Developing a Web-based and Competition-based Quiz Game Environment to Improve Student Motivation

Kuan-Cheng Lin*, Ting-Kuan Wu, Yu-Bin Wang
Department of Information Management, National Chung Hsing University, 250, Kuo Kuang Rd., Taichung 402, Taiwan
*kclin@nchu.edu.tw

Abstract—Game-Based learning (DGBL) has become an attractive pedagogy in recent years because it can effectively improve the intrinsic motivation of learning. Besides, the development of web-based e-learning systems can help students to carry mastery learning out. In this study, we develop a web-based and competition-based multi-player quiz game environment (WCMQGE) by incorporating DGBL into the web-based e-learning system. During the process of the game, the WCMQGE system can help players (students) review what they learned from school and use their knowledge to compete with their peers. Moreover, the WCMQGE provide three item generation algorithms to increase the randomness of quiz items and enhance the interest of students. Furthermore, the WCMQGE system also provides the learning management module for the students and teachers to review the learning outcome of the students.

Index Term: e-learning, digital game-based learning, mastery learning

I. INTRODUCTION

A. Background

Computer games are a growing part of our society, the value of game industry which includes the selling of games and other related media such as magazines and internet communities, has increased continuously. According to research, game industry is worth multi-billion dollars and its revenue and influence on related industries are not less than those of Hollywood [1]. It shows that more and more people are attracted by the games’ characteristics: fantasy, challenge, and curiosity, and more and more people choose video games as their entertainment so that the impact of games becomes significant. Now there is increasing interest in researching why games attract so many people and what powerful supports can games provide to learning activities.

On the other hand, because of the development of internet technology and portable devices, people are able to access more types of media and highly-functioned web applications without time limitation and place restriction. In this context, e-learning is more and more an efficient way for leaning because what one of the main purposes of e-learning is to give learners opportunities to learn anytime and anywhere. To explain it in detail, a digital learning information system based on web technology has several characteristics which help learning [2]:

1. Learning anytime and anywhere without installing certain client.
2. Large and easy-to-link community.
3. Promoting visualization and operation, and linking visual and symbolic representation: computer software can visualize abstract symbols and concepts which are hard to be presented in real life.
4. Providing an immersive learning environment: multimedia learning materials provide interactive learning and simulated leaning environments.

Basis on the above characteristics, researchers believe combining web-based digital games with learning processes is an effective way to enhance learners’ motivation thus improve outcome.

Here are some cases of digital game-based learning. In Chin-Tau Wang’s Joyce, the system provided a board game-style learning environment. To win, players must reach their goal sooner than their opponents, so players would eager to enrich their skills and knowledge in order to quickly respond to given questions [3].

On the other hand, M. Minović, M. Milovanović, D. Starcevic, and M. Jovanović designed an adventure game-style learning system, this system helped educators use leaning materials construct a fictional world, in which players had to use their skills to complete phase specific target. Every time a goal was completed, players would be rewarded, so this system helped players learn by providing simulated learning environments and giving them motivation [4].

Apart from academic studies, now there are many practical applications of game-based learning systems, such as the U.S. Army (Americans Army: Operations, http://www. Americasarmy.com) in which players learn how to accomplish their task as an American Army in the virtual battlefields created by the game, and projects sponsored by other organizations [5].

B. Research motivation

Motivation is one of the most important factors in a learning process, and it directly affects the effectiveness of learning. In order to enhance positive emotions of students [6], a common way is to combine game elements in the learning environments. An example is that...
Zong-Bin Guo promoted the development of moral cognition by making students participate in various activities [7].

Generally speaking, repeating review and practice account for a large proportion in a learning process, and this is usually done by writing assessment. After all, not all of the skills and knowledge can be instructed by implementing, especially the basic knowledge of every academic subjects. For example, reciting English vocabularies of English learning, and arithmetic of mathematic. The problem is, the process of this type of review is often monotonous, and it difficultly put learners into independent thinking since learners do not have to gain basic knowledge by observation and explanation. Therefore, learners would be easily distracted and the efficiency would be reduced.

When the learning process is routine and boring, a game-like learning environment can effectively make this activity enjoyable because a game brings learners sense of curiosity, challenging, and interactivity by providing unpredictable outcome, feedback, and appropriate complexity [8]. It’s believed that if using games to improve this fact, that is, learners are interested in this reviewing process when they can feel an optimal level of uncertainty and interact with others by competition and cooperation during the writing assessment, learners’ outcome will be improved.

In this paper, we design a digital game-based learning system and learners are able to compete with others in quiz games. Furthermore, to increase playfulness, we design several types of questions and let the system to use them randomly. On the other hand, the system will collect games’ data and analyze learners’ learning history which allows learners to view their learning outcomes.

II. LITERATURE REVIEW

In this paper, group-competing game is the primary method for interaction between learners. Therefore, we’ll concentrate on “competitive learning”, “cooperative learning”; and “game-based learning”.

A. Competitive learning

D. W. Johnson and R. T. Johnson proposed the definition of competition [9]:

1. The only purpose of competition is to defeat opponents to victory, regardless of the shape of “victory”.
2. In a competition, only a few people can win, and be rewarded.

For instance, a school only provides a few numbers of scholarships to the best performance in-school students, intending to create a competing environment to give students motivation to study hard.

Whether competitive learning really increases the learning motivation, and then promoting learning, some researchers hold positive views. Stipek considered that under the premise of that the learning objectives are clear, simple, and not time-consumed to reach, compared to cooperative learning, competition learning resulted in significantly better outcomes, and the whole learning process took a shorter time [10].

However, some researchers hold a negative attitude. Hamachek found that stress from competition may reduce the trust between peers, affecting the cohesion and creativity of learning groups [11]. On the other hand, Aimeur and Frasson proposed that competition can improve the motivation of capable learners, but not applicable to incapable learners [12].

In order to moderate the side-effects of competition, D. W. Johnson and R. T. Johnson put forward several proposals [13]:

1. Emphasize the fun of learning is more important than winning or losing.
2. Use competition between groups rather than between individuals.
3. Understand the relationship between competition and cooperation, and maximize the pros and minimize the cons of competition by cooperation.
4. During the competition, instructor should pay attention to three levels of (instructor and learners, learners and learners, learners and learning materials) interaction.
5. Maximize the winners.
6. Respect others’ learning condition.
7. View the importance of quantity and quality equally when evaluating students’ achievement.

B. Cooperative learning

There are often a few winners in a competing learning environment, and this fact will result in significant backward position for learners who seldom win the competition. To buffer the impact of competition, group cooperation is a way in which learners focus on helping their teammates win instead of defeating their opponents, attempting to create a more moderate competitive conditions, but with the learning motivation the competition brings. A point the instructor should know is that all teams’ capabilities should not differ much to avoid excessive influencing the essence of “victory” [14].

The fact is that cooperation accounts for the most important role in the learning process. In the cooperative learning process, learners exchange information, generate new ideas to simplify the problem, and solve the problem. In addition, instructor becomes a learning mentor partner who assists learners to construct their own knowledge, rather than passive convey knowledge to learners [15].

The effect of cooperative learning has been well recognized, Attle and Baker pointed out that cooperative learning helps learners generate new ideas, and competition will be objective and motivation for learners [16]. If combining the heterogeneous learning methods mentioned above, using group competitive learning, it often results in achievement beyond expectations. Bulut said during to process of cooperative learning, team members support and communicate with each other to enhance the trust between team members, this help them develop good relationships [17].

However, cooperative learning also possesses risks, Ballantine and Larres proposed that, if a group lack of task management, time management, communication and coordination, it will result in low efficiency of group coordination.
learning, worse than studying individually [18]. Hong-Jia, Zhang tried to use cooperative game to improve students’ motivation in math class and he found that the competency members actively participated in group learning while the inco mpetency members seemed not engaged in leaning activity. Therefore, instructor should always pay attention to learning conditions in each group, and give the necessary coordination [19].

C. Game-based learning

It’s an effective way to improve learners’ motivation by combining gameplay in the learning process. A. Martens, H. Diener, and S. Malo pointed out that the game creates a virtual environment, allowing the players to play a completely different role from real life and into the game as part of the game. In addition, the game gives every players a common task (usually simple and can be reached in short time), and the players will be rewarded when they finish their tasks [20]. In order to achieve the tasks, the players must cooperate or compete with other players. And this novel experience, community participation, and incentive of reward, are the source of game motivation.

From the point of view of combination of learning, a good game-based learning system must maintain the users a high participation rate of the game and learning. To achieve this, Prensky and Marc proposed several principles of designing game-based learning [21]:

1) The game itself provides enough contents so users will not feel bored playing it.

2) The system makes users think themselves as the "players" rather than "students" or "trainees" when they use the system.

3) The users want to play with game until they complete their objectives, and continuing pursuing their next goal.

4) The users can feel their knowledge have grown because of investment of their time in games.

5) The users can increase their chance of winning by the experience and the knowledge gain from the game.

According to Kiili’s study, in the process of learning, to reach their objectives, learners will be in a very involved, focused state, called “Flow”. In this state, the learners can very efficiently gain their knowledge and enhance their skills from the learning experience [15].

To promote Flow, two conditions must be satisfied. First, there must be challenges, and learners can use their skills to overcome this challenge, if the objectives are too difficult or too simple to achieve, learners will not be in the state of flow. Therefore, a successful game-based learning system must take the users’ prior knowledge and skills into account, and give them appropriate challenges to help users construct new knowledge and skills based on their prior knowledge and skills, shown as fig. 1. However, although a well-designed game actually makes learner feel enthusiastic and improves learner’s outcome, the game’s effectiveness varies depends on how many time the objectives cost, learning environment, and the age of the learners [22]. A simple game is fit for short-term and single study, and a sophisticated game is suit for long-term and cooperative study.

III. DEVELOPMENT OF THE WEB-BASED AND COMPETITION-BASED MULTI-PLAYERS QUIZ GAME ENVIRONMENT

In this section, we describe the development of the web-based and competition-based multi-players quiz game environment. The WCMQGE system includes: quiz game module, item generation module and learning management module. In addition, the design of the WCMQGE system has three main considerations as follows. First, we design various types of quiz used in the games to increase the randomness of items and enhance the interest of players. Second, we set staged, short-term goals for the players to give them simple objects which are expectedly achievable. Third, the system will reward players with special titles and enhancement of capacity of their avatar if they complete each staged goal. On the other hand, the system allows players to use anonymous in games to reduce the negative impacts of competition. Moreover, the WCMQGE system will adjust the parameters of quiz game, such as difficulty of quizzes, based on players’ learning situation.

Fig. 2 shows a screenshot of the main page of WCMQGE. On the left side are the function list and the status of the user and on the ride side is the course list. The user needs to login first and enter a course in order to use the functions. After the user does that, he or she can see his or her name and what course he or she has entered on the left-bellow side.

Figure 2. Main page
A. Quiz game module

The main method of game is to compete in the quiz tests. In a game, every players receive several different questions simultaneously, then one of players chooses one question to “attack” another at the other side (here it means to make opponents do the same questions which attacker chosen) until one of the groups wins.

According to the principle of encouraging players to actively participate in game and balance, we generally put attackers in a more predominant position. On the other hand, to avoid some occasional scenarios that may influence the balance among players, the injuries that the players get in the game process would be calculated considering several conditions:

(1) If the player chooses the wrong answer of the question, he or she will get injured and the value of injury is based on the difficulty of the question. The more difficult the question is, the fewer injuries the player gets.

(2) There are more skills can be used in attacking, meaning that attackers have more strategies used to win the game.

(3) If the attacker chooses the right answer of a question when the defender does not, the defender will get more injuries when the question is difficult. However, the attacker will get more injuries if the attacker chooses the wrong answer when the defender chooses the right one.

In addition to above conditions, there are some limitations to make the game more balanced:

(1) The attacker cannot attack the same player continuously more than two times.

(2) Only a pair of players can compete by the same question at a time, others cannot intervene in the competition.

Fig. 3 shows a screenshot of the process of quiz game. Section 1 shows the players’ information such as nickname, HP, MP, and what they are doing. Section 2 places quizzes used to be the main tool to play the game, player can choose one quiz, answer it, and target one opponent to attack it, then the player who is attacked should do the same quiz. After both sides choose answer, the system will check both answers and distract the players’ HP basis on what they answer and how difficult the quiz is.

B. Item generation module

The WCMQGE system provides three item generation algorithms to increase the randomness of quiz items and enhance the interest of students. The three algorithms are described in the following:

a. Multiple Choice With Random Options:
The system randomly chooses three incorrect choices and one correct choice (there are more than three incorrect choices and one correct choice in database.) and permutes them by randomness.

Example 1:

<table>
<thead>
<tr>
<th>Question Description</th>
<th>Which is a prime number?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct choices</td>
<td>2, 3, 5</td>
</tr>
<tr>
<td>Incorrect choices</td>
<td>4, 9, 15, 21, 27</td>
</tr>
</tbody>
</table>
When this question is used in a game, it may look like below:

**Question:** Which is a prime number?
**Options:** (A) 9 (B) 3 (C) 4 (D) 21

b. Match Items
The system randomly chooses a word to substitute the variable defined in the question, and the match description will be the correct answer.

**Example 2:**
**Question Description:** What’s the definition of [\(v\)]?
**Variables and matched descriptions:**

When this question is used in a game, it may look like below:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Matched Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planck constant</td>
<td>(h = \frac{6.626069 \times 10^{-34}}{s})</td>
</tr>
<tr>
<td>Dirac constant</td>
<td>(h = \frac{1.054571 \times 10^{-34}}{s})</td>
</tr>
<tr>
<td>gravitational constant</td>
<td>(F = G \frac{m_1 m_2}{r^2})</td>
</tr>
<tr>
<td>Avogadro constant</td>
<td>(N_A = \frac{6.022141 \times 10^{23}}{mol^{-1}})</td>
</tr>
</tbody>
</table>

**Question:** What’s the definition of Planck constant?
**Option:**

- (A) \(h = 6.626069 \times 10^{-34} \, J \cdot s\)
- (B) \(h = \frac{1.054571 \times 10^{-34}}{s}\)
- (C) \(F = G \frac{m_1 m_2}{r^2}\)
- (D) \(N_A = \frac{6.022141 \times 10^{23}}{mol^{-1}}\)

c. Random Argument Computational Problem:
The system randomly generates arguments in a specific range to substitute the variables in the function defined with question, then compute the answer based on the function. When learners give the answer and the system will check whether the answer matches what it has computed.

**Example 3:**

<table>
<thead>
<tr>
<th>Question</th>
<th>What’s the square measure of the triangle with the bottom [(v_1)], height [(v_2)]?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>([v_1] \times [v_2] / 2)</td>
</tr>
<tr>
<td>Arguments</td>
<td>(v_1[3, 10], v_2[5, 15])</td>
</tr>
</tbody>
</table>

When this question is used in a game, it may look like below:

**Question:** What’s square measure of the triangle with the bottom 3, height 14?
**Option:** (A) 10 (B) 24 (C) 75 (D) 21

---

Figure 6. Item generation module

Fig. 6 shows a screenshot of the item generation module. On the above side of the figure is the section where a question can be added or edited. On the bellow side of the figure is the section where the existed questions are listed and the user can choose one of the questions to edit. The format of the questions is described before, users should decide what type of question to add or edit and input the parameters needed.

C. Learning management module

Users can view their game records which are presented as correct answer rates, and the information provided change depends on users’ role. As a learner, the user can view his or her progress by the correct answer rate of the questions the user has answered which are sorted by chapters in a certain curriculum. As an instructor, the user can view all the students’ correct answer rate in a certain curriculum so that the instructor will know which student needs more assistance on his or her learning process.

Figure 7. Learning management module (Student)
In this study, we have developed a web-based and competition-based multi-player quiz game environment (WCMQGE) by incorporating DGBL into the web-based e-learning system. The WCMQGE system includes three main modules: quiz game module, item generation module and learning management module. During the process of the game, the WCMQGE system can help players (students) review what they learned from school and use their knowledge to compete with their peers. Moreover, the WCMQGE provide three item generation algorithms: Multiple Choice with Random Options, Match Items and Random Argument Computational Problem to increase the randomness of quiz items and enhance the interest of students. Furthermore, the WCMQGE system also provides the learning management module for the students and teachers to review the learning outcome of the students.

In the future, we will apply the WCMQGE system to the practical teaching and learning. The pedagogical experiments will be designed to assess the improvement of student motivation and learning effectiveness.

REFERENCES


Kuan-Cheng Lin was born in Taiwan on September 13, 1964. He received a BS in chemistry from National Taiwan University in 1988 and a PhD in applied mathematics from the National Chung-Hsing University in 2000. From 2000 to 2006, he was an assistant professor with the department of information management at the Northern Taiwan Institute of Science and Technology, Taipei, Taiwan. From 2006 to 2008, he was an assistant professor with the department of management information systems at National Chung-Hsing University, Taichung, Taiwan. Since 2008, he has been an assistant professor with the department of management information systems at National Chung-Hsing University, Taichung, Taiwan. His current research interests include affective computing, intelligent tutoring system and data mining.

Ting-Kuan Wu was born in Kaohsiung, Taiwan, R.O.C. on June twenty-sixth. Now he is an undergraduate student of management and information system department in National Chung Hsing University (NCHU), Taichung, Taiwan. He is the chief administrator of NCHU male dormitory’s network, and he had worked in internship as a developer to build a student performance management system in Daojian High School of Commerce, Taipei, Taiwan and a volunteer serve in Sinlau Hospital for one and half month, from July 5th, 2009 to August 25th, 2009. His primary research interests are system architecture and integrating information systems with the operating process of any organizations.

Yu-bin Wang was born in Tainan, Taiwan, R.O.C on May eighth. Now he is an undergraduate student of management and information system department in Nation Chung-Hsing University (NCHU), Taichung, Taiwan. He is the administrator of school male dormitory’s network, and he had worked in internship as an experimental educator in junior care class, Tainan, Taiwan. His primary research interests are computer science, optimizing system in algorithm, and contact system from each type of user by psychology.