A Game-based Learning System using the ARCS Model and Fuzzy Logic

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***Abstract*—Traditional textbook may be replaced by digital media or e-Material. Most of the e-learning system mainly teaching material includes text, picture, video, but lacked for interaction between students and vivid materials. Online games are conducive to learning because online games have greatly interaction and competitiveness among players to enhance student motivation to learn. Therefore, this work developed a multiplayer online game-based learning system (MOGLS), which based on the ARCS motivation model. The MOGLS allows learners to acquire Enterprise Resource Planning knowledge. The MOGLS system provides learning record, rankings record, end-of-test feedback to motivate learners to learn. By competition among students, the MOGLS system would facilitate and enhance learning. Finally, we analyzed the system effectiveness and system satisfaction for MOGLS system. The empirical results show that multiplayer online game-based learning system not only helps students to obtain the ERP certification, the system also get a good utility evaluation in system effectiveness and satisfaction.**

***Index Terms*—game-based learning, ARCS motivation model, fuzzy logic , information system success model**

I. Introduction

The prominent role of e-Learning in information technology has led to advances in recent years. Given the efficiency of e-learning in education, digital media or e-Materials may replace traditional textbook in the near future. While offering text, pictures, and video, most teaching materials in an e-learning system lack interaction between students and vivid materials. Online games facilitate learning because online games create a significant amount of interaction and competitiveness between players [1][2].

John Keller developed the motivation model of attention, relevance, confidence, and satisfaction (ARCS), capable of increasing student motivation to learn [3][4][5].

Based on the ARCS motivation model, this work develops a novel multiplayer online game-based learning system (MOGLS), which creates a significant amount of greatly interaction and competitiveness among players to enhance student motivation to learn.

The proposed MOGLS systems allows for learners to acquire knowledge of enterprise resource planning by providing a learning record, ranking record, end-of-test feedback to motivate students to learn. Through interaction and competition among students, the MOGLS system greatly facilitates learning.

In particular, this work has the following objectives:

1) To apply the ARCS motivation model, in which a game-based learning system is formed based on fuzzy theory.

2) To evaluate the system components and scoring mechanism of MOGLS, as well as develop rules of fuzzy weighted scoring to calculate the total student score.

3) To facilitate and increase the efficiency of learning in order to develop an online learning system environment and provide a competitive and interactive environment to motivate student learners.

II. Literature Review

A. Game-Based Learning

Among the advantages of game-based learning (GBL) over traditional learning methods include its liveliness, vibrant nature, and ability to draw student attention. Importantly, GBL can engage and motivate students to learn.

In particular, GBL is characterized by its interactive richness in user interface, degree of difficulty options, timely feedback responses, and prolific sounds that increase student interest in learning. In sum, GBL actively promotes learning, increases student motivation to learn and reduces stress in learning [6][7][8].

B. References

Designed by John Keller, the ARCS motivation model emphasizes motivation, implying that students must actively participate in an activity to achieve a specific goal. Among the many well established motivation theories integrated in the ARCS motivation model include expectancy-value, achievement motivation, and social learning. The ARCS motivation model focuses mainly on strengthening systematic instructional design and designing materials that encourage student participation.

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Four factors in the ARCS motivation model that explain motivation are attention, relevance, confidence, and satisfaction. Keller indicated that student motivation must be compatible with these four factors to increase the motivation to learn. The following discussion introduces the four factors of the ARCS motivation model, with each factor containing three motivational learning strategies [9][10][11] (TABLES I and II).

TABLE I.

THE FOUR FACTORS IN THE ARCS MODEL

Factor	Definition
Attention	A student's attention has to be aroused and sustained.
Relevance	After the student's attention is gained, a student may wonder how the given material relates to their interests and goals. If the content is perceived to be helpful in accomplishing one's goals, then they are more likely to be motivated.
Confidence	Students have to know that they will probably be successful before completing a given task. They have to feel somewhat confident. Success is not guaranteed and people enjoy a challenge. However, the challenge can't be too difficult.
Satisfaction	If the outcomes of a learner's effort is consistent with their expectations and they feel relatively good about those outcomes, they will remain motivated.

TABLE II.

THE ARCS MOTIVATION MODEL OF MOTIVE OF LEARNING STRATEGIES

Factor	Strategies	Description
Attention	Perceptual Arousal	Gain and maintain student attention by the use of novel, surprising, incongruous, or uncertain events in instruction.
	Inquiry Arousal	Stimulate information seeking behavior by posing, or having the learner generate questions, or a problem to solve.
	Variability	Maintain student interest by varying the elements of instruction.
Relevance	Familiarity	Use concrete language and use examples/concepts that are related to the learner's experience and values.
	Goal Orientation	Provide statements or examples that present the objectives and utility of the instruction and either present goals for accomplishment or have the learner define them.
	Motive Watching	Use teaching strategies that match the motive profiles of the students.
Confidence	Learning Requirements	Help students estimate the probability of success by presenting performance requirements and evaluative criteria.
	Success Opportunities	Provide challenge levels that allow meaningful success experience under both learning and performance conditions.
	Personal Control	Provide feedback and opportunities for control that support internal attributions for success.
Satisfaction	Natural consequences	Provide opportunities to use newly acquired knowledge or skill in a real or stimulated setting.
	Positive consequences	Provide feedback and reinforcements that will sustain the desired behavior.
	Equity	Maintain consistent standards and consequences for task accomplishment.

C. Fuzzy Theory

Pioneered by Zadeh in 1965, the fuzzy theory fails to clearly define fuzzy phenomenon in life [12]. Individual feelings are subjective, and everyone's statement may different among one other. It is not everything can be expressed dichotomy only (true or false, 1 or 0, right or wrong) in life. An example is "the weather temperature" and "score". One way of defining a set A is in terms of its membership function $\mu_A(x)$. The usual membership functions with values in [0, 1]. Membership functions can either be chosen by the user arbitrarily, based on the user's experience. There are different shapes of membership functions; triangular, trapezoidal, piecewise-linear, Gaussian, bell-shaped, etc [13].

D. Information System Success Model

DeLone & McLean(1992) proposed a taxonomy and an interactive model success model as frameworks for conceptualizing IS success. They identified six variables of IS success: system quality, information quality, use, user satisfaction, individual impact, and organizational impact [14]. In 2003, Delone & McLean proposed a revised model, the updated model is shown in Fig. 1. A key addition in the updated model was the inclusion of service quality as an additional aspect of information system success. Delone & McLean also recommended assigning different weights to system quality, information quality, and service quality depending on the context and application of the model[15][16].

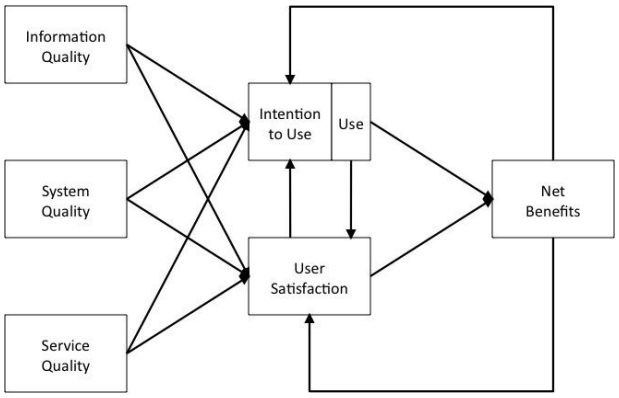

Figure 1. Updated D&M IS Success Model

III. RESEARCH DESIGN

A. Research Methods

This work develops a multiplayer online game-based learning system (MOGLS), which is based on the ARCS motivation model. Students can acquire knowledge of enterprise resource planning by using the MOGLS system, which facilitates learning through interaction and competition among students.

This system design adopts Client/Server architecture; the server adopts Multi-Thread; the database server uses Microsoft SQL Server 2005; and the interface design adopts Windows form by Visual Studio 2010.

B. System Architecture

This proposed learning system was provided mainly to students who enrolled in an undergraduate course of Enterprise Resource Planning for practice and examinations. Figure 1 illustrates features such as the user interface, manager interface, learning logs module, and examination database. Each module and database are described as follows.

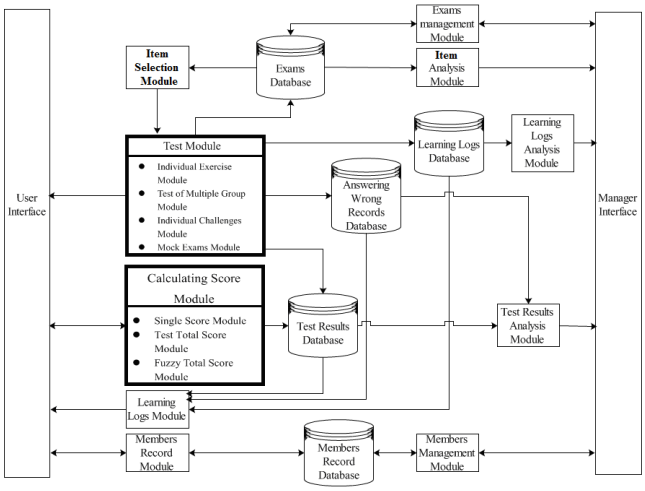

Figure 2. System Architecture.

1) Test module: This module provides four test modules to enhance student motivation to learn and keep their attention with test of variability by informing the practice results and end-of-test feedback immediately.

a) Individual exercise module: This module can allow students to select the chapter they want to practice. Students can use a help tool during practice to increase interest. Additionally, students' scores allow them to acquire nonus points to increase their learning motivation and confidence.

b) Test of multiple group module: This module provides competition among four players. Players are chosen based on their competency, according to the same level. If the number of players not enough that will generate the same level of virtual players by computer. This feature avoids student feelings of frustration and increases their confidence. Instead, this feature attracts student attention while increasing competition among students.

c) Individual challenges module: This module provides three difficulty levels of items, distinguished into easy, medium and difficult levels for students. Each student can select any one difficulty level of items to test themselves. Students having answered correctly can obtain help tools as a reward incentive. Students must answer all items correctly to be considered a successful challenge in order to increase learning motivation and satisfaction.

d) Mock exams module: This module simulates certification examinations with respect to knowledge of Enterprise Resource Planning in order to increase student confidence.

2) Item selection module: This module selects items based on the four test test modules. To maintain equity, each answer option sequence is randomly generated by a computer.

a) Individual exercise module: To increase student confidence, this module selects items that include their records of wrong answers and random questions.

b) Test of multiple group module: This module provides different difficulty levels of item based on the student competency. As students upgraded to higher levels, difficulty of items is also increased, to stimulate student motivation to learn and challenge advanced questions.

c) Individual challenges module: This module selects a specify degree of difficulty of items for student to be tested, in which the item difficulty is determined by students themselves.

d) Mock examinations module: This module simulates a certification examination, which contains 100 random items from examinations database.

3) Calculating score module: Upon completion of the test, this module calculate this test score and re-calculates the total score of this module and the other four test modules. To build student confidence, students can understand how to study diligently so that can pass the grading evaluation.

a) Single scoreing module: The module provides a test containing 10 multiple choice items, with 10 points per item.

b) Test total score module: All test scores in this test module are calculated.

c) Fuzzy total score Module: The total score uses the fuzzy theory in four test modules. Partitioning of the score includes system participation rate as 10% of the total score, individual exercise as 30% of the total score, multiple group testing as 30% of the total score, individual challenges as 15% of the total score and mock examinations as 15% of the total score.

4) Learning logs module: This module provides some query functions for students to evaluate their own performance in the system, including login information, personal ranking records, achievement records, and diagram of learning curves. Additionally, students check their test records of wrong answers and examination score record of each test. In addition to revealing learning achievement, MOGLS satisfies the self-actualization ability of students.

5) Members record module: This module provides personal information of student, including student number, email, game nickname, experience, and level. Personal information of students is also stored in the members record database.

6) Examinations database: The items are stored for each chapter.

7) Learning logs database: The learning logs of students are stored.

8) Answering wrong records database: Their records of wringly answered items are stored.

9) Test results database: Examination records of each test are stored.

10) Members record database: Personal information of students is stired. including details such as student number, email, game nickname, experience, and level.

11) Examinations management module: This module allows administrator to insert, delete, modify, and query items.

12) Items analysis module: This module allows administrator to check the correct answer rate, wrong answer rate and difficulty index of items.

13) Learning logs analysis module: This module provides statistical analysis of learning logs so that administrators can assess the learning performance of students quickly.

14) Test results analysis module: This module provides statistical analysis of examination score records so that administrators can assess the learning performance of students quickly.

15) Members management module: This module allows administrators to manage students' permission-related infomation.

C. Scoring Rules

1) Test total score: These rules help to build student' confidence. This is owing to that one poor score does not significantly affect the total score.

$$T_{(i)} = \frac{\sum_{i=1}^{n} Score_{(i)} \times (n+1-i)}{\frac{(1+n)\times n}{2}} \qquad (1)$$

Where *i* denotes the number of test scores in which the range between 1 and *n* denotes total number of test scores. Also, $Score_{(i)}$ denotes number of test scores several times.

2) Fuzzy weighted scoring

Order of merit based on the Ministry of Education of the Republic of China include a grade of A, which is more than 90 points; a grade B, which is between 80 and 89 points; a grade of C, which is between 70 and 79 points; a grade of D, which is between 60 and 69 points; and a grade of E, which is below 60 points.

Step1: In MOGLS, evaluation factors are divided into five items in which the weight of system participation rate is 10%; the weight of individual exercise is 30%; the weight of multiple group of tests is 30%; the weight of individual challenges is 15%; and the weights of mock examinations is 15%. The weights of evaluation factors set are as follows:

$$\mathrm{S} = \{0.1,0.3,0.3,0.15,0.15\}$$

Step2: This work adopts the trapezoidal membership function, in which the membership function is as follows:

$$\mu_A(x) = \begin{cases} 0, & x \le 87.5 \\ \frac{x}{5} - 17.5, & 87.5 \le x \le 92.5 \\ 1, & 92.5 \le x \le 100 \end{cases}$$

$$\mu_B(x) = \begin{cases} 0, & x \le 77.5 \\ 18.5 - \frac{x}{5}, & 87.5 \le x \le 92.5 \\ \frac{x}{5} - 15.5, & 77.5 \le x \le 82.5 \\ 1, & 82.5 \le x \le 87.5 \end{cases}$$

$$\mu_C(x) = \begin{cases} 0, & x \le 67.5 \\ 16.5 - \frac{x}{5}, & 77.5 \le x \le 82.5 \\ \frac{x}{5} - 13.5, & 67.5 \le x \le 72.5 \\ 1, & 72.5 \le x \le 77.5 \end{cases}$$

$$\mu_D(x) = \begin{cases} 0, & x \le 57.5 \\ 14.5 - \frac{x}{5}, & 67.5 \le x \le 72.5 \\ \frac{x}{5} - 11.5, & 57.5 \le x \le 62.5 \\ 1, & 62.5 \le x \le 67.5 \end{cases}$$

$$\mu_E(x) = \begin{cases} 0, & 62.5 \le x \\ 12.5 - \frac{x}{5}, & 57.5 \le x \le 62.5 \\ 1, & 0 \le x \le 57.5 \end{cases}$$

Step3: Membership function and fuzzy matrix operations are computed as follows:

a) First evaluation factors (system participation rate): $\mathrm{R_1}$={ $\mathrm{R_{A1}}$, $\mathrm{R_{A2}}$, $\mathrm{R_{A3}}$, $\mathrm{R_{A4}}$, $\mathrm{R_{A5}}$}

b) Second evaluation factors (individual exercise): R_2={ R_{B1}, R_{B2}, R_{B3}, R_{B4}, R_{B5}}

c) Third evaluation factors (multiple group of test): R_3={ R_{C1}, R_{C2}, R_{C3}, R_{C4}, R_{C5}}

d) Fourth evaluation factords (individual challenges): R_4={ R_{D1}, R_{D2}, R_{D3}, R_{D4}, R_{D5}}

e) Fifth evaluation factors (mock exams): R_5={ R_{E1}, R_{E2}, R_{E3}, R_{E4}, R_{E5}}

Step4: Composition of fuzzy relations is as follows:

$$\mathrm{C} = \mathrm{R} \circ \mathrm{S}$$

$$\mathrm{C} = \begin{bmatrix} R_{A1} & R_{A2} & R_{A3} & R_{A4} & R_{A5} \\ R_{B1} & R_{B2} & R_{B3} & R_{B4} & R_{B5} \\ R_{C1} & R_{C2} & R_{C3} & R_{C4} & R_{C5} \\ R_{D1} & R_{D2} & R_{D3} & R_{D4} & R_{D5} \\ R_{E1} & R_{E2} & R_{E3} & R_{E4} & R_{E5} \end{bmatrix} \circ [0.1,0.3,0.3,0.15,0.15]$$

$$\mathrm{C} = [\mathrm{RS}_A, \mathrm{RS}_B, \mathrm{RS}_C, \mathrm{RS}_D, \mathrm{RS}_D]$$

Step5: Defuzzifierion formulas is as follows:

$$\mu_A = (92.5 + 100)/2 = 96.25$$

$$\mu_B = (82.5 + 87.5)/2 = 85$$

$$\mu_C = (72.5 + 77.5)/2 = 75$$

$$\mu_D = (62.5 + 67.5)/2 = 65$$

$$\mu_E = (0 + 57.5)/2 = 28.75$$

D. Ddata Collection, and Measure

To test the system effectiveness and system satisfaction of MOGLS were investigated via a survey. Prior to conducting the survey, we chose two teachers and ten undergraduate students of MIS programs to pilot test the survey instruments. The feedback from pilot testing was useful for ensuring the content validity and checking the appropriateness and answerability of the items of questionnaire.

A 24-item survey questionnaire was developed to obtain the response from the students about their opinions on various research constructs. The questionnaire of this study consists of two research constructs. The questionnaire has three main sections. The first section contained 4 items sought for demographic information. In the second section, 14 items were used to measure the variables involved "system effectiveness". In the last section, 10 items were used to measure the variable involved "system satisfaction".

The items of ***system effectiveness*** were developed based on the Keller's ARCS model, and five-point Likert-type scales were used (1=strongly disagree to 5= strongly agree). The ***system satisfaction*** were measured with the scale developed by DeLone & McLean (2003), and five-point Likert-type scales were used (1=strongly disagree to 5= strongly agree).

IV. System Representation

A. learning System Based on ARCS Motivation Model

The MOGLS system allows students to be tested by the variability test module, subsequently raising student motivation to learn and their curiosity. For students aware that the learning system is related to ERP courses and have mock examinations, they are more familiar with enterprise resource planning-related knowledge. Students then use different tests, understand their learning circumstances, and then build their confidence. Finally, students involved in various tests and challenges can achieve increasingly more learning objectives and subsequently build their confidence. Owing to limited space of this article, use of the ARCS motivation model in this system is briefly explained as follows:

1) Attention strategy

a) Students can use the help tool during practice to increase their interest.

Figure 3. First Attention Strategy.

b) Players are chosen according to a similar competency level in order to encourage competition among students.

Figure 4. Second Attention Strategy.

2) Relevance strategy

a) Students familiarize themselves with enterprise resource planning-related knowledge by taking mock examinations.

Figure 5. First Relevance Strategy.

b) Use of the learning system in ERP courses encourages students to study diligently.

Figure 6. Second Relevance Strategy.

3) Confidence strategy

a) Students understand that their diligent study allows them to achieve a favorable grading evaluation and acquire bonus points to increase their learning motivation and confidence.

Figure 7. First Confidence Strategy.

b) MOGLS Provides three levels of difficulty for each item, distinguishes as easy, medium and difficult levels for students. Each student can choose any one difficulty level of items to test themselves and enhance interest in learning and degree of satisfaction.

Figure 8. Second Confidence Strategy.

4) Satisfaction strategy

Students can monitor their learning achievement records and satisfy their own self-actualization capability.

Figure 9. First Satisfaction Strategy.

Figure 10. Second Satisfaction Strategy.

V. Data Analysis

A. Descriptive Analysis

The results show that the sample (n=33) include most respondents are male (66.7%,), and they are mostly undergraduate students (72.7%). Most respondents are junior student (39.4%).

TABLE III.

THE SAMPLE PROFILE (N=33)

Respondent's profile		Freq.	Percentage
Gender	Male	22	66.7
	Female	11	33.3
Degree	Undergraduate level	24	72.7
	Graduate level	9	27.3
Grade	Freshman Year	0	0.0
	Sophomore Year	0	0.0
	Junior	13	39.4
	Senior	11	33.3
	First year master degree	4	12.1
	Second year master degree	5	15.2

B. Results of Reliability Tests

Prior to conducting further analyses it is important to assess reliability in the measurement scale. While Cronbach's alpha greater than 0.7 are employed to prove the reliability of the instrument. The results of reliability test present Cronbach's alpha greater than 0.7 for all the constructs. The results of reliability test for the construct are shown in Table IV.

TABLE IV.

RELIABILITY ANALYSIS OF CONSTRUCT

Construct	Number of Items	Crobach's alpha
system effectiveness	10	0.897
system satisfaction	14	0.876

C. Measurement Results for Research Variables

Table V to VI presents descriptive statistics for each of the questionnaire items of the relevant research variables, and Table VII present descriptive statistics for each of research construct. There are 10 items of system effectiveness, and 14 items of system satisfaction. Table xxx10 shows that system effectiveness is high for the respondents, which is indicated by mean score from 3.67 to 4.39.

Table V shows that system effectiveness is high for the respondents, which is indicated by mean score from 4.03 to 4.45.

TABLE V.

DESCRIPTIVE ANALYSIS FOR SYSTEM EFFECTIVENESS

system effectiveness	Mean	Std. Deviation
Q1. Help tool is fun	3.67	0.777
Q2. To maintain curiosity of Learning	3.94	0.609
Q3. Game-based test improve learning outcome	4.24	0.614
Q4. Simulation certification exam help me to obtain the ERP certification	4.39	0.659
Q5. To improve my grades	4.33	0.645
Q6. To enhance my motivation.	4.00	0.559
Q7. More willing to spend time and effort in learning	4.06	0.704
Q8.To enhance the learning confidence	4.18	0.635
Q9. To enhance the self-confidence to pass the ERP certification exam	4.33	0.777
Q10. The positive feedback would enhance my learning confidence	4.12	0.781
Q11. To enhance the self-fulfillment	4.30	0.684
Q12. I felt satisfied with the positive feedback	4.12	0.74

Table VI shows that system satisfaction is high for the respondents, which is indicated by mean score from 4.03 to 4.45.

TABLE VI.

DESCRIPTIVE ANALYSIS FOR SYSTEM SATISFACTION

system satisfaction	Mean	Std. Deviation
Q1. The MOGLS system interface is easy to use.	4.39	0.556
Q2. Content is accurate	4.42	0.502
Q3. I am satisfied with the system functions.	4.03	0.585
Q4. The test item in MOGLS is sufficient.	4.27	0.674
Q5. Test information is easy to understand.	4.30	0.585
Q6. Information provided by the testing system is useful.	4.24	0.614
Q7.The MOGLS provides personal records	4.24	0.614
Q8. The tests provided personal record is clear.	4.45	0.617
Q9. I willingness to use MOGLS to learn the knowledge of the ERP certification.	4.39	0.788
Q10.I would recommend the MOGLS to my classmate.	4.45	0.711

CONCLUSIONS

The empirical results show that MOGLS not only helps students to obtain the ERP certification, the system also get a good utility evaluation in system effectiveness and satisfaction.

Based on the ARCS motivation model, the proposed MOGLS system has the following benefits:

1) MOGLS, a multiplayer online game-based learning system, allows learners to acquire enterprise resource planning knowledge. In addition to raising the intrinsic motivation of students' active learning and enhancing their learning performance, the proposed system can raise the completion rate for students participating in the certification examination for Enterprise Resource Planning.

2) The MOGLS system is highly promising for use in thedigital learning sector and academia.

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