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IMPROVING STUDENTS' MATHEMATICAL REASONING IN GEOMETRY USING ADOBE FLASH LEARNING MEDIA

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ABSTRACT
The technology era provides new opportunities to improve mathematics teaching and learning. In this paper, we reported the implementation of Adobe Flash as learning media for improving students' reasoning ability. Results suggested a significantly improved reasoning ability in experimental class compared to control class, which indicated the effectiveness of Adobe Flash as media for learning geometry. The use of animation, video, and worked example, foster students' reasoning ability by making geometrical concepts transparent and reducing possible misleading spatial perception.

Keywords: mathematics learning; multimedia; adobe flash; reasoning

ABSTRAK
Era teknologi memberikan peluang baru untuk meningkatkan pengajaran dan pembelajaran matematika. Dalam artikel ini, kami melaporkan hasil penerapan Adobe Flash sebagai media pembelajaran untuk meningkatkan kemampuan penalaran siswa. Hasil penelitian menunjukkan peningkatan kemampuan penalaran yang signifikan di kelas eksperimen dibandingkan dengan kelas kontrol yang menunjukkan keefektifan Adobe Flash sebagai media pembelajaran geometri. Penggunaan animasi, video serta contoh pengerjaan menumbuhkan kemampuan penalaran siswa dengan membuat konsep geometri menjadi transparan dan mengurangi kemungkinan adanya persepsi spasial yang salah.

Kata kunci: pembelajaran matematika; multimedia; *adobe flash*; penalaran

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INTRODUCTION

National Council of Teachers of Mathematics or NCTM (NCTM, 2000), Trends in International Mathematics and Science Study or TIMSS (Mullis et al., 2008; Martin, Mullis, Foy, and Arora, 2012; Mullis, Martin, Foy, and Hopper, 2016) and Organisation for Economic Cooperation and Development or OECD via Programme for International Student Assessment or PISA (see OECD, 2016) considers Mathematical reasoning as an essential aspect of mathematical competency. Unfortunately, students found mathematical reasoning challenging (Mullis et al., 2008; Martin et al., 2012; Mullis et al., 2016; OECD, 2016). In PISA's 2015 Assessment and Analytical Framework, the ability to reason mathematically is an integral part of mathematics literacy. However, students from 21 OECD countries still could not attain level 3 proficiency: they have not engaged in successful interpretation and reasoning (OECD, 2016). On the importance of reasoning skills, NCTM (2000) emphasizes that mathematical thinking and reasoning skills are essential because it lays a foundation for developing new insights and promoting further study. The assertion is corroborated by Benbow, Lubinski, Shea, and Eftekhari-Sanjani (2000) study. In their longitudinal studies, students with high mathematical reasoning ability in their teens demonstrated high educational achievement in their adulthood in which they successfully earned baccalaureate, master, or doctorate degrees well beyond base-rate expectations.

The importance of mathematical reasoning has inspired educators to improve and to develop students' mathematical reasoning, for example, by understanding how students conduct mathematical reasoning activity (Francisco and Maher, 2010; Mata-Pereira and da Ponte, 2017), by designing instructional methods embedded with metacognitive strategies (Kramarski and Mevarech, 2003; Mevarech and Fridkin, 2006), or by designing practical tasks assessment (Boesen, Lithner, and Palm, 2010). Improvement via technology such as

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computer program application in learning settings have also used in mathematics education research (Foletta and Leep, 2000; Kramarski and Zeichner, 2001; Zembat, 2008; Huscroft-D'Angelo, Higgins, and Crawford, 2014; Santos-Trigo, Reyes-Martínez, and Aguilar-Magallón, 2015; Higgins, Crawford, Huscroft-D'Angelo, and Horney, 2016; Goldstone, Marghetis, Weitnauer, Ottmar, and Landy, 2017). Technology-integrated mathematics curricula can help students develop mathematical concepts and procedures in a meaningful way (Zembat, 2008). The use of technology heightens mathematical reasoning activity by making implicit dynamism of a mathematical object (Santos-Trigo et al., 2015). Goldstone et al. (2017) further revealed that reasoning depends on spatial perception and learning to reason mathematically involves learning to overrule potentially misleading perception.

Presenting mathematical concepts in the form of visual representation and 3D shapes can stimulate students understanding of mathematical concepts (Ahmad, Yin, Fang, Yen, and How, 2010), and in planning their problem-solving activity (Kim, Sharp, and Thompson, 1998) as well as meaning-making in mathematics (Moreno and Mayer, 1999). Adobe Flash is a multimedia software commonly used to deliver high-impact and rich content. This interactive software potentially effective to use in delivering and improving mathematical reasoning, particularly in overcoming the misleading perception of a mathematical context.

Geometry was the focus of this present study because TIMSS found that in many countries, students' ability to reason in geometry problems still below the international benchmark (Mullis et al., 2008; Martin et al., 2012; Mullis et al., 2016) and became an area of mathematical weakness in 19 countries (Mullis et al., 2016). Furthermore, studies have proved the beneficial effects of multimedia in improving geometry understanding (see Hwang, Chen, Dung, and Yang, 2007; Chang, Sung, and Lin, 2007; Hwang, Su, Huang, and Dong, 2009) and geometry can shift students' arguments from figural to conceptual (Küchemann and Hoyles, 2006). Therefore, this present study aimed to implement a learning media with adobe flash software to improve students' mathematical reasoning in geometry.

METHOD

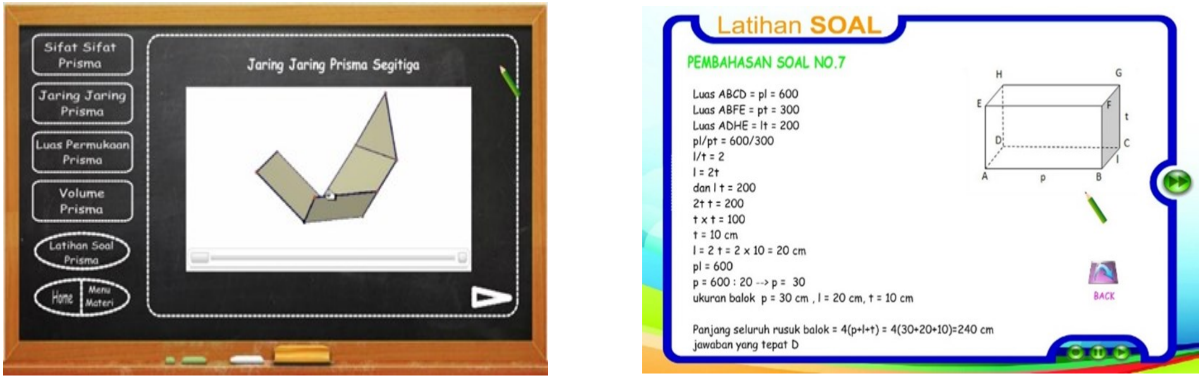
Twenty-six seventh-grade students in Kuningan Regency-West Java public school, served as sample and divided into two classes: experimental class (learning with Adobe Flash) and control class. Students' were predetermined to have equal geometric ability, and both classes were taught the same geometry materials. Students in the experimental class were learning the materials delivered with adobe flash, whereas students in the control class were learning the materials conventionally (chalk and board learning). In experimental class, geometry concepts were delivered interactively in animation and video, such as animation for a traingular prism. Triangular Prism concept was delivered with animation. Students can click a button for learning about characteristics of a prism, net of a prism, prism surface area, and volume of a prism (Figure 1a). Students' reasoning ability after learning was evaluated with pretest and posttest, with N*gain* as improvement indicator (Hake, 1998). Students' and teachers' activity was observed with Cai, Lane, and Jakabcsin (1996) holistic rubrics. Students' learning attitude was probed with a questionnaire and interview. Students' reasoning ability was statistically tested and deemed normal (P-value = 0.200 > 0.05) and homogenous (P-value = 0.147 > 0.05). Therefore, reasoning ability difference between classes was determined with a t-test.

RESULTS AND DISCUSSION

The Posttest score showed that students in the experimental class significantly outperformed students in the control class (P-value = 0.024, $p < 0.05$, Table 1), indicating that learning with Adobe Flash increases reasoning ability. Students' questionnaire also showed that learning with Adobe Flash was positively welcomed by the students because it helped them understand the geometrical shapes better. Triangular prism, for example (see Figure 1a). To calculate the surface area of a triangular prism, students must understand that a triangular prism has five faces: two triangles and three rectangles. A triangle face is considered as the base, and a rectangle face is a lateral face. Students can understand how a triangular prism is constructed and understand its rotational symmetry with animation and video. The possible misleading perception of a triangular prism could be overruled and do not interfere with their activity to reason and answer triangular prism questions. This notion is supported by questionnaire and interview results in which the students stated that the use of the media helped them understand geo-

Table 1. Average Students Reasoning Ability and Improvement after Learning

Class	N	Pretest	Posttest	N*gain*	Learning Achivement Difference
Control	26	4.7	9.8	0.49	t_{value} = -2.597, P_{value} = 0.024. P < 0.05,
Experimental (Adobe Flash)	26	4.8	10.4	0.59	Learning achievement difference was significant between learning group



(1a) (1b)

Figure 1a-b. Triangular Prism Concept Animation, students can click below-left button to access worked example (1a) and work example for rectangular prism (1b).

metric shapes better and help them avoid possible misunderstandings. The results are in line with previous research that multimedia can stimulate understanding (Ahmad et al., 2010) in a sophisticated and meaningful way (Zembat, 2008) and heightens mathematical reasoning activity by making implicit dynamism of a mathematical object (Santos-Trigo et al., 2015). Further, mathematical reasoning depends on spatial perception, and to reason mathematically involves learning to overrule potentially misleading perception (Goldstone et al., 2017). Students' improved reasoning ability in this study proved that when misleading spatial perception was minimized, their ability to reason was improved.

Worked example is also available in the learning media so that students can understand geometric problems better (Figure 1b). Schwonke et al. (2009) study proved that the use of worked example reduces students' learning time and increase procedural skills and conceptual understanding. Further, Sisman and Aksu (2016) study found that students' misconceptions in spatial measurement are a possible byproduct of inadequate comprehension in spatial measurement fundamental procedures and formulas for measuring length, area, and volume. The use of animation, video, and worked example in the media making the process of measuring rectangular prism (see Figure 1b) becomes conceptually transparent for the students, which helps them reason inductively.

CONCLUSION

Learning geometry with Adobe Flash software significantly improved students' reasoning ability. The use of animation, video, and worked example, foster students' reasoning ability by making geometrical concepts transparent and reducing possible misleading spatial perception. Aside from Adobe Flash, other multimedia software are currently available commercially and it will be intriguing to design and implement learning with those media to understand how these products of technology could benefit students' reasoning. Small sample size and limited length of program implementation should be put under consideration when making generalization from this study results.

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