Augmented Reality and Blended Learning: Engaging Students Learn Word Problems with Bar Model and the Geometer's Sketchpad

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Abstract: *The purpose of this study aims to explore the students' perceptions of teaching approaches using Augmented reality, blended learning in mathematics via smartphone. In the 2019, action research was conducted in mathematics class of a lower secondary school in Bangkok, Thailand. The total of 35 Secondary Year 1 students participated in this study and the duration of the action research was about three months. In mathematics classroom, the researcher created mathematics lessons, activities and learning instructions of her lectures. The students studied mathematics word problems and used the Geometer's Sketchpad outside classroom. They used smart phone to scan QR Code Reader to explore mathematics animations and mathematics activities prior attending class. The research findings indicated that the blended learning was new teaching strategy that combined the learning on mathematics in the classroom and outside classroom via technology. The students brought assignments/exercises of mathematics concepts inside the classroom via learning activities. The research findings shown that the students' engagement in blended learning were higher than the using traditional classroom. Based on the students' interviews they revealed that using blended learning incorporated mathematics word problems, animations using Geometer's Sketchpad via smart phone, Augmented reality and QR Code Reader methods they were able to manage their learning pace and learned remotely. This learning methods made learning mathematics fun and challenging.*

Introduction

The purpose of this paper is to explore the students' perceptions of teaching approaches using Augmented Reality, and blended learning in mathematics via smartphone. Students engagement in mathematics classroom is dropping every year because they may be bored with the traditional learning style. All teachers wondered why the students did not had active learning in classroom but they paid more attention on smartphones or tablets.

In Thailand, the students learn mathematics five hours per week and there are 16 weeks in one semester. The mathematics teachers have to complete the mathematics contents in the required syllabus and the assessments. The assessment involved at Thailand National Testing such as O-NET (Ordinary National Educational Test) and also at International Testing such as PISA (Program for International Student Assessment) or TIMSS (Trend in Mathematics and Science Study). Base on Thailand Minister of Education Reports [1], the most learning difficulties in mathematics was word problems and students had poor performance in solving word problems in both primary and secondary level. The researchers had question that what will happen if we introduced the new teaching approaches and included new technology-based learning in mathematics lesson. Therefore, the researcher conducted this action research to explore the students' perceptions of teaching approaches using Augmented reality, and blended learning in mathematics via smartphone.

Word Problems

Word problems were embedded in all topics in mathematics in primary and secondary levels in Thailand. Computation skills and concepts are usually presented first in the mathematics textbooks before the word problems. Riley, Greeno & Heller [2] described the steps for solving word problem can be broken down as: 1) identifying what the problem is asking; 2) explaining how one would set the problem up; and 3) finding what needs to be done to calculate the solution. Riley, Greeno & Heller suggested that teachers should asked students to write out the steps involved in solving problems and noting where they run into difficulties. Students can be asked to explain their solutions in term of the question posed. Ballew and Cunningham [3] supported that there are four different abilities involved in solving problems. The four abilities are 1) the abilities to read the problem; 2) the ability to set up the problem so that the necessary computation is ready to be performed; 3) the ability to perform the necessary computation; and 4) the ability to integrate reading, interpreting the problem, and computation into the total solution of a word problem. They suggested that each of these abilities can be investigated to explain what areas of solving word problems present greatest difficulty to particular types of students [3].

Understanding and Solving Word Problems

Mathematics teachers in Thailand are encouraged to expose students to solve problem using George Polya [4] approach. In Polya's problem solving techniques included four steps as follows:

1) *Understanding the problem.* Polya taught teachers to ask students questions such as: Do you understand all words used in stating the problem? Can you restate the problem in your own words? Can you think of a picture or diagram that might help you understand the problem? What are you asked to find out?

2) *Devise a Plan.* Polya mentions that there are many reasonable ways to solve problems. For example: draw a picture, use a model, work backwards, guess and check, make a table, and act it out. The bar model enables students to devise a plan to solve the problem. For word problem, the model helps students to decide what operation to use to solve the problem.

3) *Carrying out the Plan.* This step is usually easier than devising the plan. The students have to persist with the plan that they have chosen and solving the problem. The students carry out arithmetic calculations in order to answer the question given in the problem.

4) *Looking Back* Polya mentions that students have to take time to reflect and look back what they have done, what worked, and what didn't, and what does the results tell us? The students have to evaluate and check if the answer satisfies the data given in the problem, or if the answer is reasonable.

In addition, Ban-Har-Yeap and Berinderjeet Kaur [5] explained that students solving word problems should engage more in making sense of the semantics of the problem and less in doing tedious computation. In order to success in solving word problems, students have to learn by understanding and the teachers have to teach them four basic principles of problem solving of Polya. The students need to have skills to read, understand, strategy, compute and check their work. They need to know not only the necessary procedures, but also how to represent the information given in the problem.

Bar Model and The Geometer's Sketchpad (GSP)

Bar Model is a model method for problem solving. It is an innovation in teaching and learning of mathematics developed by the Curriculum Development Institute of Singapore, Ministry of Education Project Team in 1980s (Curriculum Planning and Development Division, Ministry of Education Singapore) [6]. Bar Model is an effective strategy used to solve mathematics word problems. Bar model or model-drawing method used to illustrate the concepts of the four operations and to solve related word problems. It is a visual representation of the information in word problems using bar units. The structure of the model-drawing consists of a series of rectangles. The rectangles represent specific numbers and unknown values. The structure of the model is used to help students "construct appropriate set of step-by-step arithmetic procedures to solve given problems" ([7] Ng & Lee). Bar model strategy in solving word problems was introduced in Thailand since 2016 ([8], Khairiree, K).

The Geometer's Sketchpad (GSP) was introduced in Thailand since the year 2000. GSP is one of the dynamic mathematics software that provides opportunities for teacher to use GSP to facilitate students thinking about mathematical relationships among the numbers of a given word problem .GSP empowers students to use their abilities to create graphical representation, to enable them in developing their mathematical thinking skills, concepts, and understanding . In using GSP students learn by exploring, investigating and discovering .GSP enhance students 'ability in helping them visualize abstract mathematical relationships and various problem structures through pictorial representations.

Blended Learning and Augmented Reality in Mathematics Classroom

According to Garrison and Kanuka [9] Blended learning is defined as the integration of classroom face-to-face learning experiences with online learning experiences. Blended learning has it roots in both classroom teaching and online learning. Graham [10] described that Blended learning systems combine face-to-face instruction with computer-mediated instruction. Other theories offer definitions which are similar to Graham. For Staker and Horn [11], Blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path and/or pace.

Augmented Reality (AR) in education provide new ways of teaching and learning. Educators know that the learning process should be all about creativity and interaction. AR enhances students experiences by adding virtual components such as digital images, graphics or sensations as a new layer of interaction with the real world. Based on Merriam-Webster [12], Augmented Reality refers to an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a mobile device such as a smartphone. One of the sample AR used in education is its introduction in the traditional Classroom. The mathematics textbooks materials with AR examples adds another dimension to the learning process - a process that will become a blended learning of the traditional approach and innovative practical illustrations of complicated concepts. AR animated figures and contents in mathematics lessons could catch students' attention and also motivate them to learn.

Blended Learning, Augmented Reality in Mathematics, and Action Research in Thailand

In Year 2019, International College, Suan Sunandha Rajabhat University in collaboration with the Office of the Basic Education Commission, Ministry of Education, Thailand had conducted workshops on "*How to Teach Word Problems Using GSP and Bar Models? "*and *"How to Develop Learning Materials Incorporated with Augmented Reality?"* .There were more than 500 mathematics teachers from at least 350 schools participated in these workshops. After attending the workshops, many teachers changed their teaching method in mathematics. They employed blended learning incorporated with AR, GSP and used bar model strategy in their mathematics classes.

The researcher selected one mathematics class of the teachers who participated in the said workshops to be a sample group of this action research. The researcher created mathematics lessons, activities and learning instructions incorporated with AR, GSP and used bar model strategy of her lectures uploaded online and in a hard copy. The blended learning was employed with the students in the sample group. The students studied mathematics word problems and used the Geometer's Sketchpad inside and outside classroom. In this action research, the Augmented Reality (AR) is a type of AR where a smartphone is used to display and interact with virtual contents. The students used smart phone to scan QR Code Reader to explore mathematics animations and mathematics activities prior attending class. By scanning at QR Code Reader on the printed targets the smartphone showed the animations of each steps in solving word problems and the students were able to interact with it.

The action research questions were:

1. How to implement blended learning method on word problems using bar model strategy incorporated with AR and GSP effectively?
2. What are the students' perceptions on using learning instructions incorporated with AR, GSP and bar model strategy in solving word problems in mathematics?

Question 1: How to implement blended learning method on word problems using bar model strategy incorporated with AR and GSP effectively?

Based on the classroom observations and interview the researcher found that the bar model strategy in solving word problems was employed in blended learning in Secondary mathematics classes. Based on the action research findings, this approach has shown that it was an appropriate way to bring about Augmented Reality (AR) in mathematics to students. When students used the bar model method in conjunction with GSP and AR, they saw the animations of each steps in solving word problems and the students were able to interact with it. The blended learning method on word problems using bar model strategy incorporated with AR and GSP was employed as follows:

(1) Teacher taught word problems based on four principles of problem solving of Polya focus on bar model strategy in traditional mathematics classroom;
(2) Students learned how to solve word problems using bar model strategy and GSP in classroom and from internet; and
(3) Students did their word problems exercises by using bar model strategy in conjunction with GSP and AR inside and outside mathematics classroom.

The following examples showed lessons and activities used bar model and GSP strategy in solving word problems which were implemented in this action research in Thailand.

Example 1.

Alisa bought 2 boxes of cupcakes for her party. The first box contained 9 cupcakes more than the second box. After giving 3 cupcakes to each of the 38 children present, she had 7 cupcakes left in the first box and none left in the second box. How many cupcakes were there in the first box?

Solution:

Step 1: Understanding the Problem

How many pieces of cupcake that Alisa bought for her party?

Step 2: Drawing a Bar Model

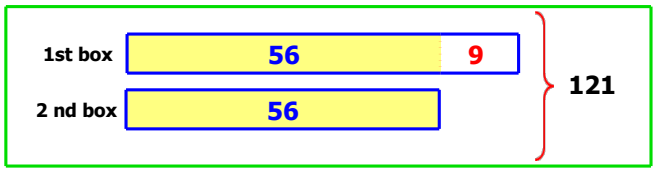
Alisa bought 2 boxes of cupcakes for her party. The first box contained 9 cupcakes more than the second box.

Find total number of cupcakes bought.

After giving 3 cupcakes to each of the 38 children present, she had 7 cupcakes left in the first box and none left in the second box.

The cupcakes were given away $= 3 \times 38 = 114$

Therefore: Alisa bought cupcakes $= 114 + 7 = 121$



Step 3: Carrying out the Plan

From the Bar Model:

Let the number of cupcakes in 2nd box = 1 part

The 1st box contained 9 cupcakes more than the second box.

The number of cupcakes in 1st box = 1 part + 9

Alisa bought cupcake = 121 pieces

cupcake in 1st box + cupcake in 2nd box = 121

(1 part + 9) + 1 part = 121

2 parts = 121– 9

1 part = $\frac{112}{2} = 56$

There were 56 cupcakes in the second box;

there were 56 + 9 = 65 cupcakes in the first box

Step 4: Looking back

Number of Cupcakes in 2nd box – Number of Cupcakes in 1st box = 65 – 56 = 9 ▣

Solution:
Alisa bought 2 boxes of cupcakes for her party. The first box contained 9 cupcakes more than the second box. After giving 3 cupcakes to each of the 38 children present, she had 7 cupcakes left in the first box and none left in the second box. How many cupcakes were there in the first box?

Using Smart Phone to explore how to solve this problem by scanning this QR Code.

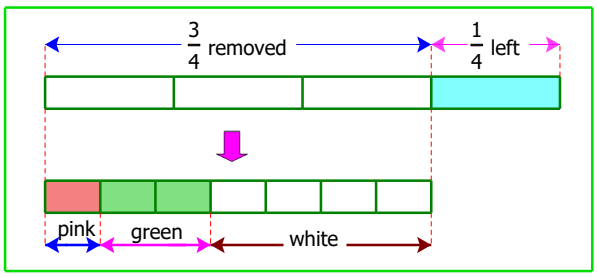
Example 2.
Supatra removed $\frac{3}{4}$ of the beads from a box. She found that $\frac{1}{7}$ of those beads removed were pink and the rest were either green or white. The number of green beads was twice the number of pink beads. There were 36 more white beads than pink beads. How many beads were left in the box?

Solution:
Step 1: Understand the problem.

Supatra removed $\frac{3}{4}$ of the beads from a box. She divided her beads into 4 equal parts, and she removed 3 parts.

Step 2: Developing a Plan by Drawing a Bar Model

Supatra removed $\frac{3}{4}$ of the beads from a box. She found that $\frac{1}{7}$ of those beads removed were **pink** and the rest were either **green** or **white**.
The number of green beads was **twice** the number of pink beads.



Step 3: Carrying out the Plan

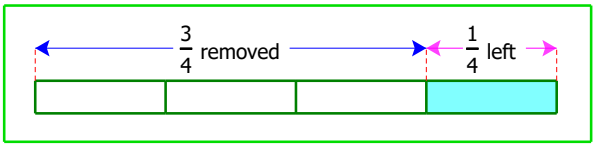
From the bar model diagram:

white beads = 4 parts and pink beads = 1 part
4 parts -1 part = 3 parts

From the question: There were 36 more white beads than pink beads.

Hence, 3 parts = 36
1 part = 36 ÷ 3 = 12
and 7 parts = 7 × 12 = 84

Therefore, Supatra removed 84 beads from the box.



From the bar model diagram:

$\frac{3}{4}$ of beads in the box is 84, or

3 parts = 84

1 part = 84 ÷ 3 = 28

There were **28** beads left in the box.

Step 4: Looking back

Supatra removed $\frac{3}{4}$ of the beads from a box. $\frac{1}{7}$ of those beads removed were **pink**, $\frac{2}{7}$ were **green**, and $\frac{4}{7}$ were **white**.

$\therefore$ Number of pink beads $= \frac{1}{7} \times 84 = 12$

Number of white beads $= \frac{4}{7} \times 84 = 48$

The difference in number of the white beads and the pink beads is 48 – 12 = 36. ▣

Using Smart Phone to explore how to solve this problem by scanning the QR Code.

Exercises:

1. Suda has 55 toffee and Jan has 87 toffee. How many toffee must Jan give to Suda so that they will have an equal number of toffee?

2. Marisa spent $\frac{3}{7}$ of her salary on food and $\frac{1}{2}$ of the remainder on books. The cost of books was less than that of food 2,400 baht. How much salary did Marisa earn?

Question 2: What are the students' perceptions on using learning instructions incorporated with AR, GSP and bar model strategy in solving word problems in mathematics?

Based on the interview, the researcher found out that the students in the sample school now liked to learn mathematics and they have more understanding on solving word problem. The students can explained, knew what to do and knew why they had to do. The research findings shown that the students' engagements in blended learning were higher than the traditional classroom. In addition, the students revealed that using blended learning incorporated mathematics word problems, animations using Geometer's Sketchpad via smart phone, Augmented reality and QR Code Reader methods they were able to manage their learning pace and learned remotely. This learning methods made learning mathematics fun and challenging.

Conclusions

Due to the rising use of Augmented Reality in many areas, but Augmented Reality in education is still new and do not implement in schools yet. Based on this action research the Augmented Reality in teaching and learning is very fruitful, it providing new ways of learning. Teachers are able to motivate students better than the traditional method. Therefore, teachers should implement blended learning on word problems in mathematics using bar model strategy incorporated with Augmented Reality and GSP in all levels from primary until secondary level.

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