3D GAME-BASED LEARNING SYSTEM FOR IMPROVING LEARNING ACHIEVEMENT IN SOFTWARE ENGINEERING CURRICULUM

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ABSTRACT
The advancement of game-based learning has encouraged many related studies, such that students could better learn curriculum by 3-dimension virtual reality. To enhance software engineering learning, this paper develops a 3D game-based learning system to assist teaching and assess the students' motivation, satisfaction and learning achievement. A quasi-experimental design is based on the ARCS Theory (Attention, Relevance, Confidence, and Satisfaction) to investigate the effectiveness of game-based learning strategy in 3-dimension virtual reality scenario. The students are randomly assigned into two groups for quasi-experimental design. In game-based learning, the curriculum content is mapped into the game to provide a scenario learning environment. After implementation of quasi-experimental design, the pre-test and post-test results shown that 3D game-based learning system with software engineering curriculum could achieve a better learning achievement and motivation than using traditional instruction. The statistical test displayed that learning motivations of students have significant impact on learning achievement, and learning achievements of students with game-based learning are better than those who use traditional face-to-face teaching. After re-checked the questionnaire, this paper finds that game-based learning challenging and attractiveness can lead to learners' curiosity and immersion in learning activity. And the results show that 80% students are satisfaction, and 83% students are confidence for the course learning after use the game-based learning system. Lastly, the research results could provide to related educators as references.
Keywords: Game-based learning; ARCS Model; software engineering curriculum

INTRODUCTION

Internet is a rich source of information, and more and more people make information available online. One day, the knowledge from internet will be more than teachers alone can provide. Obviously, the traditional teaching and unilateral knowledge acquisition has not attracted the attention of young people, and cannot fulfill the needs of the information society. Because the convenience of network and interactivity results in increasing time and location flexibility, e-learning has become the development trend of education and learning.

Since the global economic downturn 2012, revenues of all industries have been declining. People cut their expenses and the economy is in recession. This time, the game industry has launched a leisure and entertainment of free or lower consumption, creating another business opportunity. As the players spend more money on virtual goods, the game industry is unaffected by the economic downturn and keeps growing. Online games seem to gain more and more popularity.

Today the internet has become an indispensable element of the business community. Due to its prevalence, the network provides quick information technology access to various industries. Information systems improve the effectiveness and save time, becoming an important tool for business management, decision-making, competition and development.

Regardless whether the economy is flourishing or weak, the company gives the Information Technology (IT) budget priority and has high expectations in the systems. Information Technology has become the number one key to successful business.

Therefore, the system developer, who the business needs, must have some knowledge and skill understand the concept of the system development, and be proficient in information system analysis, design, maintenance and management, in order to develop high-quality information systems. System analysis through a systematic collection, analysis and comparison, proposes an effective solution approach. On the other hand, system analysis is the process of effective problem solving, which makes "system analysis" become an important task.

Systems analysis is a combination of many academic disciplines with a certain expertise which needs to be practiced to be familiar with implementation procedures. But now most learning approaches of system analysis

are in accordance with the traditional face-to-face way, and textbooks often seem esoteric with their many steps, theories and case studies, but lack practical exercise. Students only learn "what to do", but they cannot really understand "how to do". This study shows that the opportunities of practical exercise, interest and achievement of students can be improved by using game-based learning combined with high interaction and high feedback.

There are some reasons for introducing the game presented in this study: From the educational point of view, John (1938) proposes “Learning by Doing”. The learning pace and way of each student is different, and with the traditional face-to-face teaching approach it is difficult for teachers to give different directions to each student. The game-based learning has abundant characteristics, such as Representation, Fun, Play, Goals, Outcomes and feedback, Win states, Competition/Challenge, Problem solving, Task, Story and so on (Felix & Johnson, 1993; Prensky, 2001), to increase the learning motivation of student. Games are used to improve the dull and hard curriculum, where curriculum content corresponds to game levels, making the knowledge and skill of the curriculum teaching available through game-based learning. In summary, there are original different purpose between learning and game, but there are some problems in the traditional teaching curriculum, along with the prevalence of the On-line game, and the development of the e-learning, we expect, via the digital game-based learning system most people love, that using system analysis unit of software engineering curriculum as activity content, lets students through “Learning by Doing” achieve personalized learning, bring the entertainment of game, fun, interactive into education, achieving the purpose of edutainment. The purposes of this research are the following: Firstly, we use a scenario-based learning system to improve traditional education in order to make students learn better. Secondly, we evaluate satisfaction of game-based learning system. Thirdly, we would like to understand the relationship between learning motivation and learning achievement.

LITERATURE REVIEW

Game-based learning

Computer games meet the actual needs and interests of children, and are becoming the most popular computer activity and provide a new mode of interaction. Some of the advantages of games are that they are attractive, novel, provide a better atmosphere and help keep the learner focused on the task (Heinich, Molenda, Russell, & Smaldino, 2002), therefore suggesting games as valuable educational tools. Kids like all humans love to learn when it is not forced upon them. Modern computer and video games provide learning opportunities every second or fraction thereof (Prensky, 2003). Gee (2003) argues that “the real importance of good computer and video games is that they allow people to recreate themselves in new worlds and achieve recreation and deep learning at the same time”. Therefore, the approaches and technologies of game design should be applied to design educational software, which can be used in school.

Some educators consider game-based learning to be a powerful instructional approach (Von Wangenheim & Shull, 2009). Chang et al. (2009) also indicate game-based learning is an evident and popular direction, which keeps the educational purpose and improves the ability of player that is utilized to real life. The educational game makes the learner become the center of learning, which allows the learning process to be easier, more interesting and more effective.

The related research in game-based learning such as applied in medicine (Beale, Kato, Marin-Bowling, Guthrie & Cole, 2007; Salajan et al., 2009), nature (Huang, Lin & Cheng, 2009), language (Liu & Chu, 2010; Barendregt & Bekker, 2011) and some area has considerably progressed. There are some research applications developed to aid the teaching, but the teachers are unable to customize an appropriate game, and the game may not completely fit the curriculum content and purpose of research. In literature (Papastergiou,2009; Thomas, Thomas, Mark & Elizabeth, 2011; Miller, Chang, Wang, Beier & Klisch, 2011), there are some developed systems by aims of research, and the game-based learning had been shown more effective than traditional teaching in learning achievement and motivation. However, these systems do not have a theoretical basis in teaching assessment.

ARCS model

The ARCS model is a problem solving approach to designing the motivational aspects of learning environments to stimulate and sustain students’ motivation to learn (Keller, 1983). There are two major parts to the model. The first is a set of categories representing the components of motivation. The second part of the model is a systematic design process that assists in creating motivational enhancements that are appropriate for a given set of learners. To accurately measure the change in learner motivation, Karoulis and Demetriadis (2005) indicated that the ARCS model (Keller, 1987) can be the standard of how much the learning motivation is increased by the game. The four dimensions of ARCS are the following: Attention- attention which increases the learner's curiosity, Relevance- establishment of the relevance of the learning content to learners, Confidence- feedback to the learner, through the effort and the learning process of self-control, Satisfaction- the satisfaction or reward the

learner can gain.

RETIAN model

The Relevance Embedding Translation Adaptation Immersion & Naturalization (RETAIN) model was founded on an appropriate combination of these elements (Gunter, Kenny & Vick, 2007) to conduct developing and evaluation a successful educational game. There are two major features in RETAIN model:(1) assess how well games based learning contains and incorporates learning content,(2)support game based learning design. The RETAIN model includes six dimensions: (i) Relevance: presenting and ensuring the learning content are relevant to learners' previous learning experience, (ii) Embedding: assessing how closely the learning content is coupled with the fantasy/story content, (iii) Translation: how the player can use previous knowledge and apply it in other domain, (iv) Adaptation: a change in learning activity as a consequence of transfer, (v) Immersion: the player intellectually invests in the context of the game, and (vi) Naturalization: the development of habitual and spontaneous use of information derive within the game. RETAIN model can be directly correlated into game design and can also serve as a measurable and objective checklist for educational game developers. Meanwhile, several researches suggest that good game design model will allow the curriculum to be successfully embedded within the scenario of the game.

METHODOLOGY

This section introduces research concept, research framework, quasi-experimental design, design questionnaire and curriculum design.

Research concept

This study not only uses the game-based learning to coordinate the practice of curriculum, it also applies the ARCS model to analyze the learning motivations of students. When teaching the curriculum, all students can play games to get curriculum knowledge. After the students play the game, a questionnaire test is employed to obtain the student's impression for system interface and curriculum content. Then the proposed hypotheses are verified by data analysis and statistical tests to shown the learning achievements in a quasi-experimental design. The detailed research process shown in Figure 1 and is separated into the following two research phases.

(1) System development phase: In developed game, uses the ARCS model to construct the research theory fundamental, and make the game-based learning system that cooperates with curriculum based on the content of system analysis for experiment. In design game questionnaire, questionnaire design is justified by experts and modified as the formal questionnaire by experts' opinions and literature.

(2) Achievement assessment phase: In order to evaluate the effectiveness of their learning and how they feel about game-based learning system. After the teaching experiment, the students are asked to test curriculum contents and complete the ARCS questionnaire, the questionnaire items include game contents, interface, system feedback and user perspective. In the collected questionnaire data, we test the reliability and validity of the questionnaire. Then, employ ANOVA, T-test and Regression analysis to analyze whether the Achievement of the game-based learning system have achieved.

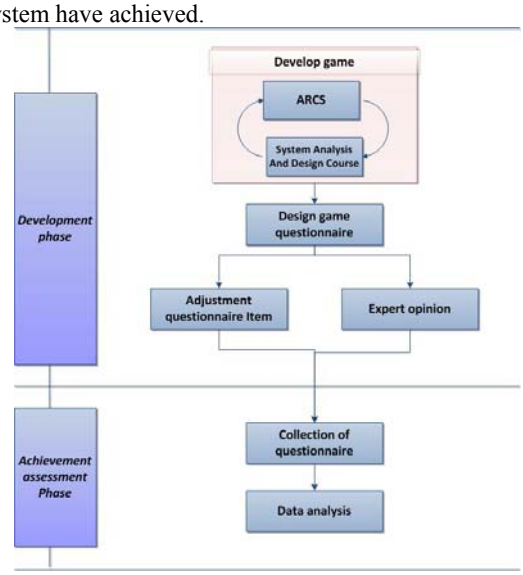

Figure 1 Research process

Quasi-experimental design and hypothesis

This study analyzes the learning achievements of experimental and control group in the pre-test and post-test by the system analysis unit of software engineering curriculum, to check if there is significant difference between the learning achievements of two groups. This study analyzes the important demographic variables in experimental students whether impacts the learning achievement and motivation. From the collected ARCS questionnaire, we can understand the viewpoint of students on game-based learning system and their willingness for re-using the system. The proposed research framework is shown in Figure 2.

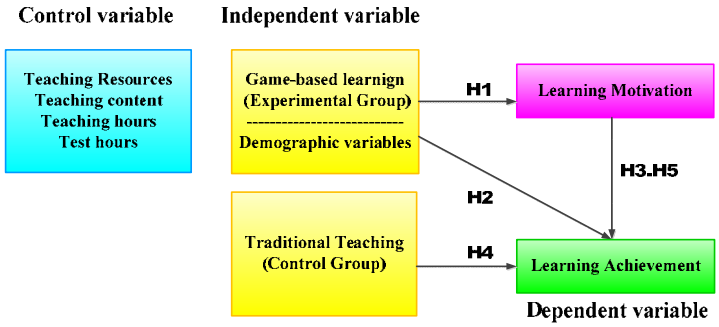

Figure 2 Research framework

According to the motivation and objective of this study, we formulate the following null hypotheses:
H1: The student's background variables do not affect the learning motivation.
H2: The demographic variables do not affect the learning achievement.
H3: The learning motivation does not affect the learning achievement.
H4: There is no difference between traditional learning and game-based learning.
H5: ARCS factors cannot predict learning achievement.

The independent variables are the different groups that are subject to different teaching strategies. The experimental group uses "game-based learning", and the control group uses the "traditional face-to-face learning". Figure 3 to show the experiment design for comparing the Game-based learning and the traditional face to face learning approach. Both of two groups are taught the same system analysis unit of software engineering curriculum. Experimental group: There are 33 students playing the online learning game, and completed the questionnaire and individual information afterwards. The demographic variables in individual information include gender, major, and the computer usage. Control group: There are 30 students doing traditional learning. After the different teaching strategies, In order to avoid influence from other factors, except from independent variance, the control Variables of this study are as following: (1) Teaching resources: The experimental group is given a lesson in a computer class, the control group in regular class, while the teachers are the same. (2) Teaching content: During the study experiment, the experimental and control group have the same teaching content. (3) Teaching hours: The experimental and control group have one lesson per week for 150 minutes (Min), and total experimental teaching time has 8 weeks. 4. Test hours: The experimental and control group are given the same time (100 minutes) to do the tests in pre-test and post-test phases.

This study develops a 3D game-based learning environment, with system analysis unit of software engineering curriculum as its basis, and cooperates with the teacher who has the teaching background of the information curriculum. The students study the system analysis unit of software engineering curriculum, and all students have the same learning content and resource, one group uses game-based learning, the other takes the traditional face-to-face teaching. After the class ends, all students must take the test and complete the questionnaire. We then compare the difference of the test results and questionnaire analysis of game-based learning, and look at the discrepancy of the learning results between the game-based learning and traditional face-to-face teaching approaches.

This study randomly selected students with a background related to information technology as system testers, where the students were all enrolled in the third-year undergraduate level. All students who study the system analysis unit of software engineering curriculum, based on their information and technology background, can quickly familiarize with the learning environment, although they have never used the newly developed system before. During the research process, the class tests and the related data are collected for analysis. The test scores serve as a comparison of the learning outcomes between game-based learning and face-to-face teaching, and the questionnaire content includes the feedback about the game-based learning content, interface etc., which reflects the students' perception. This study uses a quasi-experimental design. The study analyses the grades achieved in

the pre-test and post-test, to check whether there are significance differences between the experimental group and control group. Eventually, according to the questionnaire results of game-based learning students, we obtain an integrated view of the game and teaching approach.

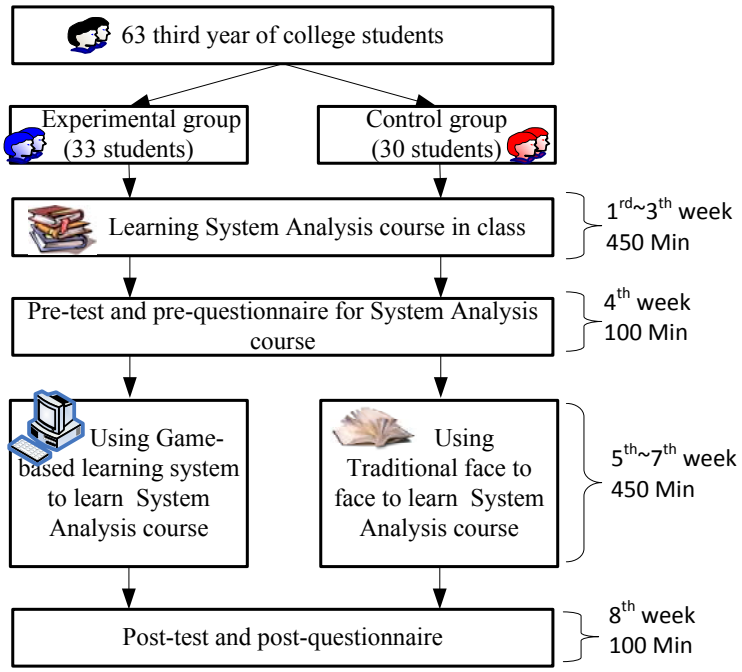

Figure 3 Experiment design for comparing the Game-based learning and the traditional face to face learning.

Questionnaire design

This study practically collects questionnaire data about the effectiveness of implementation of game-based learning, and the procedure of questionnaire forming: The definition of measuring aspect and the items is based on literature and expert opinion, which are used to create a formal questionnaire.

The designed questionnaire integrates the questionnaires of Su, Yang, Hwang, Zhang (2010) and Liu and Chu (2010). These two questionnaires have fairly high reliability, as all questions have been revised by experts, and therefore fit the needs of this study. The proposed questionnaire is based on Keller's ARCS motivation model with its four dimensions attention (Dimension A), relevance (Dimension R), confidence (Dimension C) and satisfaction (Dimension S) with a total of 17 questions. Responses to all questions were on a five point Likert questionnaire: "5:totally agree" means absolute agreement with the given formulation; "4:agree" means general agreement with the formulation.;"3:average " stands for 50% agreement with the narration; "2:do not agree" represents general disagreement; "1:totally do not agree" represents absolute disagreement with the narration of this question.

The narration of the questionnaire is as follows: this study uses a game-based learning system to improve the learning effect of system analysis unit, after the end of experiment, let the students participate the system test and complete the questionnaire, to understand the degree of students' acceptance for this system. There are four parts: in the first part (Dimension A), students evaluate whether there is attraction in game content; in the second part (Dimension R), students assess whether the game content is helpful and worth learning; in the third part (Dimension C), students evaluate whether the game gave them self-control over the learning process and whether it was able to build confidence in students to finish whole activities; in the fourth part (Dimension S), students assess the their overall degree of satisfaction and acceptance for the system.

The ARCS questionnaire has 17 items, and the effective samples are 64. The total average of the item is 3.81 points which shows the learning motivation is positive; the ARCS-C and ARCS-S are 4.12 and 4.01, all items are also higher than 3 points as shown in Table 1, which shows the learning approach and content design can be much better. The reliability is the credibility and stability of the questionnaire result which stands for there are consistencies among every question. This study uses Cronbach's alpha value to verify the reliability standard of the questionnaire. Carmines & Zeller (1979) also consider the excellent educational test that the Cronbach's

alpha value is higher than .80, The Cronbach's alpha values of four dimension are all higher than .80, and the entire questionnaire is α=.95 which indicate the questionnaire is reliable. Table 1 lists the Cronbach's alpha of ARCS questionnaire.

Table 1 Cronbach's alpha of questionnaire

Item	Number of Item	Mean	Cronbach α
ARCS-A (Attention)	5	3.43	0.93
ARCS-R (Relevance)	4	3.69	0.89
ARCS-C (Confidence)	4	4.12	0.98
ARCS-S (Satisfaction)	4	4.01	0.87

Content mapping to game

The game of this study is designed to provide students a self-learning environment, and the curriculum content is based on the procedure of system analysis, which allows students to gain real-world experience. Furthermore, the game should provide challenge, repeated self-learning and attraction, which can increase the learning motivation of students.

The game story is set in a company office environment. To develop a new system, the player's task is to perform a series of system analysis processes. As there are different staff who participate the process of system analysis, the learner can take on different roles and freely choose to act which character, such as project manager, system analyst and programming staff, where different roles corresponds to different scenes in the game. The role exerts characteristic to play the game, which is aimed at finishing all level tasks, learning the work of each role in the process of system analysis unit.

Game-based learning system

This study develops a scenario game with learning goal under the self-learning environment for system analysis, and makes students execute tasks according to story situation, and learn system analysis process via different characters corresponding to different situation. This section mainly explains the detailed steps of game system design and construction.

This development work integrates the suggestion of teachers, the RETIAN model (Gunter, Kenny & Vick, 2007), to develop the game-based learning system; RETIAN model combines successful game theory, instructional design and educational learning, to allow the curriculum contents to be successfully embedded within the stories and scenario of the game.

This study uses a 3D scenario game based on ARCS, and learning strategy to develop a game-based learning system for students to learn the "waterfall development model ".The game-based learning process is shown in Figure 4 and divided into three layers: course content layer is the content of game design curriculum; learning process layer is the process of the learning with ARCS model, game process layer present the game interface design and game function implementation. Further description of the three layers is given in the following.

Course content layer: Waterfall Model System Development Life Cycle (SDLC) is applied to this course. Such a method presents the following features. (1) It is suitable for projects with definite demands and Domain Know How being easily accessed. (2) It emphasizes the management control of complete planning, analysis, design, test, and documentation in the development process. (3) A stage is entered after completing the previous one, and each stage is cycled for merely once. (4) It does not require certain stages to be divided, but documents are output at each stage. There are five phases in this layer: **Phase 1** Definition and Planning, **Phase 2** System Analysis, **Phase 3** System Design, **Phase 4** System Development and Evaluation, **Phase 5** System maintenances. Various working roles, such as project managers, system analysts, system development engineers, system test and maintenance personnel, and service personnel, are included in the five process of Waterfall Model SDLC to complete all software project works which covered in the stages, containing System Feasibility, Requirements Analysis, High level and Detailed Design, Coding, testing and system instillation, and final product delivery and maintenances. The integration of the instruction with Waterfall Model SDLC and learning process could enhance and collect learning data.

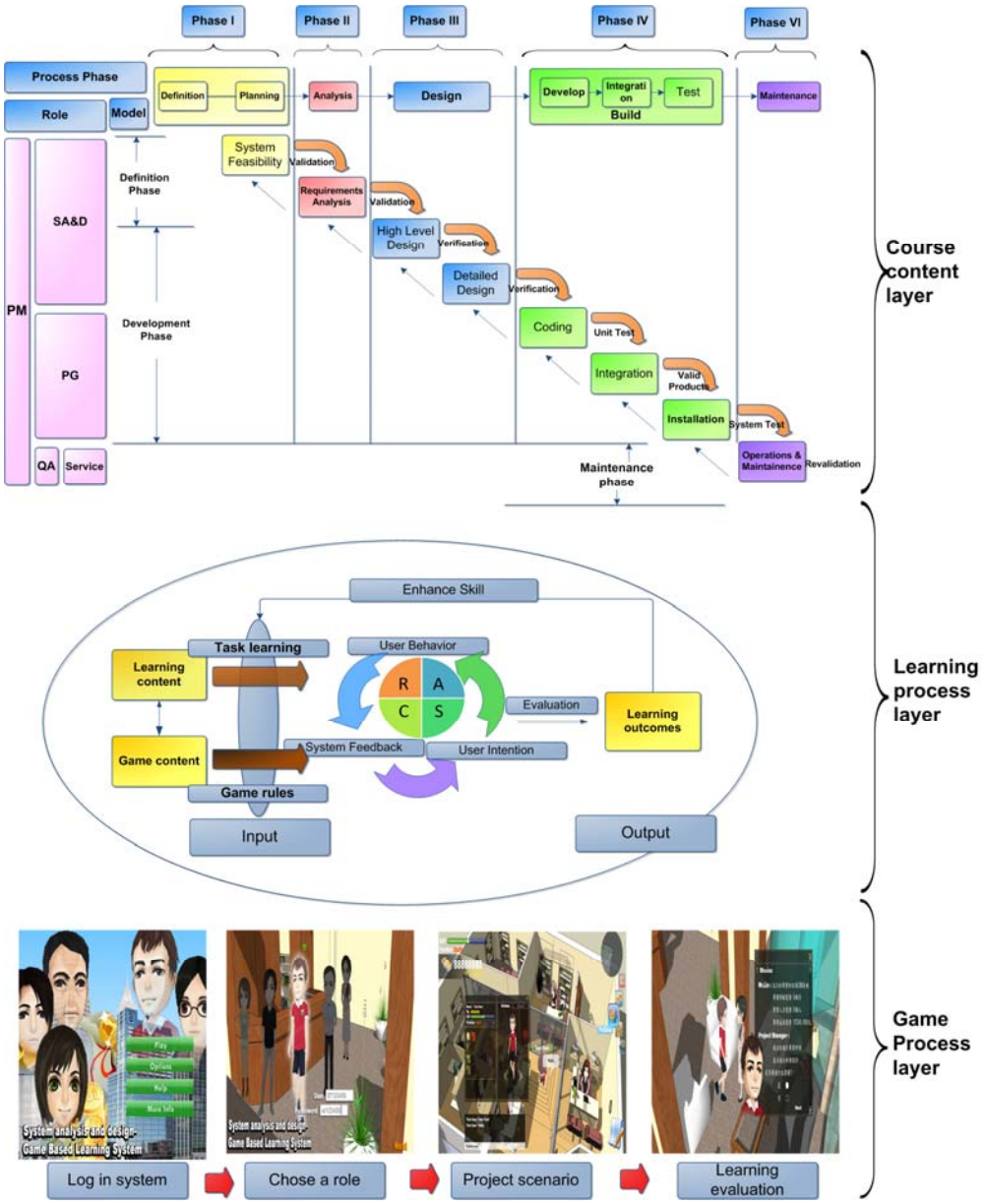

Figure 4 Game-based learning process of system analysis unit of software engineering curriculum

Learning process layer: there are three processes in this layer, 1. Input: By mapping teaching content into the game content, and through the game skill, task learning, reward institution and the interesting gameplay, the learners blend into the game situation. 2. Process: Explanation with internal ARCS; Attention (A): through the characteristics of the game, such as challenge, diversification and uncertainty, to inspire the curious of players and catch their attention, which influence user intention; Relevance (R): allowing user to learn new skills in different ways , to define the learning goal and raise learning motivation and to relate to familiar things, which impact user behavior; Confidence (C): Using the feedback of the game, such as grades and treasure, to make the user believe that his/her effort will directly cause achievement, helping students understand the possibility of success and prevent him/ her from thinking it is impossible to achieve the goal; Satisfaction (S): when the new skills which the user learned during the game are useful and can be applied to other game tasks, the player will want to solve increasingly harder tasks which gives him a positive feeling of success. The various tasks and skills given by system attract the attention of student, and further raise the learning motivation, increase the abilities of student progressively, and keep cycling on user intention, user behavior, system feedback and ARCS and reach the ultimate learning goal. 3. Output: The Output phase, which includes directed goal achievement evaluation and repeated practice, monitors the progress and Achievement of students and provides the results to teachers for improvement of their teaching.

Game process layer: Four steps are implemented, the user logs in system and then selects an avatar for the game to play with software develop project scenario. When learner finishes a game, he/she will be ask some question for learning achievement evaluation.

System Architecture

During the system implementation, the number of concurrent users and the accessed data will be within reasonable limits so system overloading is not a problem. Therefore, this system uses a cloud-based (Three-Tier) architecture show in Figure 5. On the server side, the database includes two parts: the evaluation database which records the content of the game level(game stage) access, including game skills, level information, tasks and testing; the member database records the role, time, experience, level, learning portfolio and so on for player. The game-based learning services includes 5 services which are Filter Service(FS)-to filter player's portfolio and provide suitable game-based learning content, Score Service(CS)-analysis learner's learning Achievement, Evaluation Service(ES)-provide a testing after the learning, Personal Portfolios Service(PPS)-personal learning portfolios content, Game Content Service(GCS)- Content mapping to game. The player plays the game via a 3D game interface to access the game-based learning system, and to access the level information of two databases and the player information. At the end of the game, you can see the score that you get from the game. The teacher can understand the learning abilities and effects on students in each level by using a special interface to observe all the game results and scores of students.

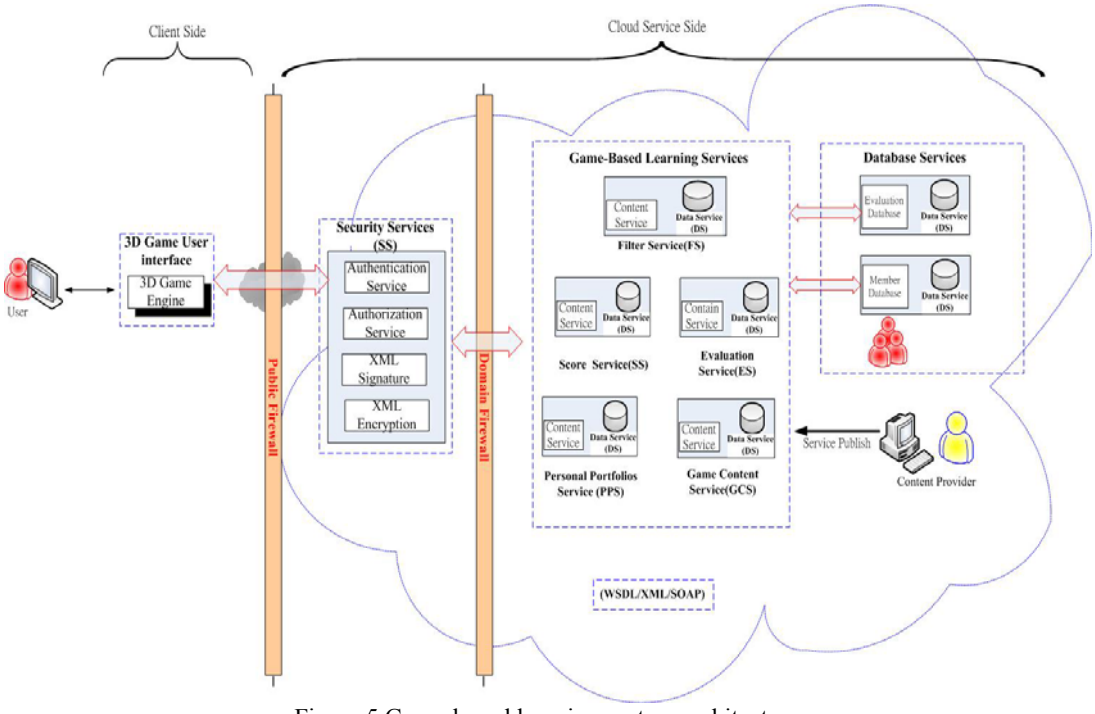

Figure 5 Game-based learning system architecture

The process of game-based learning is introduced in Figure 6. After the player logs in to the game, the player must choose one role according to which he will enter a different game scene. There are different non-player characters (NPC) and tasks in each game scene. The player must talk with NPC to take the specified task from the game-based learning system, and enter the next level after completing all tasks; in other words, if the player doesn't finish the specified task, the game will not end. After receiving the task, player must find various tools and solutions in the game, to complete the task. Once all tasks are completed, the learning of curriculum content is over, and the system will show the player's game score, letting the player know the result of self-learning.

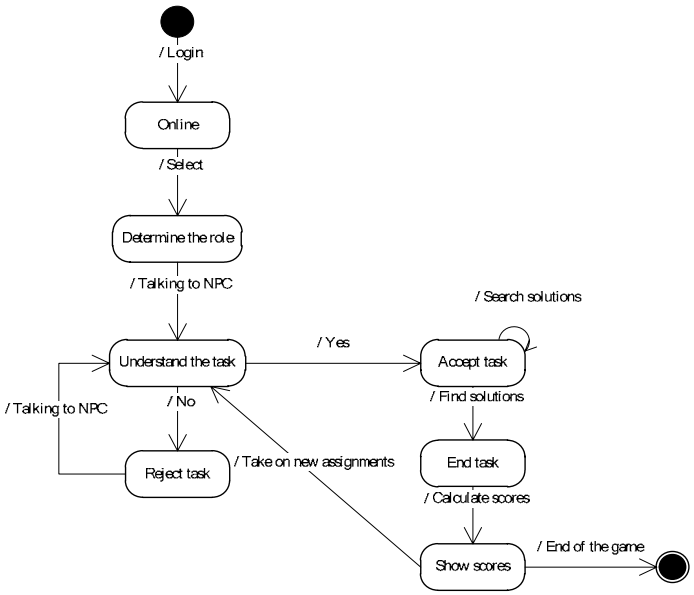

Figure 6 Activity Diagram of Game-based learning system

System interface and system function

According to the system planning mentioned, this study develops a role-play game which functions as follows: (1) The game situation- The construction of the game, besides the design of the game screen, also includes the drama and character design. The story is set in a computer and internet service company whose clients and complicated equipment are getting more and more. This company therefore wants to develop systems that can answer questions of clients and increase the efficiency. The player must help the company evaluate and develop software, act as different roles in the developing process and complete different tasks as different roles to complete the software development. (2) The interface design- The game this study develops takes the story background, environment and age of players into consideration, in order to increase the authenticity of the game, uses the office model as scene, the Q-office worker as people and the 3Ds Max to complete the actual interface that is interaction with players in the system.

The game provides five different roles to be chosen. The Figure 7-1 shows to select a role fore the game task and Figure 7-2 show that every role corresponds to different situations and tasks, and the player can go through the different roles to learn all different tasks of various positions. In the requirements analysis, this study uses the maze game, which will show the problem sign and player position. When passing a problem sign, the character must stop, and the player must solve the current problem in order to keep going forward. In this task, the multiple choice questions are designed by the meeting record from the game. Besides solving all problems in the maze, The Figure 8-1 show that the player must find a way out in order to increase his interest and keep the player's attention on game-based learning. In this task, the player must distinguish the requirements into functional and non-functional. The screen includes a countdown, health points and scores. If the answer is wrong the health points will decrease by one and the question will reappear and the countdown will be reset, in order to give the player the chance to correct the mistake. The player must answer in limited time, to increase the challenge of the game. At the end of the learning phase, shows in Figure 8-2, the player have to take an evaluation then he will get the score which will provided to the teacher for reference.

DATA ANALYSIS AND RESULTS

The goal of this study is to discuss the effect of different teaching methodologies on learning motivation and achievement in a system analysis unit of software engineering curriculum. For the learning system designed by this study, the ARCS questionnaire and system analysis test are used to collect data which is then analyzed with SPSS 17 for Windows. The participants in this study are randomly selected college students, who are separated into two groups, the experimental and control group, to study the effect on the learning achievement from the different teaching approaches, traditional curriculum and game-based learning. There are totally 63 students participating in this study, of which 47 are male and 16 female, with the average age of 20-21 years. There are 30 students (20 males and 10 females) in control group, using the traditional face-to-face teaching approach; there are 33 students (27 males and 6 females) in experimental group, using the game-based teaching approach.

Figure 7-1 Select a role in the game

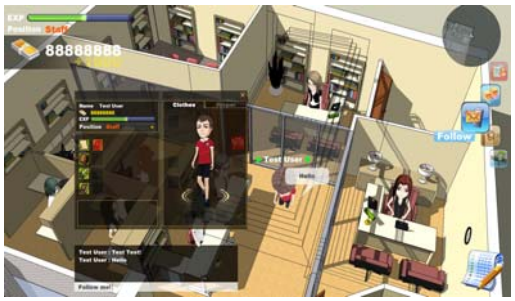

Figure 7-2 Role information in the game

Figure 8-1 identify the requirements

Figure 8-2 System evaluation test for a role

ARCS Data analysis

The hypothesis H1 to H5 states with a significant impact on the learning motivation which is shown in Table 2.The hypothesis H4 states that the achievement when using game-based learning is higher than with traditional face-to-face teaching strategy. The hypothesis H5 states that the learning achievements of students are significantly related to the learning motivation. In pre-test comparison, t-test shows no difference in learning achievement between group A and group B as shown in Table 3. However, the post-test comparison has a significant difference, Table 3 shows the average scores of students in Group A who use the game-based learning are Mean=80.24 and SD=9.327, which are higher than who use the traditional face to face learning (Mean=72.14, SD=12.010). Lastly, comparison with the scores of pre-test and post-test shows that, in the Group B who use the traditional face-to-face learning does not have a significant difference on the scores of pre-test and post-test, but in the Group A who use the game-based learning have significant differences in the scores of pre-test (Mean=71.36) and post-test (Mean=80.24).

Table 2 Hypothesis results

Hypothesis	F	Sig.
H1: The student's background variables do not affect the learning motivation.	5.782 **	p<0.010
H2: The demographic variables do not affect the learning achievement.	6.782 *	p<0.040
H3: The learning motivation does not affect the learning achievement.	2.153 **	p<0.003
H4: There is no difference between traditional learning and game-based learning.	3.025 **	p<0.004
H5: ARCS factors cannot predict learning achievement.	4.020 ***	p<0.001

* P□0.05 ** P□0.01 *** P□0.001

Table 3 the results for the learning achievement of different teaching strategies

	Group	N	Mean	SD	t-test for Equality of Means			
					t	df	Sig. (2-tailed)	Comparison
Pre-test	A	33	71.36	8.287	-0.381	62	0.705	NA

	B	30	72.37	12.489				
Post-test	A	33	80.24	9.327	3.025	62	0.004	A>B
	B	30	72.14	12.01				

Note: Group A denotes students who use the game-based learning, Group B denotes students who use the traditional face to face learning. NA denotes no significant.

CONCLUSIONS

This study aimed at investigating how game-based learning strategy affects student's motivation and learning achievement in software engineering curriculum. To enhance software engineering learning, a 3D game-based learning system has been developed and evaluated to explore the students' motivation, satisfaction and learning achievement, it is effectively helps students to enhance in learning activities based on ARCS learning model. The results show that learning motivations of students have significant impact on learning achievement, and learning achievements of students with game-based learning are better than those who use traditional face-to-face teaching. Therefore, we re-check each questionnaire item; this paper finds that the game-based learning challenging and attractiveness can lead to learners' curiosity and immersion in learning activity. Meanwhile, nearly 80% students are satisfaction and 83% students are confidence (see Table 1) for the curriculum learning after use the game-based learning system.

From the results, some findings could be provided to other educators. Firstly, the students, who major in information, can be more familiar with the game process and curriculum content for getting the knowledge. Secondly, an interesting research result is that the students who play the game two hours each time and less than once a week with higher learning motivation. Thirdly, regarding gender issues, as shown in the study, the achievements of game-based learning have no significant differences between the males and females, which agrees with the same conclusion of the study (Ke & Grabowski, 2007), which found that gender does not impact the learning achievement. This study has also shown that the learning achievement is not impacted by accommodation. Fourthly, in the experimental group, the students who use game-based learning have better achievement than pre-test. Fifthly, the experimental group is higher than the control group for learning achievement. This result shows that the game-based learning system obviously improves the learning achievement of students. Last, educators should offer more interesting, challenging and attractive course content for students with interactive way. Furthermore, instructional design is extremely important in order to realize motivational improvements using technology-based instruction.

Future work can make more interactive contents to enrich the game graphics and contents, and build feasible evaluation criteria to inspire the learning motivations of students. Additionally, although this study has significant achievements for experimental group students, the experiment only includes partial university students in southern Taiwan and in specific subjects. Therefore, in future study, we could expand the experiment to other university and subjects.

REFERENCES

Barendregt, W. & Bekker, T. M. (2011). The influence of the level of free-choice learning activities on the use of an educational computer game. *Computers & Education*, 56(1), 80-90.

Barry, W. Boehm. (1988). A Spiral Model of Software Development and Enhancement. *IEEE Computer Society*, 21(5), 61-72.

Beale, I. L., Kato, P. M., Marin-Bowling, V. M., Guthrie, N. & Cole, S. W. (2007). Improvement in Cancer-Related Knowledge Following Use of a Psychoeducational Video Game for Adolescents and Young Adults with Cancer, *Journal of Adolescent Health*, 41(3), 263-270.

Bokyeong, K. , Hyungsung, P., Youngkyun, B.(2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning, *Computers & Education*, 52(4), 800-810.

Camines, S. F., & Zeller, R. A.(1979). Reliability and validity assessment. *Beverly Hill*s, CA: Sage.

Chang, Wen-Chih., Wang, Te-Hua., Lin, Freya H., Yang, Hsuan-Che. (2009). Game-Based Learning with Ubiquitous Technologies. *IEEE Internet Computing*, 13(4),26-33

Csikszentmihalyi , M., & LeFevre, J. (1989), Optimal experience in work and leisure, *Journal of Personality and Social Psychology*, 56 (5), 815–822.

Felix, J. W., & Johnson, R. T. (1993). Learning from video games. *Computers in the Schools*, 9(2-3), 119-134.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *ACM Computers in Entertainment*, 1(1), 1–3.

Gunter, A. G., Kenny, F. R., & Vick, H. E. (2006). A Case for a Formal Design Paradigm for Serious Games. *The Journal of the International Digital Media and Arts Association*, 3 (2006), 93-105.

Gunter, A. G., Kenny, F. R., & Vick, H. E. (2007). Taking educational games seriously: using the RETAIN model to design endogenous fantasy into standalone educational games. *Educational Technology Research and Development*, 56(5-6),511–537.

Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (2002). Instructional media and technologies for learning. *New Jersey: Merrill Prentice Hall*

Huang,Yueh-Min., Lin, Yen-Ting., Cheng, Shu-Chen. (2009). Effectiveness of a Mobile Plant Learning System in a science curriculum in Taiwanese elementary education, *Computers & Education*, 54(1), 47–58.

John D., (1938). Experience and Education. *New York: Collier Books.*

Karoulis, A., & Demetriadis, S. (2005). The motivational factor in educational games. Interaction between learner's internal and external representations in multimedia environments, *Research report, Kaleidoscope* NoE JEIRP, D21-02-01-F, 296-312.

Ke, F., & Grabowski, B. (2007). Game playing for maths learning: Cooperative or not? *British Journal of Educational Technology*, 38(2), 249-259.

Keller, J.M., Official site of John Keller's ARCS Model, from the World Wide Web: http://www.arcsmodel.com/

Keller, J. M. (1983). Motivational design of instruction. In C. M. Reigeluth (Eds.), Instructional-design theories and models: An overview of their current status (pp. 386-434). *Hillsdale, NJ: Lawrence Erlbaum Associates*.

Keller, J. M. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development*, 10(3), 2 – 10.

Liu, Tsung-Yu., & Chu, Yu-Ling. (2010). Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation, *Computers & Education*, 55(2), 630-643.

Miller, L. M., Chang, Ching-I., Wang, Shu., Beier, M. E., Klisch, Yvonne.(2011). Learning and motivational impacts of a multimedia science game. *Computers & Education*, 57(1), 1425-1433.

Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation, *Computers & Education*, 52(1), 1–12.

Portnoy, LG. & Watkins, MP (2000). Foundations of clinical research: Applications to practice (2nd ed.). Upper Saddle River, NJ: *Prentice-Hall*.

Prensky, M. (2001). Digital game-based learning. *New York: McGraw-Hill.*

Prensky, M. (2003). Digital game-based learning. *ACM Computers in Entertainment*, 1(1), 1–4.

Salajan, F. D., Perschbacher, S., Cash, M., Talwar, R., El-Badrawy, W. & Mount, G. J.(2009). Learning with web-based interactive objects: An investigation into student perceptions of effectiveness. *Computers & Education,* 53(3), 632-643.

Su, Y.S., Yang, J.H., Hwang, Wu-Yuin., & Zhang, Jia. (2010). A Web 2.0-based collaborative annotation system for enhancing knowledge sharing in collaborative learning environments, *Computers & Education*, 55(2), 752-766.

Thomas H., Thomas M. C., Mark S., Elizabeth A. B. (2011). Evaluation of a game to teach requirements collection and analysis in software engineering at tertiary education level. *Computers & Education*, 56(1), 21-35.

Von Wangenheim, C.G., Shull, F.(2009). To Game or Not to Game? *IEEE Computer Society*, 26(2), 92-94