learners who have superior ability of self-regulation received higher scores in technology-based course. The implication of this study is that providing self-regulation scaffolding enhances students' performance in game-based e-learning system.

Furthermore, the data also indicated that the learners with high expectancy of parents performed significantly better than the lower ones. The result was similar to the studies of Stevenson [23] and Stevenson et al., [24] that parents' expectancy is the significant determinant of learning and mental development for Chinese students. The implication

of this study is that providing explicit awareness of parents' expectancy promotes students' learning motivation.

4.2 No Significances on Gender Difference and Parents' Expectancy

The mean scores of gender and participants' perceived expectancy of parents on attitudes are shown in Table 5. The male group scored higher than their female counterpart in the perceived usefulness (4.215 > 4.025), perceived ease-to-use (3.781 > 3.679), and willingness-to-use (4.048 > 3.958). Furthermore, participants were identified as high or low perceived expectancy of parents group by the mean score (M=2.09). The results show that high expectancy group scored higher than the low group in the perceived usefulness (4.276 > 4.064), perceived ease-to-use (3.797 > 3.714) and willingness-to-use (4.147 > 3.923).

Table 5: The *t*-test summary of gender and learners' perceived expectancy of parents on attitudes

Attitudes	N	Descriptive Statistics			*p*
		M	SD	*t*	
Gender					
Perceived usefulness					
Male	54	4.215	.579	1.528	.122
Female	24	4.025	.450		
Perceived ease-to-use					
Male	54	3.781	.702	.600	.550
Female	24	3.679	.679		
Perceived Willingness-to-use					
Male	54	4.048	.592	.640	.524
Female	24	3.958	.524		
Expectancy of Parents					
Perceived usefulness					
High	34	4.276	.537	1.727	.088
Low	44	4.064	.542		
Perceived ease-to-use					
High	34	3.797	.619	.526	.601
Low	44	3.714	.749		
Perceived Willingness-to-use					
High	34	4.147	.558	1.747	.085
Low	44	3.923	.566		

According to the Table 5, *t*-test results showed that the effects of gender difference on perceived usefulness (t=1.528, p=.122), on perceived ease-to-use (t=.600, p=.550), and on perceived willingness-to-use (t=.640, p=.524) were all nonsignificant, indicating that gender difference did not affect participants' attitude and acceptance toward 3D skill learning with the game-based design significantly.

Furthermore, the *t*-test results demonstrated that the effects of participants' perceived expectancy of parents on usefulness (t=1.727, p=.088), on the effects on perceived ease-to-use (t=.526, p=.601), and on perceived willingness-to-use (t=1.747, p=.085) were not significant, revealing that learners' perceived expectancy of parents did not affect the attitude and acceptance toward 3D skill learning with the game-based design significantly.

4.3 Higher-group of Teachers' Expectancy Show More Positive Attitude

To investigate the effects of perceived expectancy of teachers on learners' attitudes toward the game-based e-learning, participants were identified as high or low expectancy group by the mean score (M=2.88). The results of *t*-test are shown in Table 6.

Table 6: The *t*-test summary of learners' perceived expectancy of teachers on attitudes

Attitudes	N	Descriptive Statistics			*p*
		M	SD	*t*	
Expectancy of Teachers					
Perceived usefulness					
High	46	4.313	.500	3.212	<.01
Low	32	3.931	.539		
Perceived ease-to-use					
High	46	3.917	.635	2.661	<.01
Low	32	3.509	.708		
Perceived Willingness-to-use					
High	46	4.191	.530	3.382	<.01
Low	32	3.775	.542		

Some significant effects of expectancy of teachers on learners' attitudes toward game-based e-learning were obtained from the results. The effects of expectancy of teachers on perceived usefulness was significant (t=3.212, p < .01) with the high expectancy group (M=4.313) scored higher than the low expectancy group (M=3.931). In addition, the effects of expectancy of teachers on perceived ease-to-use (t=2.661, p < .01) were significant as well. The high expectancy group (M=3.917) scored higher than the low expectancy group (M=3.509). Finally, the effects of expectancy of teachers on willingness-to-use (t=3.382, p < .01) were also significant. The mean values revealed that the high expectancy group (M=4.191) scored higher than the low expectancy group (M=3.775).

The data indicated that the learners who perceived stronger expectancy of teachers outperformed those who perceived weaker expectancy of teachers while learning in the e-learning system with the mechanism of game-based design. The result is interesting and worthy of further investigation on how game-based e-learning design could result in this outcome.

4.4 Learners with Higher Perceived Initiative Show Higher Score on Willing-to-use

Finally, participants were identified as high or low perceived initiative group by the mean score (M=2.47). The *t*-test results on learners' attitudes toward the game-based e-learning are shown in Table 7.

Table 7: The *t*-test summary of learners' perceived initiative on attitudes

Attitudes	N	Descriptive Statistics			*p*
		M	SD	*t*	
Initiative					
Perceived usefulness					
High	40	4.245	.485	1.480	.143
Low	38	4.063	.598		
Perceived ease-to-use					
High	40	3.768	.717	.228	.820
Low	38	3.732	.674		
Perceived Willingness-to-use					
High	40	4.145	.536	2.018	.047
Low	38	3.889	.582		

The results showed a slightly significant effect of learners' perceived initiative on attitudes toward game-based e-learning. More specifically, the effects of perceived initiative on willingness-to-use was significant (t=2.018, p=.047), with the high perceived initiative group (M=4.145) scored higher than the low perceived initiative group (M=3.889). However, the effects of perceived initiative on perceived ease-to-use (t=1.480, p=.143) and on willingness-to-use (t=.228, p=.820) were not significant.

According to the Table 7, the initiative learners showed more positive attitude in aspects of willingness-to-use toward game-based e-learning than the less initiative learners. This finding supported the hypothesized assertion of "e-learning learners have to be active learners". Although learners' achievements were not examined in this study, the results suggested that the initiative learners would enjoy and benefit more from game-based e-learning than the less initiative ones.

5 Conclusion

In this study, the development and use of 3D animation e-learning system with game-based design was based on the pedagogical needs in order to facilitate learning. Although there are still some weaknesses and drawbacks in the implementation of game-based learning, learners showed high preferences toward its features in facilitating thinking and mental model construction for the 3D animation skills learning. Our reflections on the responses from the participants during and after the initial study of the gamed-based e-learning system were summarized as follows.

5.1 Pedagogical Design with Fascinating Technology

Game based learning has become the most popular learning platform for various educational purposes. More and more the desktop applications are gradually integrated with game-based design for better authenticity. Learners are motivated to be more engaged and active in learning activities when the new technology is used in a meaningful way. Therefore, it is desirable to develop instructional implications on how these fascinating technologies can be incorporated to the customary learning activities.

5.2 Expectancy is the Significant Determinant of Learning for Chinese Students

In this study, learners with stronger expectancy of parents performed better than the lower ones. Similarly, learners with stronger teachers' expectancy also demonstrated higher acceptance to the e-learning system on perceived ease-to-use, perceived usefulness, and perceived willingness-to-use. Based on our analysis, the Chinese educational system seems to place more emphasis on the active participation of parents and teachers, learners' perceived expectancy from their parents and teachers will likely result in higher learning motivation. Thus, for Chinese students, expectancy is the critical determinants of learning

5.3 Initiative Learners Show More Positive Attitudes toward Game-based e-Learning

Game-based e-learning as an emergent learning strategy and process are exciting to learners with technology novelty. This study examined learners' attitudes through perspectives of various individual differences. Learners in all groups have become more initiative in information comparing, more curious in experimenting phenomena, and more frequent in communicating with each other in coordinating classroom works. Based on self-reports and questionnaires, initiative learners showed more positive attitudes in willingness-to-use, ease-of-use, and usefulness aspects than less initiative learners. In other words, initiative learners enjoy and benefit from game-based design than less initiative learners.

In conclusion, learners' intention in using game-based e-learning system begins with positive attitudes toward using them in the classroom. Given the rapid growth of applying game-based design to learning around the world, measuring attitudes towards the use of them will be critical in establishing appropriate interventions that help instructors integrate these resources into the education situation. In this study, the integration of game-based e-learning system and asynchronous discussion forum to facilitate 3D animation skill has been validated to be a feasible way in constructing an effective learning environment.

Acknowledgement

This study was sponsored by the National Science Council of Taiwan, project number: NSC 98-2511-S-147-001-MY2.

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