

# Designing Role-Playing Games to learn Mathematics

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**Abstract** — *Most of the pupils nowadays spend bulk of their out-of-school time playing computer games. Although computer games are perceived as unhealthy to the young minds, there are studies that highlight the potential of using educational computer games as a medium of learning. These types of games provide the opportunity for integration of the social, cognitive and affective aspects of learning. This paper discusses on the design of a role playing game that could be used to learn mathematics. A simple prototype of the game is being developed for children between the ages of 10 to 12 years to learn basic mathematics. This prototype is built with a storyline, challenges and a reward system. The methodology used in the developing the system is Spiral model. The system is developed using Flash 8, Photoshop CS2 Macromedia FreeHand and Sound Forge & Audacity. Ten students were involved in the preliminary evaluation of the prototype. Separate interview sessions were also conducted for each student once they completed the game. The results of these interview sessions will be used to enhance the prototype.*

**Index Terms** — computer games, mathematics, role playing game

## INTRODUCTION

Computer games are today an important part of most children's leisure. Computer games, formerly referred to as PC-based games are software artifacts that combine multimedia and other computing technologies such as networking to enable the game player to experience goal directed play in a virtual environment [1]. Role-playing games (RPG's) is a game in which the participants assume the roles of an avatar (fictional characters) and collaboratively follow and/or create stories [2]. Characters in RPG game can be divided into two categories: the player characters and non-player characters (NPC). Player characters, are played and controlled by real players, through roaming or adventures helped the development of game plot; NPC cannot be controlled by players, but they played indispensable supporting role in guiding or obstructing game players , such as providing games mission to them, helping them or just as the enemy[3]. In other words, RPG's allow students to assume the role of a character in the game world and to determine the actions of their characters based on the characterization.

Most students think that mathematics is a difficult, complicated and confusing subject because it involves formulae and calculations. Others see mathematics as a boring subject which sometimes is unrelated to their real-life situations. On the other hand, conventional learning instruments for learning mathematics such as text book, revision book, and courseware are not very effective in ensuring a mastery of the subject. Among the problems associated with the conventional learning instruments are: lack of motivation, not very interesting / boring , little encouragement for self-learning , less meaningful and no continuity.

According to [4], people learn best when they have a strong and immediate motivation to acquire new knowledge, and when they are having fun. Game based learning is able to create a fun, motivating, and interactive virtual learning environment. Furthermore, for today's kids, raised on computers and video games, presenting concepts in a form they are predisposed to love is a great formula for success [5].

However, studies on how mainstream games could be used in school found that the most frequent obstacles encountered are: i) it was difficult for teachers to identify quickly how a particular game is relevant to some of the curriculum, as well as the accuracy and appropriateness of the content within the game; ii) the difficulty in persuading other school stakeholders as to the potential/actual educational benefits of computer games; iii) the lack of time available to teachers to familiarize themselves with the game, and methods of producing the best results from its use; iv) the amount of irrelevant content or functionality in a game which could not be removed or ignored, thus wasting valuable lesson time [6]. A study discussed in [7] had recommended that game designers design games that mimic closely specific contents of the curriculum.

This paper describes the design of a role-playing game prototype, Math Quest, in learning mathematics. The process involves two phases, developing the game and the learning modules. The focus of the current prototype is on the design of the game for the topic on numbers and its operations.

## MATH QUEST

Math Quest has been developed as an on-line role playing game and is considered a computer game. There are six key structural elements, which combined together, will strongly engage the player. These elements are: rules, conflict/competition/challenge/opposition, goals and objectives, interaction, outcomes and feedback, representation or story [8]. Computer game may include action games, adventure games, knowledge games, simulation games such as management and strategy games, drill-and-practice games, logical games and math games [9]. In designing games based learning, it is important to present learners with learning material in the form of narrative and storytelling so that they can learn through game-playing and study the properties and behavior of in-game components and at the same time able to solve the problems in the defined scenario [2]. In addition, learning theories such as behaviorism, cognitive and constructivism is also considered during the development. Spiral development methodology as shown in Figure 1 has been employed in the design of the prototype.

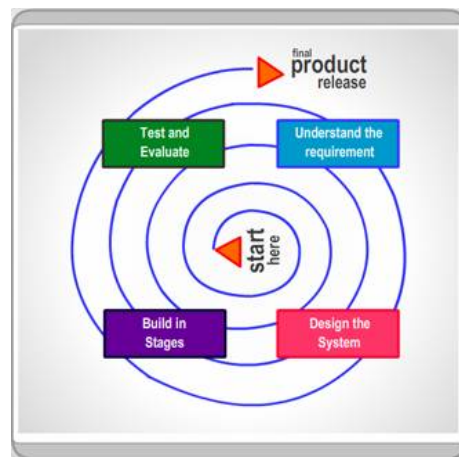


FIGURE 1  
SPIRAL METHODOLOGY

## OVERVIEW OF MATH QUEST

Math Quest is developed as a means of introducing a supplementary material in teaching Mathematics at the primary school level. Figure 2 shows the level of the game structure.

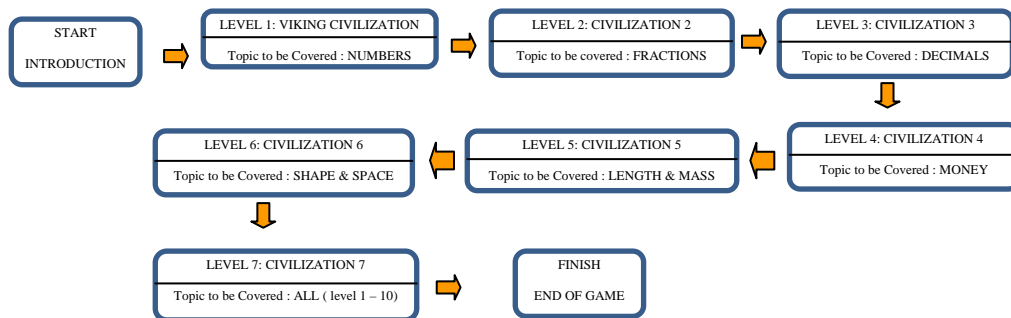


FIGURE 2  
MATH QUEST LEVEL OF STRUCTURE

In this game, a player is given a main mission which is to bring peace to the land by bringing back the knowledge of Mathematics to the people. In order to do that, the player will have to achieve a certain level of proficiency of each aspect of mathematics throughout the journey inside the game, by cracking ancient puzzle and riddles, helping people to perform their everyday tasks or defeating enemies with mathematical calculation. Gradually as the people learn and apply the knowledge of mathematics, they can fend off the attacks of their enemies which in the end will lead them to lead a peaceful civilization. The game is best described as a linear game where there is only one possible ending, yet the player still has a great deal of freedom inside each of the “pearls” that make up the backbone of the story.

In the full version, the game will incorporate seven civilizations and the Math concepts at each of the civilizations form part of the Mathematics curriculum for the primary schools in Malaysia. Students are expected to understand these concepts at the end of Year 6 in their primary education. The tools used in the development are Adobe Flash 8, Adobe Photoshop CS2 and Macromedia FreeHand and Sound Forge & Audacity.

### QUEST INTERFACE

Figure 3 shows the math homepage. Each of the topics available in the game is characterized by the civilizations that are shown in Figure 4. This screenshot is the main page of the game. Users have the choice to learn the topics by visiting each of the civilizations. Players are expected to click on the highlighted civilizations (in the complete full version) to proceed with the game. Together with this screen is the narration of the story.



FIGURE 3  
MATH QUEST HOMEPAGE



FIGURE 4  
SEVEN CIVILIZATIONS

Figures 5 and 6 show the main interfaces that the user will see in most parts of the games. On this screen, users will be shown a series of animation, text, images, NPCs and sound to immerse players into the game’s storyline together with the tutorials on how to play the game. Table 1 shows the components on the screen that relate to the game play.



FIGURE 5  
MAIN INTERFACE



FIGURE 6  
TUTORIAL FOR PLAYING GAME

NO.	COMPONENT	DESCRIPTION
1	Animation screen	The story of the game will be displayed in this area in a form of animation, graphic, text and sound. It also shows the character's movement and interaction as being played by player.
2	Game option	Player will have menus of options such as start, pause, save, load, and exit the game.
3	Character's Status	Main character's current information on life points and strength is shown here. Players need to make sure that the life point did not get to zero as it means 'Game Over'.
4	Book of Knowledge	When this button is clicked, a new pop-up will appear to display learning objects available for the player to learn, do exercises, thus assess their current understanding on certain topic.
5	Inventory	When this button is clicked, a new pop-up will appear to display all items that the player possessed during the game.
6	Magic	When this button is clicked, a new pop-up will appear to display all the magic that the player possessed during the game.
7	Award	When this button is clicked, a new pop-up will appear to display all the awards that the player possessed during the game.
8	Quest Log	Showing current quest or mission that the player needs to accomplish.
9	Minimap	The player may use this map to guide him while playing the game.
10	Event	When this button is clicked, a new pop-up will appear to display the tutorials that is found in the game
11	Blackboard	When this button is clicked, a new pop-up will appear to display a calculator for the player to use.

TABLE 1  
MAIN INTERFACE COMPONENTS

In this game, the player may earn the rewards through tasks that were assigned by some of the NPCs found in each of the civilizations. The player is required to answer some mathematics questions in order to fulfill the tasks. These questions will provide the students with practice of the topics that they learned. The NPCs at each of this task helps the player by giving tips and guide to arrive at the correct solutions. An example of the task is for the player to help Olaff, the baker, bake some bread.

In Step 2 of this activity, the player needs to add 15 cups of flour into the dough. The player needs to key in how many spoonfuls of flour is required given that a cup is equivalent to 3 spoonfuls of flour. In the next stage, the player needs to maintain the heat meter to be 100 degrees for the bread to be cooked. Currently, the meter reading is 70 degrees, thus another 30 degrees needs to be added. However, the player is required to know that the number 30 is obtained from the multiplication of 6 and 5. Upon clicking these values, the heat meter will change and another random value that is multiple of 6 is generated. The player will have to keep on doing successively, the subtraction and multiplication of values until the 100 is achieved on the meter. These activities are shown in Figure 7 and 8 respectively.



FIGURE 7  
TASK INTERFACE



FIGURE 8  
TASK INTERFACE

Besides the tasks, the game is also designed with combat screens. Combat occurs where the player needs to deal with enemies they have encountered. When this happens, the player will be transferred into a new combat screen where the player will decide whether to attack the enemy, defends himself/herself. The player may attack using the weapons earned throughout the game or choose to answer a random Mathematics question of the intermediate or advanced level that will be loaded onto the main screen in objective format. By choosing to answer the question and getting it correct, the player will earn double hits and able to do damage to the enemy much faster than just to attack with the weapon. Once the enemy's life reaches zero,

combat mode will end, and the player will be returned to their previous screen. In this combat, students can test their theories and strategies along with providing practice in multi-steps problem solving. Figure 9 shows the interface of Combat.

The player may choose to go through the book of knowledge as shown in Figure 10 to revise, learn, or do exercises prior to playing the game or anytime he or she prefers. A new pop-up will be displayed. The topics and subtopics will be displayed on this screen and group into three levels of difficulty, basic, intermediate and advanced. Icons for practice, grades and assessment will be displayed on the screen for easy navigation. In this civilization, the topics will be on introduction to numbers and the basic mathematical operations as shown in Figure 2. Animation will be used to further explain each of the topics. The interface of the learning module is currently under development.



FIGURE 9  
COMBAT INTERFACE



FIGURE 10  
LEARNING MODULE

## EVALUATION OF MATH QUEST

The prototype was played by 10 (5 boys and 5 girls) pupils of mixed abilities aged between 10 to 11 years old. Two of the students were from the lower ability, while three were of average ability and the rest are from the higher ability group. An interview session that lasted about 15 minutes was conducted with each of the pupils upon completion of playing the prototype. The interview is focus on the appeal of the game. The responses of the pupils while playing the game were also recorded.

### SPECIFIC OBSERVED USABILITY ISSUES WITH THE MATH QUEST

Through the observation from the video recordings, the following usability problems were observed. Even though the game could be paused which allow them additional time to read and understand the story, however, none of the pupils appeared to notice the message on how to pause, skip some parts of the game, and none of them actually pause and read what is on the screen.

Another observation recorded was the students immediately started playing the games once it is loaded. 9 out of 10 pupils appear to be randomly clicking their screen in their early attempts to play the game. None of them click on the tutorials although they are playing the game for the first time. These 9 pupils needed an explanation on how to play the game and also the task encountered. Following the explanation they seem to grasp the concept of the game and be able to do the task. In some of the tasks, the NPCs were used as mechanism to provide hints or assist the students in answering the questions. However, most of the pupils did not notice this. Only after several incorrect attempts of the questions, was this feature used. It was apparent that this feature had not been fully explained in a way that the players could understand. Nevertheless, the pupils like the game even though they found it confusing at the beginning.

### RESPONSES OF PUPILS

The following are some guided questions posed to the pupils

- (1) Do you think that Math Quest is fun?
- (2) Would you want to play Math Quest again?
- (3) Do you think that you will enjoy a math class conducted using Math Quest?

On the whole, positive comments were received about the game. The responses to Q1 until Q3 are given in Figure 11. All of pupils had expressed that the game is fun and would like to play Math Quest again except for one student. The reason given is she does not like to play computer games. Furthermore, all of the pupils expressed that they would like the game to be used in the classroom while learning mathematics feels that they would enjoy the lessons more. One of the pupils commented that:

- “While playing, I know that I’m doing calculations but I don’t feel like I’m doing math. In class, when you do math, you really do math and sometime boring”.

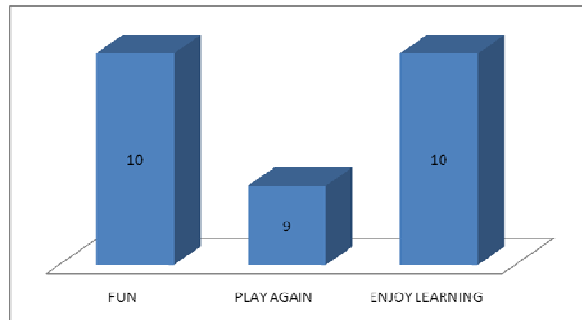


FIGURE 11  
RESPONSES TO Q1, Q2 AND Q3

A list of seven items is given to the students to answer Q4 and Q5. The items are; scenery, story, characters, weapons, colour, combat and tasks. Figure 12 shows the responses to “ Q4; What do you like about Math Quest? “.

On the whole, most of the pupils are satisfied with the story, the colour and the characters that were used in the development of the game. One of the boys expressed the following:

- “When I play the game, there are many colours inside. There is a king, a baker and many people. Also there is a story in the game. Not only use paper and pencil like in class”

One of the female students liked the idea of doing math this way.

- “ I like the story. The boy have to do many things before he find the ring. Like in combat. If he get right answer, the enemy will die.”

Seven of the pupils like the bread making activity and commented that had practice math while answering these questions, This is because they are required to find solutions to each of the questions that are posed before they progress the game. Among the comments made by the higher ability students are;

- “Even the task questions require time to finish, I still want to do because I want to see what happen after this”
- “I want to see what is the next task. Because next task is different, I must finish. Also I will get more stars.”

Only four students like the combat mode and these responses are from the boys, which is not surprising.

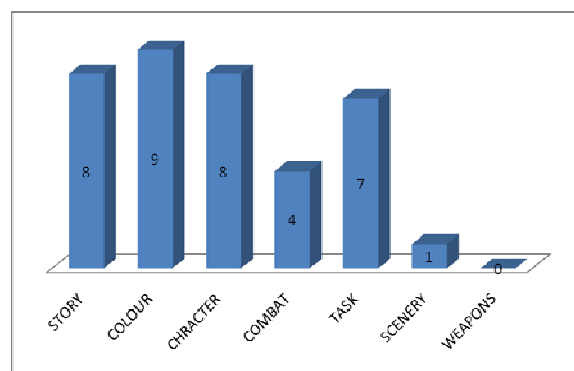


FIGURE 12  
RESPONSES TO Q4

Figure 13 shows the pupils’ responses to “ Q5: What do you dislike about Math Quest? “. Six of the students (mainly girls) do not like the combat component of Math Quest. Among the responses given are:

- “ I don’t like to fight. I don’t know how to play the combat game”.

- “ Too many combat. Everywhere you go combat...Boring. You fight the same thing.”
- “ No combat. It’s not good to fight”.

The three students who dislike the tasks were from the lower ability groups. One of the reasons given was there were too many questions to be answered before the task is complete. Another comment given by the student is on the level of difficulty of the questions. Furthermore, some of the sentences are a bit long. One student commented that she does not understand the questions even though she read it a couple of times.

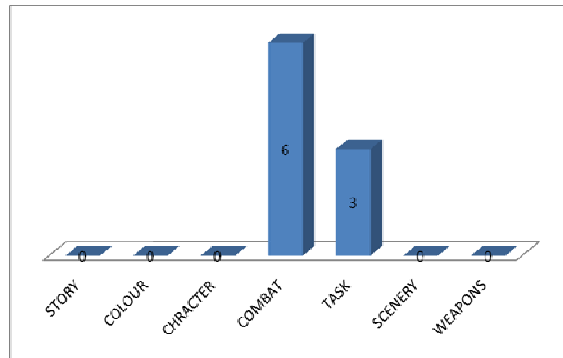


FIGURE 13  
RESPONSES TO Q5

Some of the responses to “Q 6: How can Math Quest be improved? “are as follows:

- The combat should also include other forms of activities besides fighting.
- The questions for the task should be much easier.
- The number of questions should be reduced for each task.
- There should be an option on the level of difficulty for task. This would allow the lower ability students to enjoy playing the game as well.
- Besides music, the game should also incorporate sound activities. This would help the players if they do not pause the game to read the instructions.
- A demonstration on how to play the game should be made available besides the tutorial.

## CONCLUSION

This paper has discussed the design and development of the game phase of a prototype of a role playing game, Math Quest in learning mathematics. On the whole, positive feedback has been obtained from the evaluation carried out to 10 pupils despite some usability issues. This feedback together with the suggestions given by the respondents will be used to further improve the prototype.

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