Learning Basic Mathematic Concepts with Computer Games

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Abstract— *Mathematics lays the foundation for abstract, logical and analytical thinking abilities. Therefore teaching basic mathematic concepts such as addition, subtraction, multiplication and division are started in schools from primary grades. It was revealed that teaching mathematics only in the traditional classroom environment with teacher centred learning has yielded poor performance so far among learners. Therefore in this project a computer game was developed to teach the basic mathematics concepts in a gaming environment considering the interest of small children in playing computer games. Levels of the games are developed based on Bloom's taxonomy to ensure that the pedagogical objectives are met. According to evaluation results student acceptance of the system was very high because they have been able to grasp the concepts in a very friendly and an effective manner. The teachers also had a very positive acceptance indicating the high level of effectiveness mainly due to aligning the games with levels of Blooms taxonomy because it aids achieving educational objectives. Thus the system was recommended as an additional support tool for learning mathematics, for primary students.*

Keywords— *Game Playing, Blooms Taxonomy, Learning Mathematics*

I. INTRODUCTION

Mathematics is one of the core subjects in the school curricula in Sri Lanka. Though mathematics is taught from very early stages starting from primary grades, yet the results for mathematics subject is very poor in school exams as well as in ordinary level examinations according to analysis reports issued by the Ministry of Education in each year. It was identified that one major reason for this low performance in mathematics subject is due to lack of understanding of basic concepts in primary grades. It has identified that basic mathematics concepts should be taught to school children on a very firm and in a very friendly manner. The fundamental operations used in primary school mathematics syllabus are addition, subtraction, multiplication and division. Even though above operations are easy, some students find it difficult to apply the concepts. The abstract presentation of these concepts to younger children makes it difficult for them to understand leading to boredom of students. It was revealed in teacher discussions that the time allocated for teaching mathematics is also not sufficient enough sometimes to cover the syllabus especially when there are weak students in a class. In such instances those less than average students find it really difficult to understand the concepts in given time frames. Due to workload pressure teachers also find it difficult to pay them individual attention. In western world in addition to classroom teaching, alternative approaches are taken to address difficulty in teaching as well as learning difficulties in less than average students. One such example is teaching through games and activities etc., (Ke, 2008). In considering all these facts along with the desire of these young children in playing computer games, in this project a gaming system was developed to teach these basic mathematics concepts.

II. METHODOLOGY ADOPTED

The system was designed as a computer game with various levels of entry as well as game levels. Games in each level were designed according to various levels of the Blooms taxonomy to take the learner from the knowledge level to evaluation level. For each successful completion of a level the player is rewarded, to maintain the motivation and the enthusiasm.

A. Bloom's taxonomy

Bloom's taxonomy of learning objectives is used to define how well a skill or competency is learned or mastered. A fuller description of Bloom's taxonomy is given in (Krathwohal, 2002) and the Figure 1 below gives a pictorial summary.

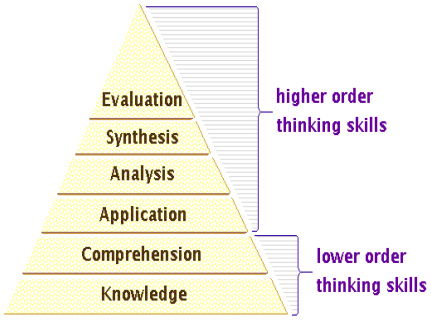

Figure 1.Blooms Taxonomy

At each level of Bloom's taxonomy the work to be done is different and is described below.

- At **Knowledge** Level of learning a student can define terms e.g. student can identify what is addition, subtraction, multiplication and division
- At **Comprehension** Level of learning a student can work assigned problems and can do examples of what they did e.g. student can understand the process by using examples (such as 1+1=2)
- At **Application** Level of learning a student recognizes what methods to use and use the same effectively in practical situations e.g. student should answer the questions with the knowledge gained at the previous level (Students have to do the addition of 1+1=?)
- At **Analysis** Level of Learning a student can explain why the solution process works e.g. student should answer the question without using image help.
- At **Synthesis** Level of Learning a student can combine the part of a process in new and useful ways.
- At **Evaluation** Level of Learning a student can create a variety of ways to solve the problem and then, based on established criteria, select the solution method best suited for the problem e.g. student should be able to solve simple math questions related to these basic concepts, in real life.

B. JMonkey framework

The game framework consists of a set of tools for the game play engine that is created by the game play designer. It consists of an interface for the communication with the framework and a basic tool to create all the surroundings of the game. The resulting game framework is defined as a middleware between the game play engine and the jMonkey framework. Some of the game frame work requirements are interpretation and displaying of topographical maps in a game environment, Interface for game playing engine, Way points handling and Creation of surroundings (Asher 2001).

C. Basic Design of a jMonkey Game

The jMonkey framework is based on the classic game design framework and consists of methods for Initialization, Update Game State, Draw Scene and Clean-up as shown in Figure2.

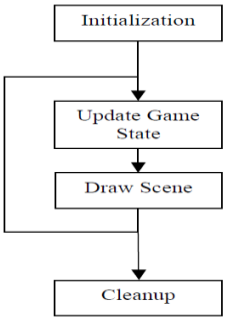

Figure 2. Design of the jMonkey Game Engine

In the system implementation the functionalities of each of these methods are as follows. In the initialization state all the basic objects are created and added to the scene. In the update and game state initially it updates all the necessary elements of the game including animations. In the draw scene state display of the entire system is shown. The clean-up state becomes active when the game is terminated. In this state all the objects and variables used are cleaned up before the game ends.

III. DESIGN OF THE SYSTEM

The overall system consists of several modules namely data acquisition module, knowledge base, maths house system and the graphical user interface as shown in Figure 3.

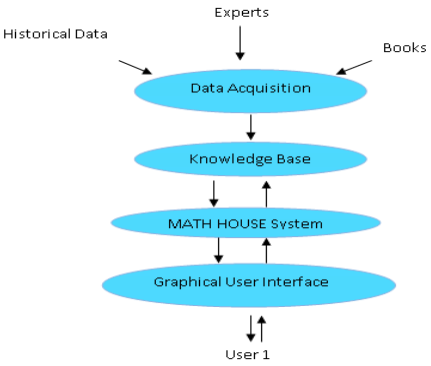

Figure 3. Design of the Maths House System Application

These modules have varying functionalities as described below.

Data Acquisition module: Data acquisition module is designed to acquire data in different formats. Primary

sources of data acquisition are from books written on subject matter and the rest are publications and the World Wide Web.

Knowledge Base module: In this module the acquired knowledge is compiled and stored in a manner which is compatible with the inference engine.

MATH HOUSE System module: MATH HOUSE system was designed to fire the rules with the given facts to make decisions.

Graphical User Interface module: User interface is the communication media for the player and the system. It is designed to capture the user performance interactively in an attractive user friendly manner.

A. Overall architecture of the system

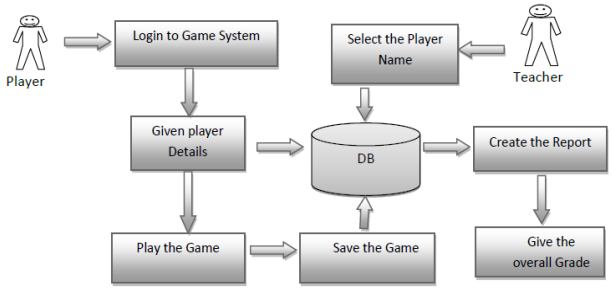

Figure 4. Block Diagram for the Math House System

Initially a player has to register with the system and select one of the modules out of addition, subtraction, multiplication and division. Each module is sub divided into 3 levels easy, medium and hard, based on the level of complexity of the given questions. There are a total of fifteen (15) questions in each module.

Players have to sequentially advance to the next level by answering correctly the minimum number of questions specified at each level. For example, in the level easy all questions needs to be answered, in the level medium four (04) questions needs to be answered and in the level hard at least three (03) questions has to be answered. Scores given at each level is different.

IV. HOW MATH HOUSE GAME SYSTEM WORKS

A new player has to register with the system and start a new game. Whereas a returning player can continue a previous game or start a new one. Figure 5 shows the module selection screen of the MATH HOUSE game.

Figure 5. MATH HOUSE Game select module interface

A player who completes all fifteen questions without an error is given a bonus level which again consists of five (05) questions to play with. Figure 6 shows the bonus level in the addition module.

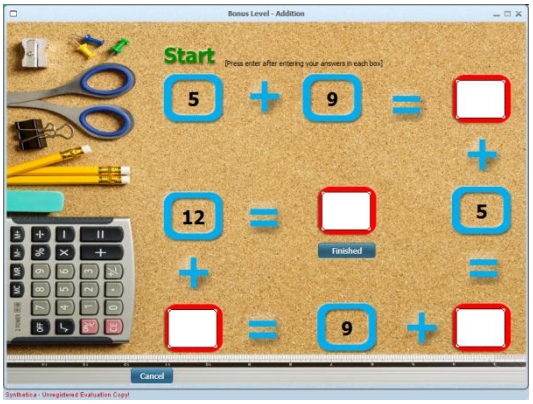

Figure 6. MATH HOUSE Game bonus level interface

Marks allocated for the bonus level is more to keep the momentum of the player. This is particularly required so that the keen players can score more than an average player. The system can generate a summary report of all the players who played with the system with their scores as shown in figure 7.

Figure 7. MATH HOUSE Game High score interface

In addition to the total score individual score of a player for each module too can be obtained as shown in figure 8.

Figure 8. MATH HOUSE Game Player score interface

A. WEB APPLICATION MODULE

The web application module is specially designed for parents and teachers. The aim of the MATH HOUSE game is to improve the level of knowledge in mathematics among primary grade students. Therefore it has become mandatory to view the performance of the players either by parents or by teachers. Figure 9 shows such a report generated.

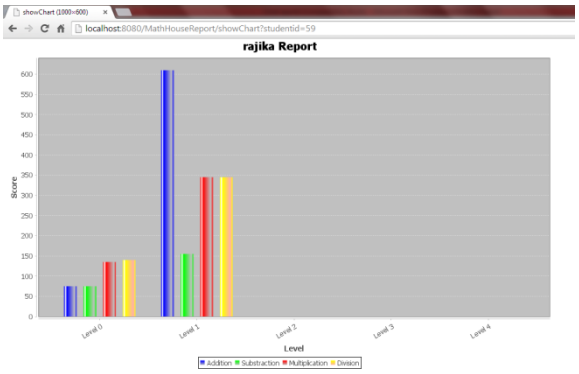

Figure 9. MATH HOUSE Web application player detail report interface

V. EVALUATION OF THE SYSTEM

The evaluation of the system was done from two ends, with teachers and with students. The student evaluation is carried out in order to find out whether the use of the system has made any impact in improving their knowledge in basic mathematics. The teacher evaluation was mainly carried out to identify the usability of the system as an alternative mode of teaching mathematics, user friendliness and to identify any limitations in the system.

In the student evaluation a question paper that consists of basic mathematics is given to answer with a time limitation. The sample size was 50, randomly selected from grade 3 students in a particular school. After that half of the students are given the opportunity to play with the MATHS HOUSE game exploring all four (04) modules. Secondly all the students are given another question paper based on basic mathematics concepts. This paper was little more advance than the previous. The outcome is analysed to identify whether the students who were exposed to the MATH HOUSE game has performed better. After basic statistical analysis such as mean and median it was found that the students who were exposed to the game environment have performed better with varying degree of percentage when compared with the control group. There was one student who has scored 45 percent more for the second paper after playing with the system.

For the teacher evaluation of the system five (05) primary teachers teaching in grade 3 and 4 were selected from the same school. The teachers were given the system to play around and asked to fill the questionnaire. The teachers were highly impressed about the attractiveness of the user interfaces, the level of interactivity and the process of progression from one level to the other. These features have scored a high satisfaction rate from all the teachers. One teacher had a reservation about using games and new technology for teaching mathematics.

VI. DISSCUSSION AND CONCLUSION

The MATHS HOUSE computer game was developed with the aim to give it as an additional support tool for learning basic mathematics concepts for primary students specifically designed for grade 3 Government mathematics school syllabus. The game has four modules and each module consists of three levels. Questions in these modules are designed according to the levels of Bloom's taxonomy. A player has to progress through these levels by answering the minimum required number of questions. If a player completes all levels 100% accurately then he can play a bonus level as well.

The entire game was designed to maintain the user interest and motivation. Unlike in other computer games the MATH HOUSE game has a facility to monitor the progress of the player. This is a very important feature of the system because a teacher or a parent can identify the level of performance of the player/student. Since questions are based on Bloom's taxonomy a teacher can give a better guidance in the areas where the student performs less.

According to the evaluation of the system both teachers and students welcomed the system as an alternative

mode of learning of basic mathematics concepts. Students were very enthusiastic because they were learning abstract concepts in a gaming environment. The success of the system was clearly indicated by scoring higher marks for the second paper by the students who played around with the game system.

Based on the success of the implemented MATH HOUSE game system there are many possible avenues that improvements can be done. One such avenue is to integrate intelligence to the system via question selection. As an example if a student fails in answering questions in comprehension level he should be given more of comprehension level questions before giving application level questions. Therefore the process should not be a pre-determined mechanical process instead it has to be a process that identifies the level of knowledge of the player and needs to adjust accordingly. Finally based on the overall performance and the evaluation of the MATH HOUSE system we can conclude that this system can be used as an effective alternative supportive mode for teaching basic mathematics concepts for primary students.

REFERENCES

Ascher M, (2001), Learning with Games of Strategy from Mongolia. Teaching Children Mathematics Vol. 8, No 2.

Ke. F. (2008), A case study of computer gaming for math: Engaged learning from game play? Computers and Education, 51(4), 1609–1620.

Math Blaster Ages 6-9 [online] Available via WWW in http://www.sheeparcade.com/find-games/math-blaster-ages-6-9 Last accessed on September 21th, 2013.

Watterman, D. and Hayes-Roth, F. (1978), Pattern-Directed Inference Systems. Orlando: Academic Press

Quiz-Tree.com Math, reading, Spanish, Geography and much mare [online] Available via WWW in http://www.quiz-tree.com/ last accessed on September 27th, 2013.

Kath David R. Krathwohl, (2002), A Revision of Bloom's Taxonomy: An Overview, Theory into practice, Volume 42, Number 4, College of Education, The Ohio State University