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# Gamified Mathematics practice:

# Designing with e-commerce and computational concepts

Chien-sing LEE, Jing-wen WONG, Peh-yenc EE,

Department of Computing and Information Systems,
Sunway University, Malaysia.
chiensingl@sunway.edu.my, jing.w8@imail.sunway.edu.my, peh.e@imail.sunway.edu.my

## ABSTRACT

This paper addresses two problems which usually occur in learning Mathematics: first, students who face difficulty understanding and are too shy to participate in discussions and subsequently do not manage to resolve their doubts, and second, dull e-learning websites. The many rules in Mathematics compounds the problem further. We thus aim to address these problems through a gamified e-commerce-oriented Mathematics learning practice system, Alzebra, for informal learning. Focusing on principles of Information Systems Analysis and Design, e-commerce-oriented computational concepts are embedded in the game to motivate online practice. The system concept, design methodology and user testing outcomes are presented. Significance lies in deriving perception towards gamification and components which users liked or disliked and the efficacy of our hybrid approach in systems development.

## KEYWORDS

Design; gamification; Mathematics practice; e-commerce; computational concepts.

## 1. INTRODUCTION

Blended learning is increasingly popular. However, educators may not be available face-to-face at all times to help students with their problems. Hence, two problems need to be addressed (Chen & Jones, 2007; Li, 2016). First, students who have difficulties grasping concepts in class and who are shy. They tend not to participate in the activities or interact with their peers in class even though they do not understand what they are learning in class. Instead, they would be forced to revise topics on their own. The second problem arises if the e-Learning platforms are dull and mostly text-based or unexciting.

In the learning of Mathematics (MVid, 2016), the enormous number of rules that need to be followed often makes understanding complex Mathematics frustrating. These pose challenges to motivate students to access online materials to carry out self-study and to keep them engaged throughout their online learning process. Hence, we aim to develop a gamified computer-aided learning system, Alzebra, to carry out revision and reinforcement outside the classroom.

Bearing in mind several learning strategies, our objectives are to:

a) assess the improvements that can be made to existing related systems and choose the best features that can be adopted;
b) explore the possibilities of gamified learning in online education.

## 2. RELATED WORK

### *2.1 Learning difficulties faced by students in Mathematics*

Other than the small number of students who have been identified as having dyscalculia (Mathematics learning disability), there are a few reasons why students face difficulties grasping concepts in Mathematics (Taylor & Galligan, 2006; MVid, 2016):

a) students who experience this problem often possess characteristics such as lack of confidence due to constant failure, do not activate prior knowledge to solve problems, have trouble memorizing basic Math functions, have problems focusing when facing questions involving multiple steps, lack of cognitive thinking skills, and afraid of being wrong..
b) there are also a few teacher-related variables, which cause students to have problems in understanding concepts in Mathematics.
c) research has also suggested that curriculum-related variables such as spiralling curriculum causes students to experience significant problems learning and applying Mathematics concepts. This may be due to cognitive overload.

### *2.2 Mathematics Learning Strategies*

Many Mathematics strategies have been around and are used by educational institutions. Some of the approaches available are classroom-based techniques such as metacognitive strategies, cognitive strategies, and social or affective strategies while others are software-based approaches where educational technology, is used as one of the teaching strategies (Taylor & Galligan, 2006; Yang, Chang, Cheng, & Chan, 2016; Centre for Advanced Research on Language Acquisition, 2016; MVid, 2016). Due to the fact that both means of instructional delivery methods are diverse, the outcomes from both approaches in relation to students' performance may however, also differ.

### *2.3 Gamification in Educational Websites*

Gamified learning is a term used to describe the integration of game mechanics in learning the process to make instructions more engaging and fun. It has the potential to help the way students need to feel engaged when learning, that is, through growth and advancement, recognition and rewards, a higher goal to pursue, and a sense of teamwork

Kapp's (2012) study states that there are researchers who suggest that gamification can be used as a tool in education to spark interest in students to learn. Moreover, students who have used a gamified e-Learning platform produce higher practical test scores compared to those who use the non-gamified version.

Furthermore, according to the Gamification Survey carried out by Talent LMS (2016), 79% of the participants have shown a positive attitude towards the integration of gamification in their university or institution. Out of 75%, the participants are already gamers themselves whereas 50% of them play casually and 27% of them moderately to fairly often. In addition, over 60% of the participants would be motivated by leader boards and increased competition between students and 89% would be more engaged with an e-learning application if it had a point system.

Based on this, it can be concluded that the strong interests of the participants in game may indicate that implementation of gamification in educational websites can be accomplished. An example of existing systems implementing gamification in education is the Khan Academy.

## 3. SIGNIFICANCE

There are several contributions from this study:

a) This study contributes to how Information Systems Analysis and Design principles and computational components integrated with e-commerce and gamification can be used to design applications which have the potential to motivate online practice. The application of computational concepts to the real-world corresponds with computational thinking (Wing, 2006).
b) A deeper understanding of the perceptions of the student community needs to be first identified and designed for if gamification is to work well. This finding supports that of an earlier paper (Wong & Lee, 2016).
c) Consistent with (TalentLMS, 2016), prior user gaming experience influences acceptance of gamified applications.
d) Object-oriented design is cost-effective and sustainable.

## 4. METHODOLOGY

### *4.1 Sample*

The sample students are 10 students who are weak in Mathematics studying at the pre-university level. Learning Mathematics online is foreign to them though they know that these systems exist. The testing period is one week each (initial survey and user-testing).

### *4.2 Procedure*

Adopting agile methodology, rapid prototyping and design thinking, two phases are carried out, involving two iterations in each phase. The first phase involves the initial survey and the second phase the beta testing. These are elaborated on below.

**First phase:**

An evaluation of existing e-learning websites (objective a above) based on Nielsen's criteria: Website Content, Website Interface, and Website Functionality is carried out to determine improvements which can be made and opportunities for developing systems meeting our objectives.

Subsequently, for design and development, the first iteration includes the basic content management features. The second iteration includes the add questions page, practice page, show hint and check answer section in practice page, quiz page, and view result page. Next, a survey is carried out to determine students' attitude towards the use of technology in learning Mathematics online.

**Second phase:**

The first iteration involves the point-accumulating function in the prototype, user garden page, marketplace page, leaderboard section, and FAQ page. Within the user garden, e-commerce-oriented activities are introduced to motivate practice. The second iteration includes a comment section in all topic pages.

## 5. SYSTEM CONCEPT

This Website is developed to integrate the concept of gamified learning into an online educational website. On registering to become a member, users will get their very own garden which they can visit through the link located at the User Login Information dropdown list.

The system works like a normal online educational website which enables students to learn on topics, do practices, attempt quizzes, and view their results. Other than those minimal requirements for an educational website, an extra enhancement is incorporated into the system, that is, a point-accumulating system.

The main idea of this point accumulating system is to encourage students to revise topics by attempting practices and quizzes and keep them engaged when they are on the website. For every correctly-answered question, students get to earn points. Points will also be given when students have completed a quiz.

On registering, each student will have their own page called "My Garden", this is where they have plants they need to nurture in order to gain more points. The way they cultivate their plants is by buying materials from a page called

"Market Place". There are four items that need to be used on each seed in order for it to be fully grown. Once the plant is fully grown, it can be sold to earn points. The names of students with the highest points accumulated will be shown on a leaderboard at the home page.

The final system's use case diagram (Figure 1) and user interfaces (Figures 2, 3, 4 and 5) are presented below.

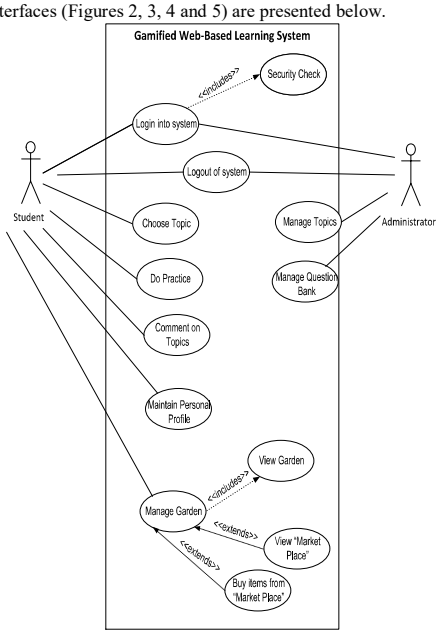


*Figure 1.* Use Case Diagram

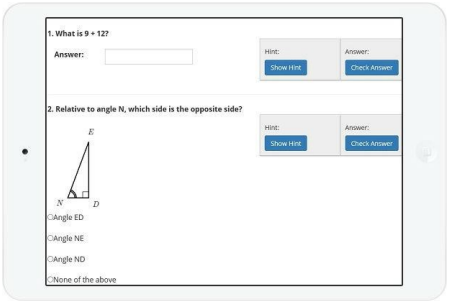


*Figure 2.* Practice Page Screenshot

Figure 3 shows the layout for the User Garden Page. Computational concepts are used here to design the game story for the topic trigonometry. There are altogether ten slots in the garden. Five of the slots are open, while the other five of them are locked. These open slots will be where the seeds received by users are planted. The locked slots needs be purchased for 150 points each to get more space for users to plant their seedlings. Upon registering, each user will be given a seed. Each seed has to be watered, weeded, fertilized, and cleared of pest once respectively to be completely grown. To grow the seeds, users have to visit the market place to buy the materials needed.

Grown plants can be sold by users to earn more points. A mysterious seed will be given for free to users every time their accumulated points have reached 100 points. Each time users get a seed, it will be automatically be planted in one of the open slots in their garden. If users do not have any open slots left, the seed will be discarded. Users will be competing with other members on the system to get the highest ranking on the leaderboard based on the points they have accumulated. To earn points, users must do practices. With each question correctly answered, users will get five points. Besides that, users can also gain points by doing quizzes.


*Figure 3.* User's Garden

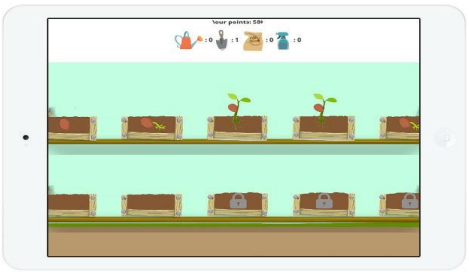

*Figure 4.* User's Garden Page Screenshot


*Figure 5*. Market Place Screenshot

## 6. FINDINGS

### *6.1 Findings from the initial survey*

Findings from the initial survey involving 30 users are as follow:

- 73% of the participants think that learning Mathematics will be useful for them in their future. 20% of them do not think that learning Mathematics will be important to them. The rest have a neutral attitude towards learning Mathematics.
- 61% of the participants have a great experience learning.
  23% of them do not have a positive attitude towards classroom experience while 16% of them have a neutral attitude towards the classroom experience. Those who have a positive attitude towards the learning experience mostly understand what they have learned in class and have friends who can help them when they face problems understanding Mathematics.
- 73% of the participants think that they can do well in Mathematics. 13.5% of them think that they are not good in Mathematics and another 13.5% of the participants have a neutral attitude towards their self-confidence in Mathematics.
- 47% of the participants find learning Mathematics through technology easier to understand. 23% of them find it uncomfortable learning Mathematics through technology while 30% of them have a neutral attitude towards the use of technology in learning Mathematics.

Subsequently, based on the result of this survey, a basic gamified Web-based learning platform was developed.

### 6.2 *Findings from beta testing*

Beta testing involves 10 students. Findings based on the Technology Acceptance Model indicates that overall, Alzebra has received positive response from the ten participants. Furthermore, it is observed that:

- All of the participants managed to use the website without any difficulties (ease of use). 80% of the students think that the design and layout of the system are acceptable. They can navigate through the site easily. 20% of the students find the layout of the website can be made more interesting.
- 70% of the participants have a positive attitude towards the concept of game in educational website. They are able to accept gamification in education while 30% of the students prefer the normal web-based learning system with no gamified concept included.
- Similarly, 60% of the students think that online competition such as leader board is challenging and fun while the rest think that it is annoying.
- 60% of the students will use the comment section provided to interact with other members online when they are facing problems understanding the concepts of the topic while 40% of them think it is unnecessary.
- A majority agree that they can do better if the website is incorporated as part of the Mathematics subject.
- Three of the suggestions made are to improve the gamification portion in the website. The point-accumulating system can be motivating as the majority (6 out of 10) finds online competition stimulating while the rest of the participants think that the reward provided is gimmicky.

## 7. CONCLUSION

From these results, students appear to prefer attractive websites and prefer not having their performance or comments displayed publicly. The latter is typical of more conservative Asian culture and the influence of prior gaming experience towards acceptance of gamification in e-learning. Furthermore, there is improvement in acceptance towards such learning environments compared to the initial survey. This finding supports that of two other related projects, i.e., on teaching augmented reality to youths and e-crafting (Wong & Lee, 2016; Low & Lee, 2016). Noting the comments and suggestions above, to meet the needs of a majority of the users who are not gamers, we need to improve on our design with game mechanics which matter to the users.

This is a course assignment. The sample size is small and findings are not generalizable. Nevertheless, we hope that eventually, this e-Learning platform will provide a better user experience for students, hence keeping them enthused to carry on their self-studies outside of a classroom.

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