A Game-based learning system for improving student’s learning effectiveness in system analysis course

Ching-Hsue Cheng a *, Chung-Ho Su a,b

a Department of Information Management National Yunlin University of Science and Technology Taiwan
b Department of Animation and Game Design, Shu-Te University Taiwan

Abstract

This paper practically develops a game-based learning system to improve self-efficacy for student’s learning. The game-based learning is combined with educational and information technology. From the e-learning carried on, the game-based learning is getting more attention. In game-based learning, the course content is mapped into the game to provide a scenario environment of learning, the repeated self-learning, and the ongoing interaction and feedback can increase the learning interest and motivation. Hence, game-based learning could reach the goal of learning effectively. For evaluating the learning effects, this paper uses 3D game development tools and the course content corresponding to the game level content. In the questionnaire, the questionnaire design is based on the ARCS Motivation Model, and the questionnaire items have been revised by the experts’ opinions. This quasi-experimental teaching is executed for system analysis course (at third-year undergraduate level), the subjects (students) have an information management background. The students are separated into two groups for quasi-experimental design: one is the experimental group, the other is the control group. After the implementation of game-based learning system, the achievement scores and questionnaire of the experimental group are collected practically, and the difference in learning achievement between the experimental and control groups is examined. The results show that the learning motivations of students have significant impact on the learning achievement, and the learning achievements of students with game-based learning are better than those who use the traditional face-to-face teaching. And the results could provide the related educators as references.

Keywords: Game-based learning, ARCS Model, System Analysis,

1. Introduction

The internet is a rich source of information, and more and more people make information available online. One day, the knowledge from the 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. 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. Therefore, the system developer, who the business needs, must have some knowledge

* Ching-Hsue Cheng. Tel.: +886-933-386-050
E-mail address: chcheng@yuntech.edu.tw

© 2011 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Prof. Hüseyin Uzunboylu.
Open access under CC BY-NC-ND license, doi:10.1016/j.sbspro.2011.12.122
and skill, understand the concept of the system development. System analysis is the process of effective problem solving, which makes “system analysis” become an important task. 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. 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 course, where course content corresponds to game levels, making the knowledge and skill of the course teaching available through game-based learning. In summary, People love the digital game-based learning system, that using system analysis course 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.

2. Theoretical background

2.1. 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”. Some educators consider game-based learning to be a powerful instructional approach (Von Wangenheim & Shull, 2009). The educational game makes the learner become the center of learning, which allows the learning process to be easier, more interesting and more effective.

2.2. 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). 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.

3. Methodology

3.1. Research concept

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 course content and purpose of research. This study analyzes the experimental and control group achievements in the pre-test and post-test of the system analysis course, to check if there is significant difference between the learning achievements of two groups.
3.2. Quasi-experimental design

The experimental group uses “game-based learning”, and the control group uses the “traditional face-to-face learning”. Figure 1 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 course. Experimental group: There are 33 students playing the online learning game, and filling out the questionnaire and individual information afterwards. There are 30 students doing traditional learning in control group and 33 students doing game-based learning system in experimental group. After the different teaching strategies, in order to avoid influence from other factors, except from independent variance, the control variances 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 in 3 hours per week: The experimental and control group are given the same time to do the tests in pre-test and post-test phases.

![Figure 1](image)

Figure 1  Experiment design for comparing the Game-based learning and the traditional face to face learning approach.

This study develops a 3D game-based learning environment, with system analysis course as its basis, and cooperates with the teacher who has the teaching background of the information course. The students study the system analysis course, 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 fill in 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.

3.3. Content mapping to game

The course content is based on the procedure of system analysis, which allows students to gain real-world experience. The game story is set in a company office environment. 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. 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 which show in Figure 2 is divided into two layers: the underlying layer is the process of the game learning; the course content layer is the content of game design course and the learning process layer is the game-based learning system with ARCS.
In the learning process layer, there are three processes stage. (1) Input stage: 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 stage: 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 stage, which includes directed goal achievement evaluation and repeated practice, monitors the progress and performance of students and provides the results to teachers for improvement of their teaching.

3.4. 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 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 3 shows to select a role fore the game task and Figure 4 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 5 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, show in Figure 6, the player have to take an evaluation then he will get the score which will provided to the teacher for reference.

4. Data analysis

The goal of this study is to discuss the effect of different teaching methodologies on learning motivation and achievement in a system analysis course. There are totally 64 students participating in this study, of which 48 are male and 16 female, with the average age of 20-21 years. There are 30 students (20 boys and 10 girls) in control group, using the traditional face-to-face teaching approach; there are 33 students (27 boys and 6 girls) in experimental group, using the game-based teaching approach.

4.1. ARCS Data analysis

The detailed statistical results of the four questions of the ARCS questionnaire are shown in Figure 7. The total average of the questionnaire is 3.81 points which shows the learning motivations of learners are positive; the C and S are 4.12 and 4.01, other questions are also higher than 3.43 points 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, so that the questionnaire is valuable. There is a total of 17 questions, and the effective samples are 64 (efficiency= 95%). The Cronbach’s alpha values of four items of this study questionnaire are all higher than .80, and the entire questionnaire is α=.95 which indicate the questionnaire is reliable.
4.2. The analysis of pre-test and post-test

The table 1 states that the achievement when using game-based learning is higher than with traditional face-to-face teaching strategy; T value is significant to show: pre-test shows the average scores of students in Group B who use the traditional face to face learning are Mean=72.37 and SD=12.489, which are higher than theirs who use the game-based learning (Mean=71.36, SD=12.489). Post-test 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 theirs who use the traditional face to face learning (Mean=72.14, SD=12.010). 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 1  The results for the learning achievement of different teaching strategies

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>t</td>
</tr>
<tr>
<td>Pre-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>33</td>
<td>71.36</td>
<td>8.287</td>
<td>H: ( \sigma_A = \sigma_B )</td>
<td>3.518</td>
<td>.065</td>
</tr>
<tr>
<td>B</td>
<td>31</td>
<td>72.37</td>
<td>12.489</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>33</td>
<td>80.24</td>
<td>9.327</td>
<td>H: ( \sigma_A = \sigma_B )</td>
<td>1.463</td>
<td>.231</td>
</tr>
<tr>
<td>B</td>
<td>31</td>
<td>72.14</td>
<td>12.010</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Group A denotes students who use the game-based learning, Group B denotes students who use the traditional face to face learning.

5. Conclusions

This study had implemented a role-playing game-based learning system for system analysis course, and the learning performace are significant after system evaluations. The developed system applies the situated learning to experiment with game-based and traditional learning, and discuss the impact of the two learning strategies on the learning achievement and motivation. From the results, some findings could be provided to the related educators: (1) this study has shown that the learning achievement is not impacted by accommodation and gender which agrees with the same conclusion of the study (Ke & Grabowski, 2007). (2) In the experimental group where students use game-based learning have better achievement performance than pre-test. The average motivation is 3.81>3 which highlights the effect of game-based learning with high learning motivation. In ARCS motivation model, the relevance and satisfaction factor have strong predictability for learning achievement (R Square=.903). (3) The experimental group exhibits higher learning achievement than the control group. This result shows that the game-
based learning system obviously improves the learning achievement of students. For long-term learning, the application of the game-based learning system to a classroom environment is both feasible and useful. In future work, we expect to make more use of multimedia features to enrich the graphics and contents of the game, in order to improve the learning motivations of students.

References


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


