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Using Storybook-based AR in Learning Mathematics for Elementary School: How is it applied?

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***Abstract*—Augmented Reality, technology that merges the real and virtual world became popular among educational researchers for many advantages. This technology can be combined with storybooks so that storybooks appear dynamic and interactive. The purpose of this study is to describe the stages of learning media in the form of storybooks-based Augmented Reality in mathematics especially geometry material. The method used is Design-Based Research. Stages in the product development included designing Storybook-based AR uses mobile devices and analyzing the results of limited trials. The respondents involved in the study were 10 elementary school students. The study showed that the Storybook-based AR has the potential to be applied in learning mathematics especially in geometry.**

Keywords—storybook, augmented reality, mathematics, geometry, elementary school

I. INTRODUCTION

Most elementary school students view mathematics as a difficult subject. The existence of this anxiety will certainly have an impact in the achievement of the learning outcomes [1]. Combining technology with the book will make the book dynamic and interactive [2]. Primary school students are very familiar with technological development such as smartphones, laptops and tablets. The field of education needs to be transformed with an approach for using technologies such as Augmented Reality. Augmented Reality (AR) is a technology that blends the real world with the virtual world through 3D visualization and real-time user interaction [3,4,5].

Much research in AR in educational settings as the creation of mobile learning was done [5,6] in game-based learning [8,9,10,11] and inquiry learning [12], infused robot system [13], book [13,14] mobile AR artifact [16], and mobile application [17]. Thus, AR technology provides a choice of learning settings that can be done in both formal and informal environment. In addition, AR is used in intellectual disability [18].

Previous research in AR technology was proven to be effective in helping students to improve their spatial interpretation [11], conceptual understanding [12], spatial sound [19], understanding students' conceptions of learning [20], social communication [21], motivation [6] interest in dramatic play (satisfaction); interactive engagement (sensory immersion); and empathy with media (media recognition) [13]. In education, AR also impacts in learning achievement [6], improves students' performance in learning process [7], creates collaborative learning[16], impacts affective and cognitive learning outcome [22] and autonomous learning[23].

One of the bridging gaps between technology and traditional books is integration through Augmented Reality and Storybook. Mathematics material was integrated in the storyline and was assisted by AR technology. The focus of this research is to know how the stages combine storybooks with Augmented reality through a mobile device. Hence, we analyze the limited test with the elementary school students

II. RELATED STUDIES

Storybook-based papers were used by previous researchers to assist children for vocabulary acquisition [24], literacy practices [25]. Researchers [26] developed an e-storybook used to improve students reading ability and motivation. The development of technology made e-book a known product of Interactive Storybook Reading (ISR). ISR studied much focuses on languages and print-concept skills [27] and can also be applied in teaching for young DHH children [28].

Today, AR is growing fast in the realm of education and one of them is combined with books. Survey of Torregrosa [14] through the development of AR BOOK against 211 Spanish university students showed that this technology is helpful for students' motivation, autonomous learning or spatial interpretation in understanding anatomy. Hung [15] developed the AR graphic book and tested it to 72 fifth grade students from two elementary schools including three satisfaction including a picture book, physical interactions, and an AR graphic book. The AR graphic book offers a practical and hands-on way for children to explore and learn about bacteria. Follow-up

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interviews indicated that the children liked the AR graphic book very much and they preferred it rather than the other materials.

Most of the above studies focused on storybook reviews, reading motivation and language development. However, the development of storybooks in mathematics did not undergo for advanced studies. The storybook and AR have their own advantages over the learning outcomes, learning process and learning experiences of the students. This provides the basis of combining storybooks and Augmented Reality.

III. MATERIAL AND METHOD

The method used in the current study is Design based-Research which focuses on storybook-based AR development. There were 10 elementary school students who participated in the study in the southern Yogyakarta. They took the feasibility test of the use of mathematics learning media in the concept of geometry. Stages of developing a storybook-based AR in the concept of geometry was based on the development of a tutorial-based CAI (Computer Assisted Instruction) model [29]. Generally includING 2 parts/

A. Stages of Designing Storybook-Based AR

The first step is to makeg AR modelling about geometry concept in learning mathematics. Making 3D Marker using Unity 3D and 3d max [30]. Marker results were created and registered with an account on the website Vuforia Developer. Stages of designing Storybook-based AR with the help of an Android system visualization are shown in figure 1. Making AR design is done simultaneously with developing a storybook considering the elements of storybooks and content of geometry material.

B. Limited Experiment Phase

The Experimental Phase is tested to elementary school students in South Yogyakarta in the concept of geometry. After reading AR-based storybook, the students worked in students' worksheets and a limited the questionnaire about the product.

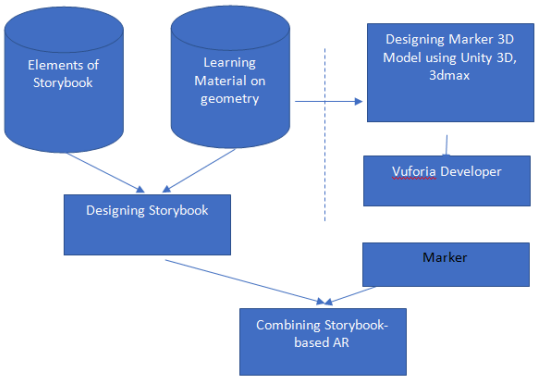

Fig. 1. Framework designing storybook – based AR

IV. RESULTS AND DISCUSSION

A. Stages of Designing Storybook-based AR

Section 1: We create a 3 dimensional drawing model design using 3ds max software. Later on, this 3 dimensional design will appear in the application. The image is exported to a 2-dimensional JPEG Image. This image will serve as a marker. Then, the 2-dimensional images are uploaded to the website "developer.vuforia.com" then downloaded into Vuforia package [29]. Further software required to connect 2-dimensional images with a 3-dimensional model image is using Unity. This 3-dimensional model image will be set with a 2-dimensional image where one image can only detect a 3D model.

After the image settings process completed and already appeared in unity, the last stage is to develop the setting of an apk (build to be an Android Application with Android Studio Application). This setting process is the final step of a series of processes mentioned above. After this process is successful, the application of the developed settings can be installed on the Smartphone or Tablet.

Section 2: We designed the storybook with a digital drawing. During the preparation, we looked at the elements of storybooks that are appropriate to the elementary school students and geometrical materials such as the area and circumference of the square, rectangular and triangular buildings. It is then combined with the marker created in section 1 and the results are printed on the paper. Three-dimensional visualization of the paper can be viewed by mobile device or tablet that has apk installed from section 1.

B. Limited Experiment Phase

In the Storybook-based AR that was developed in geometric concepts, the test was ran with 10 respondents from four randomly selected primary school classes in Southern Yogyakarta. The following are the steps of the experiments: first, the students were given a storybook and a smartphone in which the application was installed. Students read the using instructions and then read the storybook. At the end of the reading session, the students were given a questionnaire to assess the instructional media. Indicators used to assess instructional media were based on the previous researchers [30], [31]. The result of the questionnaire is shown in Table I.

TABLE I. QUESTIONNAIRES RESULT BASED ON INDICATORS

Indicators	Scores	Criterion	Percentage (%)
Learning Objective Relevance	106	120	88.33
Product Efficiency based on Time	61	80	76.25
Effectivity in Overcoming Media Limitations	95	120	79.17
Media Implementation Flexibility	65	80	81.25
Media Interface	110	120	91.67
Increasing Students' learning motivation	115	120	95.83
Learning Support capacity	110	120	91.67
Similar Media Development Prospect	34	40	85.00

Based on the figures in Table I, it is seen that each indicator has different scores based on the assessment of the respondents for each indicator by referring to the maximum criteria of each indicator. Three indicators had a range of 91,67-95,83% indicating that the development of Storybook-based AR on the indicator had a very reasonable qualification, while two indicators had a range of 75.83-79.17% which were eligible enough, and three indicators had a range of 81.25- 88.33% with qualified eligibility. The highest percentage lies in the student motivation indicators. This is in accordance with the previous research claims [6]. This media is also a very reasonable qualification in the media interface and also in the learning support capacity. Previous researchers revealed that the Media Interface aspect should be considered in AR design [32] and also in the learning support capacity [25][33].

Therefore, the product of Storybook-based AR in the concept of geometry was sufficient for students in the elementary school as a learning source.

V. CONCLUSION

Through design-based research, a product in the form of storybook-based AR on an android system has been successfully developed. The questionnaires result of Storybook-based AR on the concept of geometry has 75.83-95,83%. This result implies that storybook-based AR has the potential to be applied to the learning of mathematics, especially on geometry material in elementary school. Further research on a wider scale is necessary to know its impact on student learning.

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REFERENCES

[1] A. Sarkar, A. Dowker, and R. Cohen Kadosh, "Cognitive Enhancement or Cognitive Cost: Trait-Specific Outcomes of Brain Stimulation in the Case of Mathematics Anxiety," *J. Neurosci.*, vol. 34, no. 50, pp. 16605–16610, 2014.

[2] K. R. Bujak, I. Radu, R. Catrambone, B. Macintyre, R. Zheng, and G. Golubski, "Computers & Education A psychological perspective on augmented reality in the mathematics classroom," *Comput. Educ.*, vol. 68, pp. 536–544, 2013.

[3] P. Milgram, H. Takemura, A. Utsumi, and F. Kishino, "Augmented reality: a class of displays on the reality-virtuality continuum," vol. 2351, pp. 282–292, 1994.

[4] R. T. Azuma, "A Survey of Augmented Reality," *Presence Teleoperators Virtual Environ.*, vol. 6, no. 4, pp. 355–385, 1997.

[5] M. Billinghurst, "Augmented Reality and Education," *New Horizons Learn.*, no. figure 1, p. 21(3) 195-209, 2002.

[6] T. H. C. Chiang, S. J. H. Yang, G. Hwang, T. H. C. Chiang, S. J. H. Yang, and G. Hwang, "International Forum of Educational Technology & Society An Augmented Reality-based Mobile Learning System to Improve Students ' Learning Achievements and Motivations in Natural Science Inquiry Activities An Augmented Reality-based Mobile Learning System t," vol. 17, no. 4, 2017.

[7] J. Joo-Nagata, F. Martinez Abad, J. García-Bermejo Giner, and F. J. García-Peñalvo, "Augmented reality and pedestrian navigation through its implementation in m-learning and e-learning: Evaluation of an educational program in Chile," *Comput. Educ.*, vol. 111, pp. 1–17, 2017.

[8] D. Furió, M. C. Juan, I. Seguí, and R. Vivó, "Mobile learning vs. traditional classroom lessons: A comparative study," *J. Comput. Assist. Learn.*, vol. 31, no. 3, pp. 189–201, 2015.

[9] T. C. Hsu, "Learning English with Augmented Reality: Do learning styles matter?," *Comput. Educ.*, vol. 106, pp. 137–149, 2017.

[10] S. J. Lu and Y. C. Liu, "Integrating augmented reality technology to enhance children's learning in marine education," *Environ. Educ. Res.*, vol. 21, no. 4, pp. 525–541, 2015.

[11] L. Pombo, M. M. Marques, V. Carlos, C. Guerra, M. Lucas, and M. J. Loureiro, "Citizen, Territory and Technologies: Smart Learning Contexts and Practices," vol. 80, 2018.

[12] I. Efstathiou, E. A. Kyza, and Y. Georgiou, "An inquiry-based augmented reality mobile learning approach to fostering primary school students' historical reasoning in non-formal settings," *Interact. Learn. Environ.*, vol. 26, no. 1, pp. 22–41, 2018.

[13] J. Han, M. Jo, E. Hyun, and H. Jeong So, "Examining young children's perception toward augmented reality-infused dramatic play," *Educ. Technol. Res. Dev.*, vol. 63, no. 3, pp. 455–474, 2015.

[14] J. Ferrer-Torregrosa, J. Torralba, M. A. Jimenez, S. García, and J. M. Barcia, "ARBOOK: Development and Assessment of a Tool Based on Augmented Reality for Anatomy," *J. Sci. Educ. Technol.*, vol. 24, no. 1, pp. 119–124, 2015.

[15] Y. H. Hung, C. H. Chen, and S. W. Huang, "Applying augmented reality to enhance learning: a study of different teaching materials," *J. Comput. Assist. Learn.*, vol. 33, no. 3, pp. 252–266, 2017.

[16] F. Ke and Y. C. Hsu, "Mobile augmented-reality artifact creation as a component of mobile computer-supported

collaborative learning," *Internet High. Educ.*, vol. 26, pp. 33–41, 2015.

[17] P. E. Antoniou, M. Mpaka, I. Dratsiou, and P. D. Bamidis, "Interactive Mobile Communication Technologies and Learning," vol. 725, pp. 409–420, 2018.

[18] C. C. Smith, D. F. Cihak, B. Kim, D. D. McMahon, and R. Wright, "Examining Augmented Reality to Improve Navigation Skills in Postsecondary Students With Intellectual Disability," *J. Spec. Educ. Technol.*, vol. 32, no. 1, pp. 3–11, 2017.

[19] D. Rumiński, "An experimental study of spatial sound usefulness in searching and navigating through AR environments," *Virtual Real.*, vol. 19, no. 3–4, pp. 223–233, 2015.

[20] K. H. Cheng, "Surveying students' conceptions of learning science by augmented reality and their scientific epistemic beliefs," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 14, no. 4, pp. 1147–1159, 2018.

[21] N. T. Sahin, R. A. Med, N. U. Keshav, R. Liu, J. P. Salisbury, and A. Vahabzadeh, "Augmented Reality Intervention for Social Communication in Autism in a School.pdf," no. 5.

[22] M. B. Ibáñez, Á. Di Serio, D. Villarán, and C. Delgado Kloos, "Experimenting with electromagnetism using augmented reality: Impact on flow student experience and educational effectiveness," *Comput. Educ.*, vol. 71, pp. 1–13, 2014.

[23] J. Martín-Gutiérrez, P. Fabiani, W. Benesova, M. D. Meneses, and C. E. Mora, "Augmented reality to promote collaborative and autonomous learning in higher education," *Comput. Human Behav.*, vol. 51, pp. 752–761, 2015.

[24] T. A. Roberts, "Home Storybook Reading in Primary or Second Language With Preschool Children : Evidence of Equal Effectiveness for Second-Language Vocabulary Acquisition," vol. 43, no. 2, pp. 103–130, 2008.

[25] H. Lee, "STORYBOOK TO ENGAGE IN LITERACY PRACTICES IN ELEMENTARY SCHOOL IN KOREA," 2014.

[26] C. Kung, J. Road, and C. City, "Effects of Paper-Storybooks And E-Storybooks With Reading Comprehension Strategies on Fifth Graders ' Reading Comprehension Ability and Reading," *IADIS Int. Conf. Cogn. Explor. Learn. Digit. Age (CELDA 2010)*, no. Celda, pp. 281–285, 2010.

[27] E. Nevo, "Enhancing language and print-concept skills by using interactive storybook reading in kindergarten," 2017.

[28] J. W. Trussell, J. Dunagan, J. Kane, and T. Cascioli, "The Effects of Interactive Storybook Reading With Preschoolers Who Are Deaf and Hard-of-Hearing," 2017.

[29] S. S. Deshmukh, C. M. Joshi, R. S. Patel, and Y. B. Gurav, "3D Object Tracking And Manipulation In Augmented Reality .," pp. 287–289, 2018.

[30] F. S. Irwansyah, Y. M. Yusuf, I. Farida, and M. A. Ramdhani, "Augmented Reality (AR) Technology on the Android Operating System in Chemistry Learning," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 288, no. 1, 2018.

[31] S. Cuendet, Q. Bonnard, S. Do-Lenh, and P. Dillenbourg, "Designing augmented reality for the classroom," *Comput. Educ.*, vol. 68, pp. 557–569, 2013.

[32] M. Kesim and Y. Ozarslan, "Augmented Reality in Education: Current Technologies and the Potential for Education," *Procedia - Soc. Behav. Sci.*, vol. 47, no. 222, pp. 297–302, 2012.

[33] P. Sommerauer and O. Müller, "Augmented reality in informal learning environments: A field experiment in a mathematics exhibition," *Comput. Educ.*, vol. 79, pp. 59–68, 2014.