Development of Adobe Flash Learning Media Based on Cooperative Learning to Improve Student's Spatial Ability at Chandra Kumala Secondary School

Fajar Sukma Harsa
Mathematics Education Program
Graduate program, Universitas Negeri Medan
Medan, Indonesia
fajarsukmaharsa@rocketmail.com

Hermawan Syahputra
Mathematics Education Program
Graduate program, Universitas Negeri Medan
Medan, Indonesia

E. Elvis Napitupulu
Mathematics Education Program
Graduate program, Universitas Negeri Medan
Medan, Indonesia

***Abstract*— Spatial ability supports the results of student mathematics learning especially on geometry topics related to shape and space. The purpose of this study was to look at the quality of the development of learning media assisted by Adobe Flash based on cooperative learning to improve student's spatial abilities. This study is development research using 4-D model (define, design, develop, and disseminate) in two classes of 30 students at Secondary School at Chandra Kumala Deli Serdang and it has two trials for the developing step. The quality of development is assessed from several aspects, namely validity, practicality, effectiveness of media development and increasing the value of student's spatial abilities. The results showed that the media development validity score was 2.89 (criteria: valid). Practicality has met the practical criteria reviewed by the teacher questionnaire with an average score of 2.65 in trials I and 2.98 in trial II, and responses of students with an average score of 2.75 in trials I and 2.85 in trial II which means good responses. Effectiveness fulfills the effective criteria, namely in terms of the completeness of student learning classically has reached 86.7% in the trial II (in the trial I only 76.7%) and the use of research time according to the implementation plan of learning. Whereas N-gain increases the spatial ability of students using learning media developed in trial I in the low category with a score of 0.13, but in the moderate category with a score of 0.34 in the trial II. Furthermore, the average value increased from the first trial of 71.32 to 77.13 in the second trial.**

***Keywords*— Spatial, Developments, Media, Adobe Flash.**

I. INTRODUCTION

Mathematics is fundamental knowledge which is an important part of the modern technological revolution [1]. The success of learning mathematics for students means that it has opened up brilliant career opportunities, supports the right decision making to solve problems in everyday life [2]. O ne of the complicated mathematical topics for students to learn is the topic of geometry. Many students fail to develop a proper understanding of concepts, reasoning, and geometry problem solving [3,4]. The 2012 PISA survey shows Indonesian students are weak in geometric content, namely Space and Shape content . Of the 6 question levels according to the level of difficulty tested, Indonesian students were only able to answer 69.2% (OECD average 25.8%) at level one, 19.8% (OECD average 22.3%) at level two , 7.8% (OECD average 22.2%) at level three, and almost 0% (average 29.7%) at high levels [5] . From these facts, it can be concluded that the ability of students in Indonesia especially junior high school students is still lacking in understanding geometry or spatial material.

The facts show that indeed most students who enter education at the secondary school level have a gap of understanding in mathematics [6]. The gap in question is the lack of students understanding the material as a whole or overall so as to result in low mathematics learning outcomes, especially in geometry lessons.Ferguson [7] released the results of his research in the Journal of Learning and Individual Differences that there is a close relationship between spatial ability and learning outcomes in mathematics geometry and poor spatial ability that greatly affects students' mathematical anxiety. The same thing was conveyed by Tosto, Hanscombe, Haworth, Davis, Petrill, Dale, Malykh, Plomin, and Kovas [8] that good spatial ability strongly supports students' mathematical achievements, especially on topics that emphasize the development of technological, scientific and machine skills.

Spatial ability is the ability to think in the shape, arrangement, and change of a particular object in space when rotated, moved, or viewed at different points of view [9] While the main components of spatial thinking include spatial perception, spatial visualization, spatial orientation, spatial rotation, and spatial relations .The fact shows that spatial abilities have not received serious attention by most teachers [10]. When teaching geometry, especially about building spaces such as cubes, beams, pyramid or prisms, most teachers emphasize giving information on the number of ribs, fields, width of fields, and other memorizing information.

Therefore we need an appropriate learning activity to be able to improve the spatial abilities of students. The teacher must design meaningful learning accompanied by activities using geometric object props so as to be able to hone the spatial abilities of students [11]. Several studies have suggested efforts to improve students' spatial thinking skills by utilizing learning media. But the use of objects or physical models is not enough. Computer-based media is more promising as a three-dimensional virtual model, because in addition to being easy to use and instructional, the use of technology in class is in accordance with the digital era [12,13] .

In today's digital era, of course there are many computer-based applications that can describe three-dimensional (3D) objects such as Geogebra, Autograph, Matlab, Adobe Flash, and others. But programs or software intended not only for 3D display but also for animation, presentation devices, publications, and games areAdobe Flash [14] . Flash is able to display graph flexibility, represent concrete mathematical concepts, animations, and sounds so that it is easy for students to understand complex mathematical concepts [15] .

A teacher should ideally not only use the media without seeing the learning conditions and situations. Development of learning media needs to be done by teachers to overcome the shortcomings and limitations of existing media. Besides that, the self-developed learning media by the teacher can avoid mismatches because they are designed according to their needs, potential resources, and environmental conditions. In fact, an educator who is adept at developing learning media is an innovative, creative, and professional educator [16]

In addition to spatial ability, computer-based learning media are also able to encourage increased learning independence or self-regulated learning students [17,18] . The role of technology in the digital era today greatly enables students to explore without limits so as to be able to spur learning independence. If students are given the freedom to find the preferred way of learning, given the opportunity to use the media as a visualization of abstract concepts, then this will lead to their awareness that learning is not always only the teacher teaching in front, but also exploring with the media.

II. METHOD

This study uses developmental research. of Thiagarajan (4-D development model) which consists of the Define, Design, Develop, and Disseminate phases for the mathematics learning media assisted by Adobe Flash version CS6 on cube and beam material.

This research was conducted in Secondary School Chandra Kumala Deli Serdang . The school was chosen because it supports computer facilities and has rules for each school to use technological devices with the supervision of teachers to facilitate the research process. The subjects in this study were all students Junior Chandra Kumala Deli Serdang school year 2018/2019, but the subject test taken only class VIII A and C each have 3 0 students . Criteria for evaluating the success of development research are reviewed from three things, namely media validity, practicality, and effectiveness [19].

Tablel 1. Criteria of Assessment

Criteria	Sub-Criteria	Instrument	Data Observed	Data Analyzed	Responden
Validity	Viewed from Media Experts	Questionnaire	Adobe Flash CS6 learning media that has been developed	The total Score of Average	Expert/ Specialis
	Viewed from Mathematician	Questionnaire			
Practicality	Respon Guru	Questionnaire	Adobe Flash CS6 learning media that has been developed	The total Score of Average	Teacher
	Respon siswa	Questionnaire			Student
Effectiveness	Score of Student's Spatial Ability	Test	Test of Spatial Ability	The total Score of Average	Student
	The Increasing	-	Pre-Test and Post-Test	N-Gain	-

Indicators of success in this study are determined from : 1) the results of assessment of the development of instructional media by experts who meet the minimum valid criteria; 2) effective learning media with criteria of at least 85 % of the total number of students who take part in learning using Adobe Flash CS6 mediahave good spatial abilities, namely minimum score of 2, 51 (B-) after being converted to standard value 4 ; 3) Practicality of learning media to improve the spatial abilities of students in practical categories that are reviewed from teacher questionnaires and student responses.

III. RESULTS AND DISCUSSION

A. *Validity of the Development of Mathematics Learning Media Assisted by Adobe Flash*

The validity analysis of the mathematics learning media assisted by Adobe Flash is viewed from two aspects, namely the assessment of expert / instructional media practitioners and experts / practitioners of mathematics subjects and the results show that the developed learning media is declared valid with an average value of 2.85 for experts learning media and 2.92 for learning material experts.

B. *Practical Development of Mathematics Learning Media Assisted by Adobe Flash*

Practicality in terms of teacher assessment consists of two aspects, namely the usefulness of the media and the use of the application. From the results of the questionnaire given to the teacher, there was an increase in the value of practicality from trial I to trial II. Even though it only increased by 0.33 or around 12.4% from the trial I, this increase was somewhat influenced by the improvement of the media based on the advice and analysis of media practicality in the trial I.

Table 2 . Increased Practical Score Based on Teacher Assessment

Observed Aspects	Practicality Score		Increasing each aspect
	Trial I	Trial II	
Media Benefits	2.54	3.02	0.48
Use of the Application	2.76	2.94	0.18
Average	2.65 (Practical)	2.98 (Practical)	Average increase of 0.33 (12.5%)

In the aspect of using the application, researchers want to see whether or not the teacher is easy to use the development of Adobe Flash -assisted media . Based on the questionnaire assessment it appears that the value given by the teacher is quite good. This might be due to the development of media that does not require laptops / notebooks with certain specifications, special care, high costs, and specialists / experts in running learning media, so the process of running media is very easy and fast.

The response data of students is netted to see the extent of interest, feeling of pleasure, and the ease of students in understanding the assisted learning media ofAdobe Flash developed. Each questionnaire responses of students have statements that strongly agree (SS) agree (S), disagree (KS), disagree, disagree (TS), and each has a scale of 4,3,2, and 1.

From the results of the questionnaire that has been given to students, the average response score of students is 2.75 in the first trial and 2.85 in the second trial.An increase in the value of student responses from trial I to trial II. Even though it only increased by 0.10 or around 3.6% from the trial I, this increase was somewhat influenced by the use of media by the teacher. From these responses indicate that students feel more active and interested in learning that uses Adobe Flash assisted learning media that have been developed because of their interactive nature and provide opportunities for students to use media independently so students are more likely to explore cube and beam material, specifically on the dimensions of rotation and orientation.

C. *Effectiveness of Development of Mathematics Learning Media Assisted by Adobe Flash*

Determination of the effectiveness criteria for the use of Adobe Flash learning media that has been developed in the teaching and learning process can be reviewed based on the completeness of the students' spatial abilities. The description of the spatial ability of students in trials I and II is shown in the following table:

Table 3. Value of Pre-Test / Post-Test of Spatial Ability of Students in Trial I

Value Range	Alphabet	Pret-Test			Post-Test		
		Many students	Average	Highest / Lowest	Many students	Average	H … L
96.25 - 100	A	4			4		
87.75 - 96.24	A-	1			5		
79.50 - 87.50	B +	3			5		
71.25 - 79.49	B	3			2		
62.75 - 71, 24	**B-**	5		**Highest 97**	7		**H**
54.50 - 62.74	C +	10	**66.72**	**Lowest 47**	7	**71,32**	**L**
46.25 - 54, 49	C	4			-		
37.75 - 46, 24	C-	-			-		
29.50 - 37.74	D +	-			-		
<29.50	D	-			-		

Table 4. Value of Pre-Test / Post-Test of Spatial Ability of Students in Trial II

Value Range	Alphabet	Pret-Test			Post-Test		
		Many students	Average	Highest / Lowest	Many students	Average	Highest / Lowest
96.25 - 100	A	3	**65.21**	**Highest 96** **Lowest 50**	5	**77,13**	**Highest 98** **Lowest 62**
87.75 - 96.24	A-	2			10		
79.50 - 87.50	B +	4			4		
71.25 - 79.49	B	2			1		
62.75 - 71, 24	**B-**	4			6		
54.50 - 62.74	C +	11			4		
46.25 - 54, 49	C	4			-		
37.75 - 46, 24	C-	-			-		
29.50 - 37.74	D +	-			-		
<29.50	D	-			-		

In this research, the dimensions of spatial ability consist of visualization, rotation, orientation, perception, and relations. In addition to being assessed on an average or overall basis, spatial abilities are also assessed based on their dimensions. This is done so that it can be analyzed whether there are more prominent spatial dimensions in students. The description of the value of spatial abilities based on spatial dimensions in each trial is as follows:

Table 5. Value of Dimensional Spatial Ability

Spatial Dimension	Trial I		Trial II	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Visualization	68.2	71.4	66.9	71.6
Rotation	66.3	79.0	65.4	83.4
Orientation	70,1	71.3	74,1	73.2
Perception	72.8	73.2	69.8	72,1
Relation	85.0	85.9	86.0	87.4

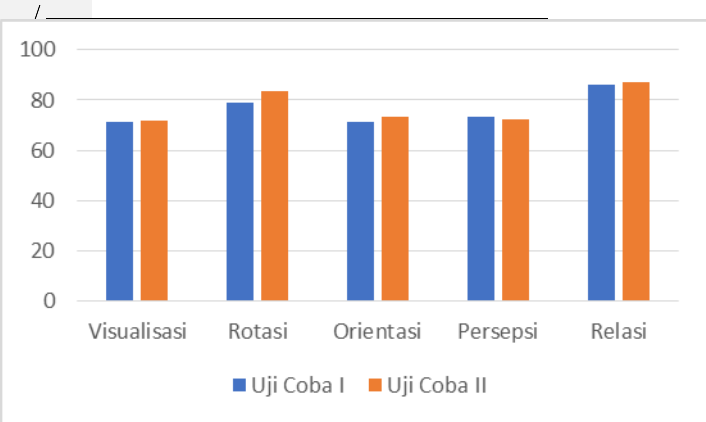

Figure 1 . Graph of Spatial Dimension Post-Test

To find out the increase in spatial ability, data were obtained from the results of the pre-test and post-test spatial ability of the test acetia. Increased spatial ability of students can be obtained from normalized gain index data as follows:

$$N - Gain = \frac{Posttest - Pretest}{Skor\ Ideal - Pretest}$$ [20] (Hake, 1999)

Normalized Gain Index Criteria (g) are:

$g > 0.7$: High

$0.3 < g \leq 0.7$: Middle

$g \leq 0.3$: Low

In the first trial, the average pre-test value was 66.72 and the post-test average was 71.32 so that the N-gain value was as follows:

$$N - Gain = \frac{Postest - Pretest}{Ideal\ score - Pretest} = \frac{71,32 - 66,72}{100 - 66,72} = \frac{4,6}{33,28} = \mathbf{0,13}$$

Whereas in the second trial obtained the pre-test average value of 65.21 and the post-test average of 77.13 so that the N-gain value is as follows:

$$N - Gain = \frac{Postest - Pretest}{Ideal\ score - Pretest} = \frac{77,13 - 65,21}{100 - 65,21} = \frac{11,92}{34,79} = \mathbf{0,34}$$

Based on the index of the normalized Gain (g), shows that the trials I increased the value of the criteria is low (≤ 0.3 g) and II trials increased the value of the criteria was ($0,3 \leq g \leq 0.7$).

The development of media in this study is indeed more dominant in the free rotation animation and net of cube animation, perhaps this is the basis of the increase in both dimensions higher than the other dimensions.

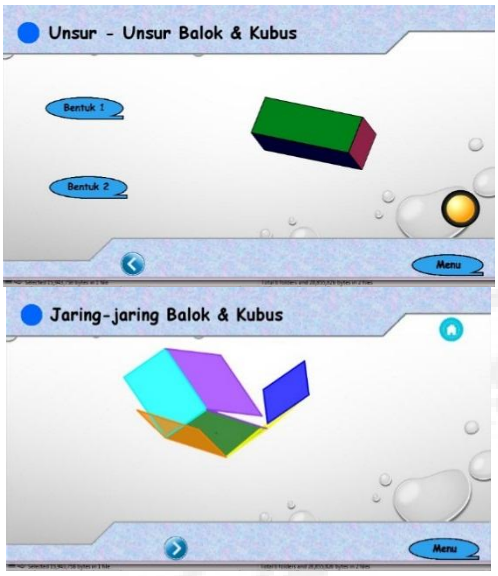

Figure 2. Display of Adobe Flash for Free Rotation and Cuboid Net

Furthermore, in one of the spatial dimensions, namely the orientation dimension, students are expected to be able to determine the space at different points of view, be able to recognize the arrangement or shape of space in general by imagining changes from the perspective of objects given accurately (recognizing the general characteristics of space).

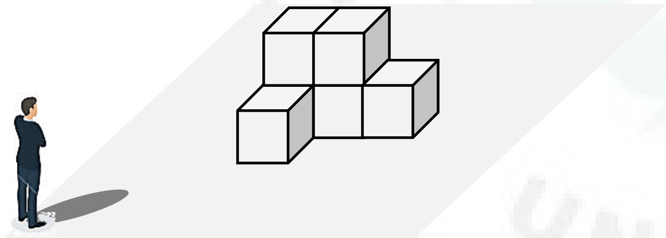

Figure 3. Orientation Problem

The picture above is one of the questions tested to see the spatial ability of students in the orientation dimension. Students are asked to draw back according to the perspective of the person in the picture. The result is that students are not accustomed to describing according to the perspective of the person in the picture.

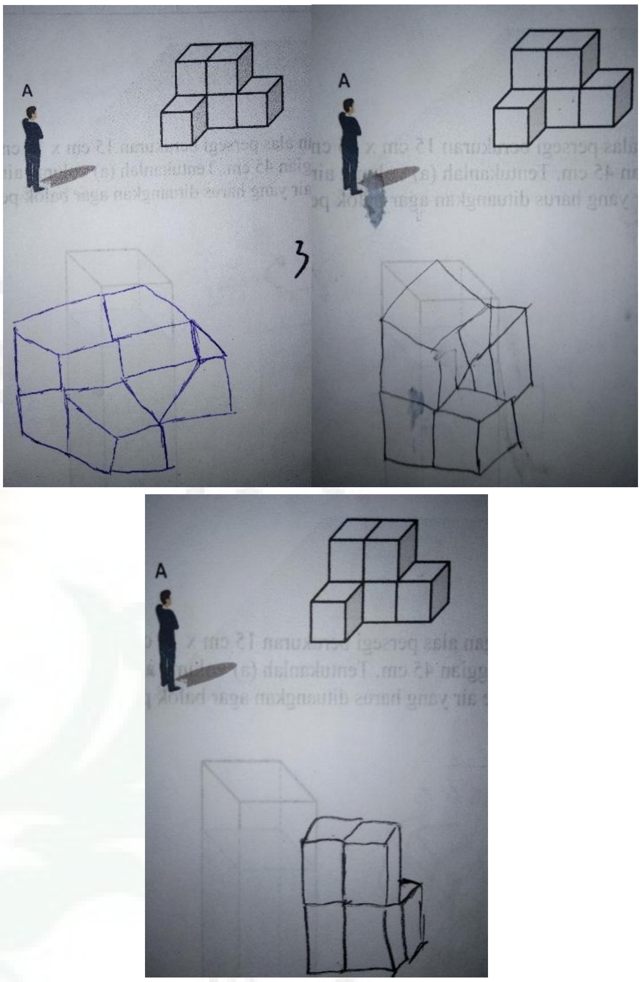

Figure 4. Student's wrong answer (Orientation)

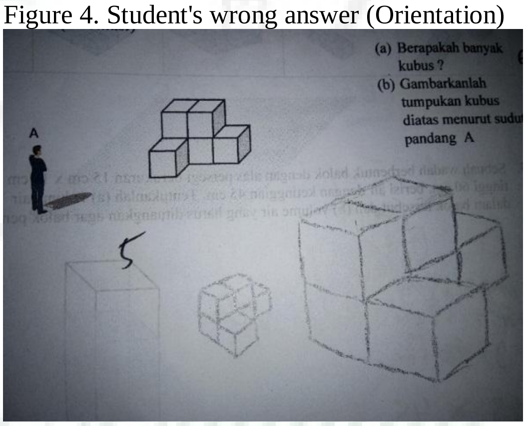

Figure 5. Correct student answers (Orientation)

Figure 4 shows that some students have not been able to construct images from a certain perspective. Only 13 of the 30 students (43.3%) were able to construct well in the trial post I. In this study, the increase in the value of the orientation dimension of the trial I to II was not too significant, but that does not mean the role ofAdobe Flash learning media does not mean at all. This is evidenced that in the second trial, 15 students (50%) could answer the dimensions of orientation correctly.

In general, the researchers concluded that the decline in some dimensions was caused by the development of media by researchers who did not focus on all dimensions (in this study focused on visualization and rotation) and students' initial mathematical abilities on the concept of high calculation so that the role of media and value changes was not significant dimension of relations.

IV. CONCLUSION

The validity of the development of mathematics learning media assisted by Adobe Flash -based cooperative learning is included in the valid category with an average value of 2.85 from media experts and 2.92 from subject matter experts, then the total RPP validity is 3.17.

The practicality of developing a mathematical learning media assisted by Adobe Flash -based cooperative learning has also met the practical criteria in terms of:a) teacher questionnaires with an average score of 2.65 in trials I and 2.98 in trial II; b) students' responses with an average score of 2.75 in trials I and 2.85 in trial II

The effectiveness of developing a mathematical learning media assisted by Adobe Flash -based cooperative learning fulfills the effective criteria, namely in terms of classical student mastery learning that has reached 86.7% in the second trial (in the first trial only 76.7%) and the use of research time as planned implementation of learning.

N-gain improvement in the spatial ability of students using learning media developed in cube and beam material in the first trial was in the low category with a score of 0.13, while in the second trial N-gain increased in the medium category with a score of 0.34. Furthermore, the average value increased from the first trial of 71.32 to 77.13 in the trial II.

REFERENCES

[1] Ernest, P. 2015. The Social Outcomes of Learning Mathematics: Standard, Unintended or Visionary? International Journal of Education in Mathematics, Science, and Technology. Vol. 3, No. 3, Page: 187-192.

[2] [2] National Research Council. 1989. Every Body Counts. A Report to The Nation on the Future Mathematics Education. Washington DC: National Academy Press.

[3] [3] Saha, A. 2010. The Effects of Geogebra on Mathematics Achievement: Enlightening Cooordinate Geometry Learning. International Conference on Mathemathics Education Research (ICMER). Vol. 8, Page: 686-693. Doi: 10.1016/j.sbspro.2010.12.095.

[4] [4] Dogan-Dunlap, H. 2010. Linear Algebra Students' Modes of Reasoning: Geometric Representations. Linear Algebra and Its Applications. 432. 2141-2159. (http://dx.doi.org/10.1016/j.laa.2009.08.037,2010).

[5]

[6]

[7] [5] National Center for Education Statistics USA, NCES. 2014). PISA 2012: Data Table, Figure, and Exhibits. Available on http://nces.ed.gov./2014024_tables.

[8] [6] Rubin, R. J.; Marcelino, J.; Mortel, R. & Lapinid, M. R. C. 2014. Activity-Based Teaching of Integer Concepts and its Operations. Presented Journal at the DLSU Research Congress. De La Salle University, Manila, Philippines March 6-8, 2014.

[9] [7] Ferguson, A. M.. 2015. On The Relation Between Math and Spatial Ability: The Case of Math Anxiety. Journal of Learning and Individual Differences. Vol. 39, P: 1-12. (http://doi.org/10.1016/j.lindif.2015.02.007).