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THE EFFECT OF EARTHCOMM LEARNING MODEL AND SPATIAL THINKING ABILITY ON GEOGRAPHY LEARNING OUTCOMES

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Abstract. *Geography learning is meaningless if it is not followed by the development of students' spatial thinking ability. Research aimed to 1) determine the effect of earthcomm learning and conventional learning on geography learning outcomes, 2) find out the effect of spatial thinking ability on geography learning outcomes, 3) find out the interaction between the application of earthcomm learning and spatial thinking ability on geography learning outcomes. Research used a quasi-experimental non-equivalent control group design. The research sample was taken from three high schools in Malang City, Indonesia. Geography learning outcomes data were obtained from paper-based test and spatial thinking ability data obtained from spatial thinking test instruments. Data were analyzed using Two Way ANOVA test using SPSS devices. The results of the research, 1) there is an effect of the application of learning to students' geography learning outcomes, 2) there is an influence of the ability of spatial thinking on geography learning outcomes, 3) there is no interaction between the application of learning and spatial thinking on geography learning outcomes. Efforts to improve learning outcomes and spatial thinking ability are needed by students to face the challenges of global competition.*

Keywords: *Earthcomm learning model, geography learning, geography learning outcome, quasi experimental, spatial thinking ability.*

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Introduction

Geography is a school subject that can develop character and skills in the face of global competition and the industrial revolution 4.0. Skills in geography learning teach students to have geography literacy and map literacy skills (Sugiyanto, Maryani, & Ruhimat, 2018; Wiwik Sri Utami, Sumarmi, Ruja, & Utaya, 2016a; Wiwik Sri Utami, Zain, & Sumarmi, 2018) and spatial intelligence (Kim & Bednarz, 2013; Metoyer & Bednarz, 2017; Mulyadi, Yani, Ismail, & Rosita, 2018; Yani, Mulyadi, & Ruhimat, 2018). However, in the reality, it was found that learning outcomes, skills and geography literacy of high school students are low (Homoki & Sütő, 2013; Utami et al., 2018), including low spatial ability (Metoyer & Bednarz, 2017; Sudatha, Degeng, & Kamdi, 2018), spatial intelligence (Mulyadi et al., 2018), and low spatial thinking (Fleming & Mitchell, 2017; Yusup, Santoso, & Istifarida, 2018). Efforts are needed to improve students' spatial thinking ability through effective geography learning.

Geography learning can be done flexibly. Geography learning outside the classroom is one of effective learning and has a positive influence on geography learning outcomes (Railienė, 2003; Yani et al., 2018). This learning involves students with the environment that requires teachers to know and understand environmental problems (Jeronen, 2004). Geography lessons can develop the ability in the field compared to other subjects such as physics and chemistry (Soobard & Rannikmäe, 2013). A learning is considered good if it is able to motivate students in improving the final grade of students (Bahri & Corebima, 2015). One of the learning that develops students' skills and creativity in scientific literacy is earthcomm learning. This learning was originally developed for chemistry subject in 1988 in America, for biology subject in 1996 and physics subject in 1998. It had just been developed for geoscience subject including geography in 2001. Earthcomm learning (Earth science in the community) is learning that involves students inside and outside the classroom by emphasizing the process of inquiry (Park, Yager, & Smith, 2005; Park, Park, & Lee, 2009) Some studies investigating earthcomm learning include: earthcomm learning towards creative thinking

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(Suharto, 2016), earthcomm towards critical thinking (Dewi, 2014), earthcomm towards 21st century capability (Mari, Sumarmi, & Handoyo, 2017), earthcomm based electronic modules (Mauliddia, Muryani, & Rintayati, 2018), earthcomm-based multimedia learning on motivation to learn (Hidayat, Sarwono, & Yusup, 2017), earthcomm in developing teacher professionalism (DY Park et al., 2005). However, earthcomm learning research in improving the quality of geography learning and student learning outcomes has not been widely studied.

Earthcomm learning is learning that develops students' literacy skills and scientific investigations at all levels of education. Scientific investigations can help students understand the earth's system contextually (Park & Park, 2013; Sumarmi, 2015). The stage of earthcomm that forms scientific inquiry is Challenge: giving stimulus to students in order to motivate them in conducting investigations, Think about it: helping students to think in planning investigations, Investigate: students do an investigation followed by Digging deeper: analyzing the results of investigations in depth by collaborating other sources, Inquiry further: the teacher can invite students to conduct further investigations. Investigations conducted require students to be creative and able to solve daily problems. Investigations must be contextual with their lives in order to form students' scientific reasoning, (Park et al., 2005). Contextual inquiry requires the ability to think in knowing the real conditions. This cognitive ability consists of recognizing space, applying space recognition technology, and using several reasons in determining space (Metoyer & Bednarz, 2017).

Cognitive ability to recognize space and its phenomenon is the ability to think spatially. This ability can help students demonstrate real space into dimensional space or vice versa (Metoyer & Bednarz, 2017). In developing the knowledge, skills and practices of geography, students need spatial thinking ability (Jo & Bednarz, 2014). The spatial thinking ability is needed by students in the future for a variety of things, including determining the strategic location of public facilities, planning regional spatial planning, analyzing impacts and benefits of land changes, projecting population numbers, distribution and its interaction with the environment. Geography learning can provide opportunities to develop these spatial thinking abilities because it studies the material and systems of the earth in terms of space, environment and region.

Some previous research showed that spatial thinking ability can be improved by various media and methods including the application of PBL-GIS (Liu, Bui, Chang, & Lossman, 2010), geospatial technology (Metoyer & Bednarz, 2017), GIS Learning (Kim & Bednarz, 2013), development of an e-book (Yusup et al., 2018) and test instruments (Aliman, Mutia, & Yustesia, 2018; Huynh & Sharpe, 2013; Jo, Bednarz, & Metoyer, 2010; Mulyadi et al., 2018). However, there are not many studies that examine the spatial thinking ability of high school students that influence the learning outcomes of geography by applying earthcomm learning although many studies have applied various learning models to improve learning outcomes. However, research to obtain an effective and efficient learning model in improving geography learning outcomes by measuring spatial thinking ability still needs to be done.

Problem of Research

The research problem was the low geography learning outcomes of high school students. In addition, the selection of inappropriate geography learning models is one of the causes of the low learning outcomes of geography. The effort that can be done to improve geography learning outcomes is to develop students' abilities in spatial thinking. The spatial thinking ability should be a point of view in studying geography. For this reason, it is necessary to know in advance the students' spatial thinking skills so that the application of learning models can be optimal in improving geography learning outcomes.

Research Focus

Research focuses on 1) knowing the application of the earthcomm learning model to the geography learning outcomes, 2) knowing the role and ability of spatial thinking on geography learning outcomes.

Research Methodology

General Background

This research used 2x2 factorial quasi-experimental with non-equivalent control group design. The details can be seen in table 1.

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Table 1. Pattern of 2x2 factorial experimental.

	Type of Spatial Thinking	Learning Model	
		Earthcomm Learning	Conventional Learning
Spatial Thinking Ability	High spatial	Group 1	Group 2
	Low spatial	Group 3	Group 4

Based on table 1, there were two applications of learning models, namely earthcomm learning models and conventional learning models. The ability of spatial thinking also has two types, namely high spatial thinking and low spatial thinking. Therefore, 1) research examined the effect of applying the earthcomm learning model and conventional learning models regardless of the influence of students' spatial thinking types, 2) examined the influence of spatial thinking types without assessing their relationship with the application of learning models. Research of interactions between variables is 3) whether there is an interaction between the application of earthcomm learning models and spatial thinking ability towards geography learning outcomes of high school students. The scope of the research was to examine the application of the earthcomm learning model, the spatial thinking ability of high school students and the geography learning outcomes of high school students. The research was conducted from March 27 to April 5, 2018.

Sample

The Senior High Schools used as the research sample came from the school population in Malang City, Indonesia. The samples were selected from 47 high schools in Malang City, Indonesia by using a stratified random sampling technique based on accreditation of superior schools, national standard schools and private schools. The high school that became the sample of the research was Public High School 5 as a superior school (the best school in the city based on the students' score average in national examination), Public High School 6 as a national standard school and Private High School PANJURA as a private school. The two classes were taken from each school to be used as experimental and control classes. The selection of the two research classes was based on the equality test from the results of the final examination in the previous semester. The selection of the experimental class and the control class was based on the average score of geography learning outcomes between classes that is almost similar. The two classes that have similar geographic learning outcomes, were assumed to have the same cognitive abilities (Table 2).

Table 2. Selection of experimental classes and control classes.

Criterion	Schools	Classes	Learning Outcomes	Experimental			Control			Total
				Class	Male	Female	Class	Male	Female	
Superior	Public High School 5	X Social 1	91	X Social 1	7	23	X Social 3	13	14	57
		X Social 2	85							
		X Social 3	89							
National	Public High School 6	X Social 1	76	X Social 2	5	23	X Social 5	11	17	56
		X Social 2	86							
		X Social 3	78							
		X Social 4	80							
		X Social 5	85							
Private	Private High School Panjura	X Social 1	70	X Social 2	10	15	X Social 3	8	21	54
		X Social 2	73							
		X Social 3	74							
				Total	22	61		32	52	167

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The experimental class consisted of 84 students and the control class consisted of 83 students. The 167 students in the research sample (113 female students and 54 male students), were given a test to find out their spatial thinking skills. Based on the data obtained, the 121 students have high spatial ability and 46 students have low spatial ability.

Instrument and Procedures

The instruments used in this research consisted of three instruments. First, instruments that were related to the application of earthcomm learning models and conventional learning models which included learning tools. Learning tools consisted of learning implementation plans (RPP), teaching materials, problem training, and student worksheets for investigations in the field. In the national curriculum of geography subject, there are several demands for competency for students, namely basic knowledge competencies and basic skills competencies. One of the basic competency demands for class X is the knowledge based competency in the form of analyzing the dynamics of the hydrosphere and its impact on human life. Meanwhile, basic skills competencies are in the form of presenting the hydrosphere dynamics process using maps, tables and graphics. The instrument of this learning device was validated by learning experts from Malang state of university and discussed with geography teachers in research schools to suit the needs of students.

Second, the final evaluation instrument for geography learning was used to determine the learning outcomes of geography. This instrument was made to measure student competency in accordance with national curriculum objectives. The instrument was also validated by learning evaluation experts and geography teachers at research site. The learning outcome assessment instrument consisted of 25 multiple choice questions with five answer choices and this data becomes a unit of analysis in data processing.

Third, the instrument used to measure spatial thinking ability was adapted from (Huynh & Sharpe, 2013) and adjusted to the thinking level of high school students in Indonesia. Spatial thinking instruments consist of 26 questions containing indicators: analysis, comprehension, representation, application, scale, spatial interaction. The questions were in the form of multiple choices and each item is composed of four answer choices. Each question has one point for a correct answer and zero for an incorrect answer. The spatial thinking instrument was validated according to the learning evaluation expert. Expert validation was done to adjust the contents of the instrument with Indonesian students' thinking ability and adjust to the national curriculum. Instrument trials were conducted on 92 students at National Senior High School 3 in Malang. Based on Instrument test results analyzed empirically by reliability tests, it was obtained Cronbach Alpha value of (.729) which means that this instrument has a high consistency. Validity test showed r results greater than r table (.207) which means that 26 instrument questions are valid empirically and can be tested in the research class. The results of spatial thinking ability obtained by students were grouped into high spatial thinking and low spatial thinking. The group divided based on total number of correct answers in which 0-13 answers defined students has low spatial thinking and 14-26 answers defined has high spatial thinking. The data gained during classroom first meeting which requires 100 minutes to complete the test.

Based on the test of spatial thinking ability that was tested on students, it was obtained high level and low level spatial thinking abilities data. The details of the distribution of the research subject can be seen in table 3.

Table 3. Distribution of research subject.

	Type of Spatial Thinking	Learning Model		Total
		Earthcomm Learning	Conventional Learning	
Spatial Thinking Ability	High spatial	64	57	121
	Low spatial	19	27	46
	Total	83	84	167

Distribution of the research samples in table 3 shows that each data analysis unit column is filled. The number of research samples for high spatial thinking columns is more in number than low spatial thinking columns. However, analysis using Two Way Anova can still find out the differences that occur when there are differences in the number of research samples.

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Data Analysis

Quantitative data analysis used prerequisite and statistical tests using SPSS version 23 software for Windows. There were two types of prerequisite tests used, namely normality test and homogeneity test. The normality test used Kolmogorov-Smirnov with a significance value ($p > .05$) and homogeneity test used Leven's test with a significance value ($p > .05$). Meanwhile, the statistical test used Two Way ANOVA. The details can be seen in the following table.

Table 4. Normality tests.

	Kolmogorov-Smirnov[a]		
	Statistic	*df*	*p*
Standardized Residual for Post	.044	167	.200*

Based on the normality test in table 4, it was obtained a significance value ($p > .05$), this indicates that the spatial thinking ability data is classified as normal. Furthermore, the homogeneity value was tested with the Levene's test as in table 5.

Table 5. Homogeneity test.

F	*df1*	*df2*	*p*
.881	3	163	.452

Table 5 shows that the significance value obtained was .45 that means greater than the significant level of $p > .05$. It can be concluded that the spatial thinking ability data is classified as homogeneous.

Research Results

The first step in processing data was to find the average geography learning outcomes of students based on spatial thinking skills (high and low) in the experimental class and the control class. Furthermore, the average learning outcomes were distinguished statistically using the independent sample t test to see whether there were differences in the average geography learning outcomes between students who have high level spatial thinking skills in the experimental and the control class and low level spatial thinking skills in the experimental and control class. The next stage, data on geography learning outcomes and spatial thinking abilities of students were processed using parametric statistics using the two way ANOVA test to see whether there were any influences and interactions between the two research variables. The details can be seen in the table 6, table 7 and table 8.

Table 6. Descriptive statistics.

Class	Spatial	*M*	*SD*	*N*
Experimental	High	20.14	3.01	64
	Low	18.63	3.77	19
	Total	19.80	3.24	83
Control	High	15.68	3.48	57
	Low	14.81	3.74	27
	Total	15.40	3.57	84
Total	High	18.04	3.93	121
	Low	16.39	4.17	46
	Total	17.59	4.05	167

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The results in table 6 explain that there are differences in the *M* (Mean) total geography learning outcomes between the experimental class and the control class namely (*M* experimental = 19.80; *SD* = 3.241) and *M* control = 15.40; *SD* = 3.567) there is a range of *M* values = 4.40. From these results, the average experimental class geography learning outcomes were higher than the control class geography learning outcomes. The results of independent test sample t test table 7 below support statistical differences from the average value of spatial thinking ability.

Table 7. Comparison of Spatial Thinking Ability Using the Independent Sample t-test.

	Equal variances assumed	Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% CID	
		F	*p*	*t*	*df*	*p* (2-tailed)	*MD*	*SED*	Lower	Upper
Spatial Thinking Skills	High	13.123	.000	3.195	119	.002	1.228	.384	.467	1.989
	Low	1.056	.310	2.393	44	.021	2.096	.876	.331	3.861

Table 7 shows the significance value of high-level spatial thinking skills ($F = 13.12$, p (2-tailed) $< .05$). It means that there were significant differences between students who have high spatial thinking ability in the experimental class and students who have high spatial thinking ability in control class. Students who had low level spatial thinking ability in the experimental and control class have significant differences according to the values ($F = 1.05$, p (2-tailed) $< .05$) in table 7.

In addition, the geography learning outcomes of students who had high spatial thinking ability in the experimental class are greater than the geography learning outcomes of students who have low spatial ability. This is proven in table 5 which shows that the average geography learning outcomes of students who have high spatial thinking ability obtain scores ($M = 20.14$; $SD = 3.01$). Geography learning outcomes of students who had low spatial thinking ability obtain scores ($M = 18.63$; $SD = 3.77$). Of the two average learning outcomes, there was a difference $M = 1.51$. The details can be seen in Figure 1.

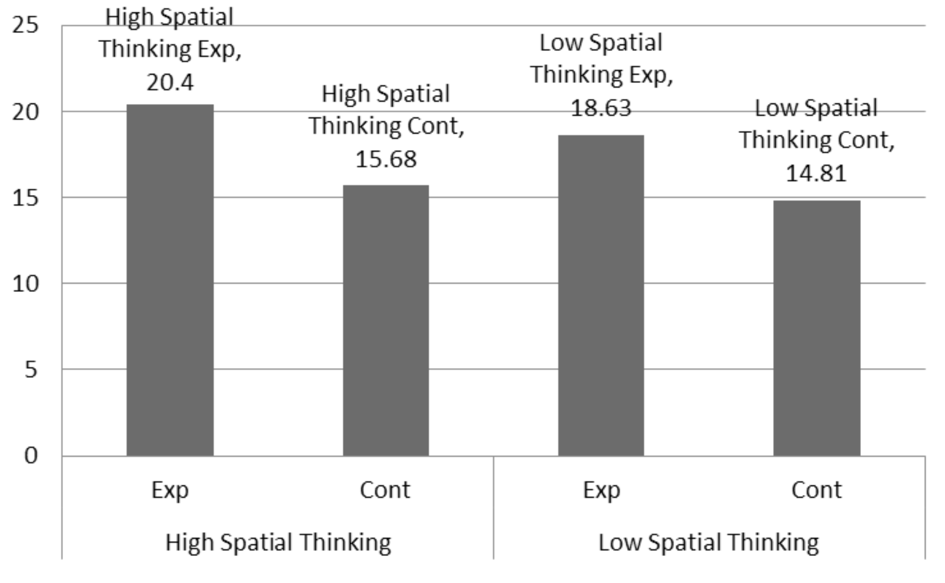

Figure 1. Geography learning outcomes based on spatial thinking ability.

In the control class, there were differences in geography learning outcomes between students who have high spatial ability and students who have low spatial ability. It is proven that the geography learning outcomes

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of students with high spatial thinking ability were greater in value (M = 15.68; SD = 3.48) than geography learning outcomes of students with low spatial ability (M = 14.81; SD = 3.74), there is a range of M values = .87. If we consider the difference in the average range of each experimental class and the control class between the geography learning outcomes of students who have high and low spatial ability, it is not too much difference. However, when it is compared to the differences in the average total geography learning outcomes of the experimental class and control class, there were quite large differences. The table 6 below shows how much influence of learning and spatial thinking ability on geography learning outcomes.

Table 8. Results of Two Way ANOVA of Earthcomm learning and spatial thinking ability.

Source	Type III SS	*df*	*MS*	*F*	*p*
Corrected Model	851.946a	3	283.982	24.746	.0001
Intercept	39063.838	1	39063.838	3404.037	.0001
Class	557.204	1	557.204	48.555	.0001
Spatial	46.053	1	46.053	4.013	.047
Class * Spatial	3.331	1	3.331	.290	.591
Error	1870.545	163	11.476		
Total	54375.000	167			
Corrected Total	2722.491	166			

a. R Squared = .313 (Adjusted R Squared = .300)

Based on table 6, it shows that there are differences in geography learning outcomes between the two research classes, as evidenced by the significance value (F = 48.55; p < .05). In spatial thinking ability data, there were significant differences between students who have high and low spatial ability in influencing their geography learning outcomes, as evidenced by the significance value (F = 4.01; p < .05). Moreover, there was no interaction between earthcomm learning and spatial thinking ability in influencing geography learning outcomes, as evidenced by the value (F = .29; p > .05).

Discussion

Effects of Earthcomm Learning on Geography Learning Outcomes

Earthcomm learning emphasizes that students directly experienced the process of learning, especially experience in conducting scientific investigations. Earthcomm learning was not only done in the classroom but also done outside the classroom by inviting students to investigate river water quality and the social conditions of the people that affect river water quality. Investigations were carried out in groups at three locations in the upper Brantas watershed area. In-depth investigations conducted by students are able to stimulate students' awareness to find out the basic problems about the river. This learning not only emphasizes the students' memory to understand the subject matter, but also teaches students to be able to provide ideas and concepts in dealing with problems in their environment (Carpenter & Hoover, 2018; Park et al., 2005). In accordance with the investigation phase, students are directly involved in investigating the causes of flooding in the Brantas river basin, Malang City. Furthermore, at the *digging deeper* stage, students conduct in-depth discussions to strengthen the results of investigations from other supporting sources such as reference books and the internet. Both of these stages function to improve students' cognitive abilities in geography learning (Park & Park, 2013). This is evidenced by data analysis which shows that earthcomm learning is also able to improve geography learning outcomes and provide students direct experience when conducting investigations in the field.

The results of this research are supported by several previous studies, among others (Dewi, 2014; Hidayat et al., 2017; Mari et al., 2017; Mauliddia et al., 2018; Park et al., 2005; Suharto, 2016). The study also proved that learning involving students in investigations in the field is also able to improve students' ability cognitively (Eysenck, 2018; Fatchan, Soekamto, Sumarmi, & Utaya, 2016; Mayer & Alexander, 2011). Even field studies involving students in certain areas and trips can sustain learning outcomes consistently (Jolley et al., 2018). Besides

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being able to improve geography learning outcomes, learning directly in the field can also improve knowledge memory, quality of knowledge and interest in knowledge (Korže, 2005). It is the same as earthcomm learning which requires students to conduct a direct investigation into the problem discussed previously. In the thought process, students' brains are able to connect spatial reasoning functions because there are various spatial basic structures which are then compiled and stimulated by learning (Anthamatten, 2010).

The application of earthcomm learning can answer the challenges of low geography literacy and geography skills. This is evidenced by the average geography literacy value of high school students in Surabaya at 64.11 and map literacy at 36.35 (Utami et al., 2018). Therefore, the application of earthcomm learning is expected to be able to improve geography literacy, as well as the application of REACT strategies that are able to develop geography skills especially in the knowledge component of geography (Wiwik Sri Utami et al., 2016a). In addition, the reality in the field found that only 8% of social studies teachers in Surakarta City understood geography literacy (Sugiyanto et al., 2018). It can be interpreted that through the application of earthcomm learning it is alleged that it can develop the geography literacy skills of social studies teachers.

The implementation of earthcomm learning involves all students' ability cognitive and affective. In earthcomm learning, there is a stage of investigation, which involves students that can stimulate their cognitive and affective responses. The response raised by students is then represented in the form of geography knowledge and attitudes in dealing with environmental problems. In addition to the investigation phase, the in-depth study phase and the understanding stage of the application play a role in training students to think critically as outlined in the form of portfolios so their knowledge can be assessed and evaluated (Chetcuti & Pace, 2012). This stage trains students to study the earth system and problems that occur from various other secondary sources. The process experienced by students can directly construct their own knowledge, this is in accordance with the concept of constructivism in education (Atkin, 2018; Park et al., 2005).

The concept of educational constructivism is very much in line with the needs of students in facing the challenges of global competition. This concept provides space for active students to be able to compile their own knowledge directly from the experience that it passes (Jančič & Hus, 2019). In earthcomm learning, investigations in the field by students are conducted in groups. In this group, students are able to train their ability to communicate with friends in getting answers of the problems found. This stage fosters the habits of students to communicate well with their peers and train students to always find the right information in accordance with the references they are looking for. The communication system between students is also useful in shaping new knowledge and enhance their knowledge memory. The process of investigation in the field by students is guided by earthcomm learning field worksheets so that it is very helpful for students in improving the learning outcomes of geography (Wiwik Sri Utami, Sumarmi, Ruja, & Utaya, 2016b). This is in accordance with social constructivism theory which states that knowledge can be built from the relationship and closeness among students (Nassaji & Tian, 2018).

Effect of Spatial Thinking Ability on Geography Learning Outcomes

Based on the results of the research in tables 6 and 8, it has been proven that there is a significant influence between students' spatial thinking ability (high and low) on geography learning outcomes. The results of this study reinforce research that states that some students in Athens have good geography learning outcomes because they are influenced by high spatial thinking ability (Klonari & Likouri, 2015). In Japan, learning outcomes related to topographic maps are influenced by spatial thinking ability (Wakabayashi, 2013). The use of giant travel map media can improve geography learning outcomes in South California (Fleming & Mitchell, 2017). A similar study states that the use of geospatial technology can improve students' geography thinking (Metoyer & Bednarz, 2017), PBL-GIS learning is also able to improve student learning outcomes in Singapore (Liu et al., 2010), this learning can improve learning outcomes because in GIS has integrated the component of spatial thinking. Some of these studies prove that the components of spatial thinking such as analysis, representation, scale, comprehensiveness and spatial interaction (Huynh & Sharpe, 2013) in geography learning have an influence to improve geography learning outcomes. Spatial thinking skills in practice can be realized in various forms such as: using colors on grammar tests that can improve test results in students who have visual-spatial learning styles in the UAE (Moradkhan, Karimi, & Aryan, 2014), the use of GIS-based learning (Kim & Bednarz, 2013) and PBL-GIS-based e-books (Yusup et al., 2018).

The ability of spatial thinking as a whole has been in the students. The students' knowledge and skills related

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to spatial thinking skills that were not trained caused the difference of ability level among them. The high or low level of spatial thinking skills of students can be functioned optimally through geography learning (Yani et al., 2018). Good geography learning is learning that brings basic concepts of geography and geographic approaches such as spatial, environmental and regional. The concept and approach of geography that has been integrated in each learning material can train students' spatial thinking skills indirectly. Moreover, good geography learning is learning that involves students contextually in their closest lives so that students recognize and understand the geographical environment including the spatial conditions of the region (Aliman et al., 2018).

This research is different from previous studies which examined the relationship between spatial ability and geography skills (learning outcomes). The study stated that there was a decline in geography skills (geography learning outcomes) in high school students due to differences in the question of spatial ability with the material being studied (Yani et al., 2018). This research also continues the research on the development of spatial intelligence instruments that are integrated with geography material (Mulyadi et al., 2018). Measurement of intelligence and spatial thinking of students can be integrated with geography material so that this instrument can also measure students' geography learning outcomes. Other studies in Vietnam state that questions and spatial concepts in geography textbooks contain little spatial components compared to non-spatial components (Nguyen, Muniz-Solari, Tien Dang, & Nguyen, 2018).

Earthcomm Learning Interaction and Spatial Thinking Ability to Geography Learning Outcomes

This research proves that there is no interaction between earthcomm learning and students' spatial thinking ability in influencing geography learning outcomes. The results of research are assumed to have no interaction because the instrument of spatial thinking ability does not integrate the material being studied by students when the tests are conducted. This is understandable because lessons at the high school level are specific and not integrated with other lessons like in elementary and junior high school lessons that apply integrated lessons such as social studies and natural sciences. Meanwhile, the spatial thinking ability test developed is a test that can be used to measure spatial thinking ability of all high school levels. The questions contained in the instrument are detailed components such as answering questions on topographic maps that have a large scale that requires spatial thinking ability. Therefore, the spatial ability of students to answer questions on a small scale matters such as answering questions about thematic maps on a small scale depends only on general knowledge and geographical knowledge, not on spatial thinking (Wakabayashi, 2013).

Although there is no interaction between the application of earthcomm learning and spatial thinking on the results of geography learning, each of the independent variables has a significant influence on the increase in geography learning outcomes. The absence of interaction between the two variables is assumed as the effect of the stages in earthcomm learning that were oriented towards engaging students directly in investigating environmental problems while students did not see the problem from a spatial perspective. In fact, one of the fundamental philosophies of earthcomm learning is community (Park et al., 2005). The existence of the community must not be involved in investigations, but students must examine that there is community involvement in these environmental problems. This viewpoint is a larger viewpoint of thinking and is a spatial thinking pattern. Not all students are able to have a mindset on a larger scope of space, but this spatial mindset must still be trained in every geography learning.

This is different from the results of research on elementary school students in Mexico. The results of research explain that there are differences in spatial ability based on the spatial scale between search tasks in the field with search tasks on the computer (Rosetti, Valdez, & Hudson, 2017). The results of this study are suspected because students are involved in the real process in the field so that students use all their motor sensors (Downs & Stea, 2011), in contrast to students who use computers because they only use smaller real spaces. It can be interpreted that learning involving students (especially elementary and junior high school students) directly in the field can make it easier for students to understand spatial conditions compared to learning done in class or through a computer.

Conclusions

Based on the discussion of research results, it can be concluded that 1) the results of student geography

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learning taught earthcomm learning and students taught conventional learning differ significantly. This shows that earthcomm learning has a significant effect on improving geography learning outcomes compared to conventional learning; 2) geography learning outcomes for students who have low spatial thinking ability and students who have high spatial thinking ability differ significantly. This proves that the high spatial ability of students is better at learning the results of their geography compared to students' low spatial ability; 3) the application of earthcomm learning and conventional with spatial thinking ability students have no interaction with the learning outcomes of geography.

Based on the conclusions, there are a number of suggestions relating to future research, among others 1) For researchers, especially teachers in schools, they can map students 'spatial thinking ability at the beginning of learning so that they can plan appropriate learning to improve geography learning outcomes, 2) researchers and teachers can modify earthcomm learning that can improve students' low spatial thinking ability, 3)Teachers need to create a meaningful lesson about spatial thinking ability through either digital application (google map, google earth, GIS) or apply manually using analog map, 4) the further research is needed to develop test instruments in measuring integrated spatial thinking ability to learning materials that can be analyzed based on gender, learning style, learning motivation and other variables.

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