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Submission date: 27-Feb-2022 08:01AM (UTC+0700)

Submission ID: 1771588901

File name: Scopus 11_IJIM wangid.pdf (759.05K)

Word count: 4336

Character count: 23453

The Use of AR-Assisted Storybook to Reduce Mathematical Anxiety on Elementary School Students

<https://doi.org/10.3991/ijim.v14i06.12285>

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Abstract—Mathematics is essential to be mastered by students because it can help students to solve various problems in daily life. Students are anxious and afraid to take mathematics lessons. Augmented Reality (AR)-assisted storybook blends fantasy reality and is developed to see the impact on students' mathematics anxiety. This study aims to determine the effectiveness of AR-assisted storybooks on students' anxiety in mathematics learning. This study uses a quantitative approach with the type of research quasi-experiment and with the design of the pretest-posttest control group design. The study sample includes 348 fourth grade students in elementary school in Yogyakarta. The sampling technique used is the cluster random sampling technique. Independent t-test techniques analyzed data. The results showed that the sig value 2-tailed in the independent t-test was 0.00 (<0.05). Thus, it can be stated that AR-Assisted storybook has a positive and significant effect on students' mathematics learning anxiety.

Keywords—Anxiety, Augmented Reality, Elementary School, Mathematics Learning, Storybooks.

1 Introduction

Mathematics lesson often regards as a difficult subject for students to understand. The survey results revealed that many students at various levels experienced mathematical anxiety, ranging from early elementary school to college-level [1], [2]. Mathematical anxiety defines as feelings of tension that interfere with the ability to solve mathematical problems in everyday life and learning [3]. Mathematical anxiety divides into two parts. It was anxiety about learning [4] and the test [5].

Students with mathematical anxiety have disliked or worried, and this will affect their physiological conditions, such as changes in heart rate, nerve activation, and cortisol [6], [7]. Symptoms of students when asked to do math assignments show

nerve activation similar to that found when individuals experience physical pain [6]. Mathematical anxiety is even considered to be similar to a phobia [4]. When individuals see attention stimulation related to mathematics, their nerve responses will see it as something threatening to create individual behavior that is controlled by fear [8]. The conceptualization of anxiety focused on cognitive interference, such as incompetence, helplessness, and concerns of students who were anxious about the test [9]. Many of the irrelevant thoughts that describe to anxious students focus on the reasons for their performance (i.e., "I am not smart enough"). This anxiety can psychologically interfere with one's performance in learning [10]. Mathematical anxiety has been recognized as an important factor that influences mathematical learning, mathematical achievement, and basic numerical abilities in the classroom [11].

The emergence of mathematical anxiety is influenced by the students' negative experience with mathematics [1], [12]. Other causes are the teacher's teaching style in the class based on conventional methods, which is done with a focus on developing skills and understanding [13], [14]. Thus, the teacher needs to pay attention to providing positive experiences for students in learning. One way that teachers can try to overcome math anxiety is to use learning media that make students feel 'enjoy' when learning mathematics.

So far, no media has been focused on the examination of mathematical anxiety impact. The steps to reduce mathematics anxiety are still in the form of strategies for teaching so that students' math anxiety can be reduced [15], [16]. This study seeks to develop media that can attract students to learn mathematics. One medium that can attract and be close to students is a storybook with mathematical material contents. Storybooks have been developed by several researchers before proven to be able to attract students' attention, create an impact of pleasure and allow the subject matter to be included in it [17], [18].

The storybook is developed using the help of Augmented Reality, a technology that integrates the real world and virtual world interactively through a 3D visualization display [19], [20]. Augmented Reality has the advantage of attracting students' attention, create learning collaborative, and become independent. It is an ocular involvement that helps students cognitive processes [21], [22]. Also, visual assistance from AR can help students understanding mathematics materials being taught [23], [24].

Thus, it can be concluded that the study design study using learning-based Augmented reality led to an increase in the hypothesis of activity [25]. AR design principles, i.e., giving challenge, fantasy, and look at the invisible part for the user [26]. Through this media, students are invited to realize abstract images or objects to be semi-real. Augmented reality technology emerges to complete the storybook to make it more interactive. The advantages of storybooks that are equipped with AR are expected to reduce students' mathematical anxiety. The formulation of this study focuses on the effectiveness of storybooks to reduce anxiety in elementary school students.

2 Method

2.1 Participant and procedure

This research was conducted in the province of Yogyakarta with a population of all fourth-grade students in state-owned elementary schools in the Yogyakarta Special Region. The sample is determined using a cluster random sampling technique. As a result, 348 grade IV elementary school students were taken with consideration of essential school representation in 4 districts/cities in DI Yogyakarta, namely Yogyakarta city, Sleman district, Bantul district, and Kulonprogo district.

They were then divided into three groups, which were 2 experimental groups (group 1 consisted of 116 students and Group 2 consisted of 116 students) and the control group (1 class consisting of 116 students). Three groups were randomly selected, but they have the same characteristics (homogeneous). The two groups became the experimental group that would be treated by using AR-assisted Storybook on mathematics learning and one other group as the control group using conventional picture media in mathematics learning. The three groups were given a pretest by filling out the questionnaire at the beginning to determine students' anxiety in learning mathematics before being given special treatment. Then, in the end, after being given special treatment, students were given a posttest by filling out the questionnaire. Data obtained were then analyzed using a paired t-test and independent t-test. A paired t-test was conducted to prove whether there was a difference in anxiety between the students and the posttest. Next, an independent t-test was conducted to determine whether there were differences in anxiety among students who treated by using the AR-assisted Storybook with a group that did not use the AR-assisted Storybook in mathematics learning.

2.2 Measurement

The instrument in this research is Children's Anxiety in Math Scale (CAMS) questionnaire adapted from Jameson [27]. The number of questionnaire items consisted of 16 items on a scale taken in a range of 1-5. This tool has been tested through Exploratory Factor Analysis (EFA) with Parallel Analysis that produces three-factor solutions, which are general math anxiety (general math anxiety), mathematical performance anxiety (math performance anxiety), and math error anxiety.

2.3 Data analysis

This research uses descriptive statistical analysis techniques and inferential statistics. Descriptive analysis was carried out by categorizing the tendency of scores into five-level, which are very high, high, medium, low, and very low [28].

Inferential statistical analysis is done to test the predetermined hypothesis. Hypothesis testing uses paired t-test techniques and an independent t-test technique to find

out whether there are differences between groups treated with unte¹⁷ed groups. The testing of inferential statistics was carried out with the assistance of SPSS version 22.

3 Results and Discussion

3.1 Results of research

The result of descriptive statistic analysis data from pretest dan posttest applied on experiment and control class are as follows:

Table 1. Anxiety Score Tendency

Class	Criteria	Pre-test		Mean	Post-test		Mean
		F	%		F	%	
Experiment Group 1	Very high	13	11.21	55.91	0	0.00	34.78
	High	58	50.00		4	3.45	
	Medium	34	29.31		13	11.21	
	Low	11	9.48		72	62.07	
	Very low	0	0.00		27	23.28	
Experiment Group 2	Very high	17	14.66	58.00	0	0.00	34.26
	High	61	52.59		1	0.86	
	Medium	35	30.17		10	8.62	
	Low	3	2.59		84	72.41	
	Very low	0	0.00		21	18.10	
Control group	Very high	26	22.41	58.09	2	1.72	41.44
	High	45	38.79		12	10.34	
	medium	34	29.31		40	34.48	
	Low	11	9.48		52	44.83	
	Very low	0	0.00		10	8.62	

Based on the data in Table 1, the tendency of the pretest scores of the three classes shows that the highest frequency is in the high category compared to other categories. This means that students' anxiety towards mathematics learning is mostly in the high category. Experimental class 1 with 58 students (50.00%) were categorized as high, experimental class 2 with 61 students (52.59%) were categorized as high, and control class with 45 students (38.79%) were categorized as high with an overall average of 58.09 (high).

However, after treatment, the posttest results showed that there was a decrease in students' anxiety levels in mathematics learning. The tendency of the posttest scores of the three classes shows that the highest frequency is in a low category compared to other categories. This means that students' anxiety towards the majority of mathematics learning has begun to fall low category. Experimental class 1 with 72 students (62.07%) then entered a low category. Experimental class 2 with 84 students (72.41%) were in a low category, and the control class of 52 students (41.44%) down to low category with the overall average amounting to 41.44 (low category).

The decrease in students' anxiety levels in mathematics learning can be seen from the decrease in the average between before given treatment and after (pretest and posttest). In experimental class 1, the average pretest score was 55.91 which meant that it was still in the high category, but after being given treatment, the average posttest dropped to 34.78 in the low category, a decrease in the average score of 21.13 from the pretest. In experimental class 2, the average pretest score was 58.00 which means it was still in the high category. However, after being given treatment, the average posttest dropped to 34.26 in the low category, a decrease in the average score of 23.74 from the pretest. In the control class, the average pretest score is 58.09, which means it is still in the high category, but after being given treatment, the average posttest dropped to 34.26 in the low category, a decrease in the average score of 41.44 from the pretest.

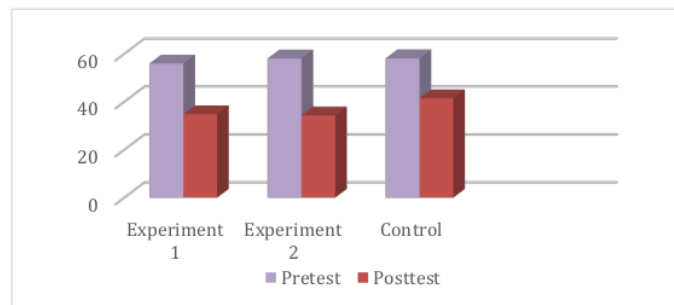


Fig. 1. Pretest Posttest Score Math Anxiety Decrease Diagram

The results of hypothesis testing with inferential statistics using the t-test paired t-test and independent t-test are as follows. The results of the paired t-test show that the value of sig. <0.05, which means that the accepted hypothesis is that there are differences in students' anxiety on mathematics learning between before being treated and after. The results of paired t-test calculations can be seen in the following table.

Table 2. Paired t-test Result

Paired Samples Test			
Pretest – Posttest	Sig.(2-Tailed)	Alpha value	Desc.
	0.00	0.05	Difference appeared

The results of hypothesis testing using the independent t-test technique indicate that the value of sig. <0.05, which means the accepted hypothesis is that there is a difference between the treated group (experimental group) using the AR-assisted storybook and the untreated group (the control group) using the AR-assisted storybook. The results of independent t-test calculations can be seen in the following table.

Table 3. Independent t-test Result

Independent Samples Test			
Equal variances assumed	Sig.(2-Tailed)	Alpha value	Desc.
	0.00	0.05	Difference appeared

3.2 Discussion

Mathematical anxiety involves various fields of science such as psychology, education, and neuroscience [29]. This can be a barrier for students in gaining achievements in learning mathematics. There are two opinions about the obstruction of learning achievement, first, the disruption accounts due to disruption of work memory performance (WM) and the second, due to reduced mathematical abilities (reduced competency accounts) which result in anxiety [2]. Students who experience anxiety will feel an increase in heart rate [16] and other researchers liken this to a feeling of phobia [4], [8].

Mathematical anxiety can be reduced if there is a comfortable mathematics learning. The teacher becomes an important factor in creating comfort in learning [30]. The Teacher's error in conveying mathematics learning can make appearing of students' math anxiety increase. Therefore, the teacher needs to use media that makes students happy and comfortable, one of them through the AR-assisted storybook.

Storybooks are developed with the aspects of content and appearance. Content aspects include story elements such as themes, setting, characterization, plot, point of view, language style, and mandate [31]. Display aspects include color, text, and position of images, pages, and sizes. Color must consider the theme of the story because it will affect the atmosphere of the reader [32]. Primary school students like striking colors [33]. The position of the text and images must match and may not overlap. The number of pages that corresponds to elementary students is between 32-64 with a maximum book size of 11 inches [32].

Exercises or mathematical problem tasks are presented as a complement to storybooks. These exercises are used to increase students' self-efficacy and self-esteem. Both of these aspects are related to students' beliefs in their abilities and respect for themselves. Self-efficacy and self-esteem negatively correlated with math anxiety [34]. Thus through lots of fun exercises through storybooks, self-efficacy and self-esteem towards mathematics will increase, and students' math anxiety can decrease.

Storybooks are equipped with augmented reality assistance. As stated by previous researchers, AR is able to attract the attention and involvement of students through the 3D visualization displayed [21]. Learning with augmented reality offers flexible learning facilitation [35] and the creation of authentic learning [36]. Books that are augmented reality feature will be more dynamic and interactive [37].

The advantage of the augmented reality feature is its ability to help students understand mathematical concepts through form manipulation, understanding (from abstract to concrete) and providing contextual learning [23]. Augmented reality also helps students' spatial abilities [24], [38] which can ultimately reduce student anxiety [39].

4 Conclusion

Based on the results of the research and discussion presented, it can be concluded that the use of media in the form of storybooks assisted by augmented reality can have a positive and significant influence on the anxiety of fourth-grade students in mathematics learning. This is indicated by the results of hypothesis testing with paired t-test and t-test techniques. The results of the paired t-test show that the value of sig. < 0.05 , which means that the accepted hypothesis is that there are differences in students' anxiety on mathematics learning between before being given treatment and after. The results of the independent t-test indicate that the value of sig. < 0.05 , which means that the accepted hypothesis is that there is a difference between the treated group (experimental group) using the AR-assisted Storybook and the untreated group (control group) using the AR-Assisted storybook.

5 Acknowledgement

Thank you to the ministry of technology research and higher education who have provided financial assistance to carry out this research.

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7 Authors

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Article submitted 2019-11-10. Resubmitted 2019-12-07. Final acceptance 2019-12-10. Final version published as submitted by the authors.

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