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CONTEXTUALIZATION OF SPATIAL INTELLIGENCE: CORRELATION BETWEEN SPATIAL INTELLIGENCE, SPATIAL ABILITY, AND GEOGRAPHY SKILLS

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Abstract. *This research attempted to find whether spatial intelligence (without context) has a correlation to (contextual) spatial ability and affects geographic skills as crystallized ability (Gc). It employed the descriptive method with subjects including students at the primary, junior high, and senior high schools. The data were collected through two instruments, namely test and questionnaire. Data of test results were processed by tabulation technique and correlated for the scores of spatial intelligence, spatial ability, and geographic skills. The results show that spatial intelligence (Gf) tended to increase from the level of primary to junior high and to senior high school level, whereas spatial ability (Gc) and geographic skills (Geo-s) tended to decrease. Despite the decline, all three (Gf, Gc, and Geo-s) had the potentials for improvement. Thus, geography teachers are encouraged to participate in improving students' spatial and geographic skills, so students can develop their potentials optimally for geographic skills and future career development.*

Keywords: *contextualization, crystallized intelligence, geographic skills, spatial intelligence, intelligence and skill correlation.*

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Introduction

As written on the title of the article, contextual means putting things in context. Literally, the word "context" means circumstances in which an event occurs, while contextual is defined as according to the context (Hornby, 1979, p. 130). Rachman analogized the contextual meaning of a yarn in a piece of cloth (Rachman, 1999, p. 122). Meanwhile, the researchers argue that the analogy of contextual meanings such as a slice of beef that will change the name according to how processed cuisine that can be a steak, beef lasagna, smoke beef, and others. Thus, contextualization of spatial intelligence is an effort to implement the real form of spatial intelligence in the spatial capabilities form and geography skills in the real life every day. Although many people assume that spatial intelligence can also be manifested in the form of geometry and engineering drawings.

To understand the meaning of spatial intelligence contextualization, below is shown an example, there is a picture of a child tying his shoelaces. If you have contextual spatial intelligence, then you can surely estimate that the child cannot run while tying his shoelaces. Another example, it was reported that there had been a landslide on a flat land. Surely, the news is confusing and illogical because landslides will not occur in flat areas but will only occur in mountainous areas and hills.

Contextualization of spatial intelligence can be used to improve geography skills. The National Geographic Society defines geography skills as the tools and techniques necessary to think geographically. Geography skills make it easy to understand physical patterns and processes, social life, and be useful in making decisions such as to buy or rent a home, find a job, determine the fastest route of travel, find a place to shop, vacation, and or go to school. All of these decisions involve the ability to acquire, organize, and use geographic information from data and facts in the form of drawing of symbols, charts, diagrams, and maps (http://www.nationalgeographic.org/geographic-skills/).

Previous research on spatial intelligence has been extensively studied, particularly in relation to spatial intelligence with geometric ability, ability to read engineering drawings, and logical abilities. Research conducted by Yenilmez, K. (2015, p.199) says that students who have visualization skills are more successful in the field of mathematics. Yenilmez also cites the results of research from Seng & Chan (2000) which mentions that mathematical achievement correlates with spatial skill and has a positive significance. In addition, research conducted by Kayhan (2005) also shows that spatial skills have a correlation to improving mathematical achievement and logical thinking ability. A recent research conducted by Rochmadi, H. (2015, p.8) showed that there was a positive and significant correlation between spatial intelligence and the ability to read technical drawings with a correlation coefficient of 0.371. Then, he also showed the correlation coefficient positive correlation between spatial intelligence and logical-mathematical intelligence together with the ability to read engineering drawing of .440 at significance level $\alpha = .05$.

Research that has not been done is about the correlation of spatial intelligence with the ability of spatial and geographical intelligence. This research wanted to know the correlation coefficient between spatial intelligence, spatial ability, and geography skills based on education level of primary school, junior high school and senior high school students. This research is useful to strengthen the role of geography learning so it will be more directed to develop spatial intelligence, spatial ability, and geography skills. In addition, spatial skills are expected to equip students who will develop careers in the field of geography, geology, astronomy, pilot, and naturalist art (especially natural landscapes).

Research Focus

The focus of this research is to know the correlation between spatial intelligence, spatial capability, and geography skills. The assumption is that children with spatial intelligence (in the form of geometry and engineering drawings) are supposed to have geographical skills and spatial skills. The second assumption, children who have the spatial ability will have good geography skills as well.

Spatial Intelligence in this research is defined as an innate potential that is measured through the Aptitude Test. To deal with spatial intelligence test, students do not need to memorize and or practice test questions because the instrument has been designed not to "relate" to the learning materials. Spatial Ability is defined as the metacognitive knowledge of students in estimating the condition of a place, space, and time according to the context of the problem he faced. In other words, the spatial ability is the spatial intelligence that is contextual, real, and occurs in everyday life. A person who has the spatial ability will be able to predict, associate, analyze, and draw conclusions from a spatial condition on the earth surface. Spatial ability is the result of learning from a number of subjects, such as geography, physics, biology, chemistry, sociology, economics, history, social studies, and others. The geography skills are defined as the ability of students to interpret geographical data in the form of narration, tables, diagrams, and maps. Geography skills are the result of learning from geography and social studies subjects.

The Development of Spatial Intelligence

In Indonesia, one of the tests used for the selection of prospective civil servants is the Academic Aptitude Test. The test is divided into four sections: verbal, quantitative, logic, and visual (spatial) tests. Verbal test serves to measure a person's ability in words and language, quantitative test to measure a person's ability in numbers and mathematics, logic test to measure the ability in reasoning and problem solving logically and reasonably, and visual (spatial) test to measure a person's spatial logic. The visual test includes questions on image matching, image series, image grouping, image shadow matching, and image identification. The visual (spatial) test is identical to the spatial intelligence test (without context). The Academic Aptitude Test was developed based on a belief that one's intelligence is not only influenced by general or "g" intelligence but also by other types of intelligence known as multiple-intelligences. Psychologists who developed multiple-intelligences were Gardner, Stenberg and Thurstone (Mandar, 2011, p 57). Thurstone (1887-1955) listed seven mental abilities: verbal comprehension, logical thinking, numerical, word fluency, associative, perceptual speed, and spatial visualization.

There is a great literature concerning the measurement of spatial intelligence, such as Miller & Bertoline (1991, p. 9) who argued that visual intelligence is "to visualize the rotation of an illustrated object, the folding and unfolding of the flat patterns, and the relative positions changes of objects in space". Thurstone (1950, pp. 518 -519) also identified several definitions of visual intelligence, namely "to recognize the identity of an object when it is seen from different angles"; "to imagine the movement or internal displacement among the parts of a

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configuration"; and "to think about those spatial correlations in which the body orientation of the observer is an essential part of the problem". There are also various ways in developing questions for visual intelligence tests; for instance, Katsioloudis, Jovanovic, and Jones (2014, pp. 88-199) developed a visual intelligence test through 2D and 3D technical drawings that were cut through computer engineering. They also developed tests called Mental Cutting Test, Differential Aptitude Test, Mental Rotation Test, and Purdue Spatial Visualization Test (Visualization of Rotations). These tests were developed on the basis of a similar assumption that spatial ability is a part of intelligence and useful for solving measurement problems (Battista, 2003), and spatial intelligence has a correlation in terms of performance with mathematical skills (Casey, Nuttall, Pezaris, & Benbow, 1995).

In the subsequent developments, spatial intelligence is not limited to the ability to imagine the changes in the rotated and cut 2D and 3D forms, but it has been recognized that visual-spatial intelligence is also related to one's ability in using charts, maps, tables, or other illustrations in solving problems. Mc. Kenzie (2005: p. 12) defined spatial intelligence as "the intelligence of spatial reasoning that can be enhanced through the use of maps, charts, illustrations, graphics, tables, artwork, crossword puzzles, and other media. Visual intelligence allows students to simulate ideas or solutions to a problem before attempting to apply." In the context of geography, spatial intelligence has a different meaning. The objective of spatial thinking in geography is to memorize and analyze the landscape on the Earth's surface and to interpret a phenomenon and symptom of the Earth's surface as a series of connected events that are also inseparable from the influence of the surrounding environment. The media generally used to measure spatial intelligence are aerial photography, satellite imagery, maps, and data in the forms of graphs and tables.

There is a different assumption underlying the tests of spatial intelligence based on absurd 2D and 3D objects and those of contextual spatial intelligence (such as one that is geographically based). In the theory of fluid ability and crystallized ability (Horn, J.L. and Cattell, R.B., 1967, pp. 107-138), the "absurd" spatial intelligence test (without context) references the theory of fluid ability, that is the ability to solve new and abstract problems through the potential, innate, genetic intelligence based on an individual's neurological development and is relatively free from the influence of education and culture. Henceforward, spatial intelligence (without context) in this paper is simply called "spatial intelligence". On the other hand, the test of contextual spatial intelligence is based on the assumption of crystallized ability theory, which is the ability to solve problems affected by previously learned experiences. Crystallized ability is influenced by learning outcomes and culture. Therefore, in this paper crystallized ability is called (contextual) spatial intelligence which is then called spatial ability.

Then, a question that arises is which one is the most reliable way to predict a person's ability to learn and work. Postlethwaite (2011, p.1) stated that "based on research that has been done about neuroscience, crystallized ability has a greater impact than fluid ability on individual success in solving life problems". On the basis of this belief, the researchers are motivated to develop instruments of (contextual) spatial intelligence or spatial ability measurement in geographical context as an attempt to predict the levels of students' geographic skills.

What are geographic skills? In the preceding section, it is described that geographic skills are the ability of a person to make decisions in everyday life that are related to spatial processes such as to buy or rent a safe and comfortable home, get a job, devise strategies to avoid traffic jams and floods, vacation, or go to school. All of these decisions involve the ability to acquire, organize, and use geographic information. One's decision in everyday life involves systematic thinking in the spatial and environmental contexts. As a process of thinking and processing information, the work process of geographic skills has been described by the National Geographic Society to consist of five steps (http://www.nationalgeographic.org/geographic-skills/) : (1) asking geographic questions, (2) acquiring geographic information, (3) organizing geographic information, (4) analyzing geographic information, and (5) answering geographic questions. These five steps do not take place formally and rigidly, but flow in everyone's thinking process.

In many cases, processing geographic information does not require one to collect data and information completely, because sometimes one piece of information is already enough to be used as a guide to make association in further thinking. For example, to detect flood hazards in the City of Jakarta (the capital city of Indonesia), Ciliwung-Cisadane River Basin Development Agency (Indonesian, BBWS) under the Ministry of Public Works and Public Housing only needs to monitor the river levels at Katulampa checkpoint, Bogor City. Katulampa Dam is located in the upper stream of Ciliwung River that empties into the Bay of Jakarta. Time of Concentration of Ciliwung is about 8 hours, so there is sufficient time to notify the citizens of Jakarta when the water level of the river reaches 150-200 cm from the bottom of the dam. This illustration gives an example that one piece of information is enough to make a decision.

As a "learned" intelligence, crystallized ability or spatial ability is inherent in every individual. Children will learn to be careful to walk on slippery floors. Spatial intelligence allows the child to understand the slippery floor warnings, so they can tread carefully. Then, teenagers can count the number of bus fares based on their distance. Similarly, newly married couples can choose ideal home locations based on distance to the workplace, potential natural disasters, good community conditions, and other geographic considerations. Such spatial abilities will continue to increase with age; on the contrary, fluid intelligence (spatial intelligence without context) will decrease with age, especially from 40 years and above.

The above explanation is based on research by Bugg's et al. (2006, p. 15). The research shows that fluid intelligence is affected by age. If the age increase is higher, then the decrease in fluid intelligence is also higher. This is indicated by the decrease in individual working memory. To better understand this explanation, see figure 1.

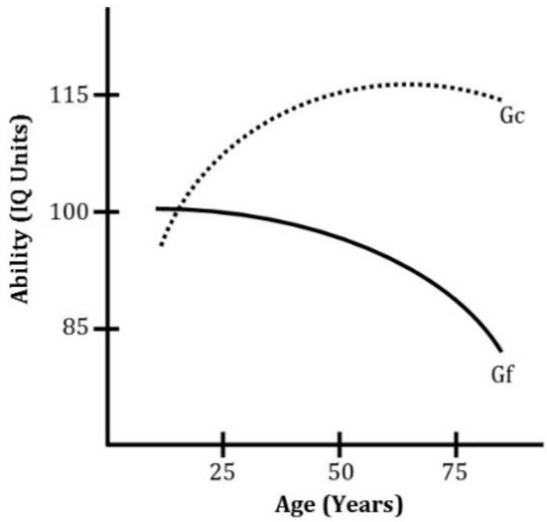

Figure 1. Fluid intelligence (Gf) will decrease with age, while crystallized intelligence (Gc) will continue to increase with age (Postlethwaite, 2011, p. 50).

In the context of education, crystallized intelligence is the concern of teachers because it has the potentials to be developed through learning processes. The crystallized intelligence can be developed through teacher involvement in the learning process (I Putu, et al 2017). Teachers are partners with students in activities characterized by exploration, connectedness and broader, real-world purposes (Whiley, et al, 2017). However, teachers need to use their time, energy and thought to create effective and student-centered learning, but keep in mind that teachers will not be paid for doing so (Wilson, Leydon, & Winncetak, 2016). If (contextual) spatial intelligence based on crystallized intelligence can be improved, geographic (thinking) skills will also be easily improved.

In describing spatial intelligence, the learned one or Gc, van Schaik (2008) reinforces that learning can improve spatial ability, because spatial ability or intelligence is closely related to the way individuals perceive their environment. It is like a person's ability to play football, namely to calculate and determine the right angle in kicking the ball, as well as the amount of force required to score goals. Kicking the ball engages the intelligence of thinking about space. Another example is from the Aborigines in Australia; this tribe has a painting that represents landscapes of their environment and bears a resemblance to the real world. In the picture, one can see streams of water, animals grazing, edible plants, hunting activities, and even hunters spearing their preys. All of these are considered spatial intelligence and geographic skills.

In another research, Newcombe and Frick (2010) viewed that spatial ability (Gc) undergoes an evolutionary and adaptive process. Every organism will be able to recognize its environment for survival. According to them, spatial intelligence (in which the thinking process takes place) is a complement of verbal intelligence. Spatial thinking helps reasoning in domains related to the environment. In real life, a geoscientist demonstrates his/her ability to explain the visualization of the formation of the earth's surface that is affected by various processes, an

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architecture can estimate the design of a building structure based on earthquake potential, and a neurosurgeon can explain the visualization of the brain's nerves from the magnetic resonance graph to determine the surgical procedure to be performed. Therefore, spatial intelligence is the ability to visualize changes in shape and position of objects in the mind.

Another relatively relevant research mentions that spatial intelligence is intelligence that is closely related to the space around people. This intelligence can analyze the condition of the surrounding environment even in a wide range. Maps, satellite imagery and aerial photographs are an effective tool to aid in spatial analysis (Diezmann & Watters, 2000, p.206). This explanation shows that spatial intelligence cannot be separated from the context of everyday life and human life. Students are certainly always aware of the existence of objects in a space of life. Bednarz et al. (2005, pp. 101-112) even argued that spatial (geographical) intelligence and spatial thinking are important points in the process of geographic skills, especially at the stage of asking geographic questions.

Spatial intelligence is similar to mental map-based thinking (Killworth and Bernard 1982, pp. 307-312), that is a person's perception or point of view of a particular area he or she is thinking about. In the process, mental maps can be built due to spatial data input and spatial data processing which include the process of organizing, sorting, memorizing, and manipulating data that can eventually be used to make decisions. The function of spatial intelligence as a "mental map" can certainly help students to understand their position in space and to engineer the space for their own needs. With this ability, humans can create space merely from the ideas that are still stored in the memory of their brain, expressed in the form of model drawings (such as maps, models, sketches, and floor plans), and to be realized in real life, such as making a model of buildings, artificial gardens, and the like.

Methodology of Research

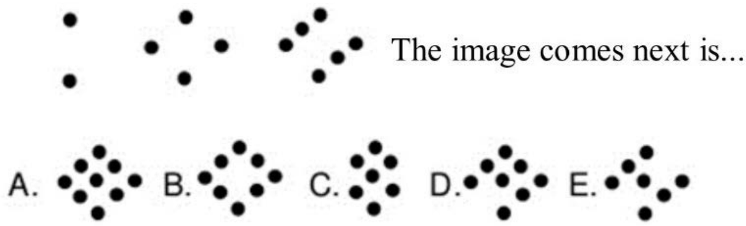
Research Context

The research aims to determine the correlation of the performance of spatial intelligence (spatial ability based on crystallized intelligence) and geographic skills. To achieve this aim, a model of test instrument of "contextualization" of spatial intelligence relevant to the education level of students was created. After knowing the test results of the developed instruments, the researchers sought to find the correlation between spatial ability and geographic skills. Learning strategies developed should attempt to lessen feelings of isolation by handing power back to the learner, reduce barriers (between teacher and student) and dissonance, and encourage creativity and the exploration of ideas through engagement with the learning process (Whiley, et al, 2017). People with high creativity will be challenged to explore problems, explore new ideas, take risks and not being satisfied quickly (Suyidno, et al, 2018). Multiple intelligence-based learning model has a significant role compared with conventional learning model. This is marked by an increase in student achievement. But this model has no significant impact on their attitudes (Gurcay & Ferah, 2017). If the results of this research are reliable, the next step would be to develop learning strategies to improve spatial intelligence and geographic skills in students of primary school, junior high school, and senior high school in accordance with the prevailing curriculum in Indonesia.

The instrument model developed as a measuring instrument in this research is divided into three tests, namely the test to measure spatial intelligence (as Fluid intelligence - Gf), spatial ability (as Crystallized intelligence-Gc), and Geographic Skills (Geo-s). The form of spatial intelligence (Gf) test is similar to the test commonly used in measuring visual ability in the Academic Aptitude Test, namely image matching, image series, image grouping, image shadow matching, and image identification. The form of questions in the spatial ability (Gc) test was drawn from May and Smith's (1998) in their book *Spatial Ability: A Handbook for Teachers*. One of the forms of spatial ability problems discussed in the book is the exploitation of the urban environment (including the ability to read and use the map). Teachers can organize learning by using augmented reality to improve spatial intelligence (Carrera & Asensio, 2016). But maybe it will do highly cost a lot. Hence, spatial ability can be measured through a mental map test, that is the ability to understand the real environment through maps, atlas, globes, and aerial photographs, including understanding direction, distance, relief, and others. The questions in the test of geographic skills are directed to measure the ability to acquire, organize, and use geographic information. The abilities measured include those of reading tables and graphics and interpreting maps.

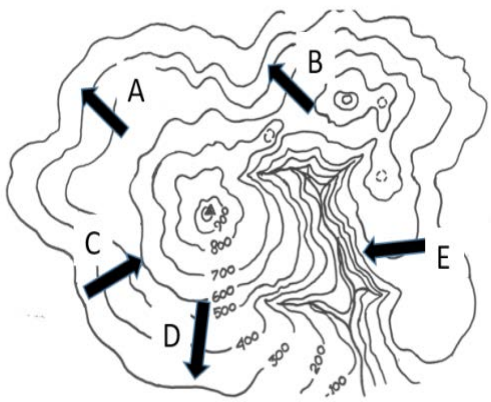
In addition to paying attention to the specification of the form, the contents of the items also take into account the subject content students have learned. The theme of the questions is closely related to the subjects of geography, namely: (1) the maps reading skill; (2) the location and distance awareness, the knowledge of density, distribution, and quality of an object on the of the Earth surface; (3) natural features, phenomena, and physical processes on the Earth's surface, such as mountains, rivers, lakes, forests, etc.; (4) natural phenomena and social processes on the Earth's surface that can be proven by their traces and impacts, and (5) interaction between natural, physical, and social aspects that can be recorded through visual images such as agricultural, mining, or trading activities. The questions are in the form of multiple choices. Here are examples of the problems:

1. An example of spatial intelligence (Gf) question:



(Image source: https://www.slideshare.net/frilisa/soal-tpa*).*

2. An example of spatial ability (Gc) question:
   Look at the contour map below!



(Image source: Sambodo, 2013).

   Judging from the contour, which arrow direction is not possible for the development of a settlement?
   (a) A
   (b) B
   (c) C
   (d) D
   (e) E

3. An example of Geographic Skills question:
   David is an American. He would strongly prefer to be contacted by phone from 07.00 – 09.00 a.m. local time. Therefore, it would be appropriate to call David from Indonesia at. . .
   (A) 08.00 Western Indonesian Time
   (B) 11.00 Western Indonesian Time
   (C) 19.00 Western Indonesian Time
   (D) 23.00 Western Indonesian Time
   (E) 24.00 Western Indonesian Time

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Population and Sample

The research population of this research were primary, junior, and senior high school students in Bandung, West Java, Indonesia. The population number is about 2500 students (http://data.bandung.go.id) which is spread across six schools. The sample was selected purposively based on the title of the best schools in Bandung. Hence, 62 participants were taken from two primary schools (State Primary Schools of Patrakomala and Banjarsari), 68 participants from two junior high schools (State Junior High School of 29 Bandung and 12 Bandung), and 64 participants from two senior high schools (State Senior High School 15 Bandung and 4 Bandung).

Table 1. Research sample.

No	Education Level	Age (years)	Male	Female	Total
1	Primary School	10 - 11	31	31	62
2	Junior High School	14 - 15	31	37	68
3	Senior High School	16 - 18	28	36	64

Research Instruments

The data were collected with two types of instruments, namely test and questionnaire. The test consists of three types of questions: spatial intelligence, spatial ability, and geography skill. The questionnaire questionnaires are used to analyze the learner's tendency toward professions that rely on spatial intelligence. The details about the research instruments are shown in the table 2.

Table 2. Research instruments.

No	Education Level of Respondents	Number of Questions for each Instrument (items)			
		Spatial Intelligence	Spatial Ability	Geography Skill	Questionnaire
1.	Primary School	5	10	10	10
2.	Junior High School	5	10	10	10
3.	Senior High School	5	10	10	10

The question test of spatial intelligence used is a well-tested question list developed by Taufiqurrohman downloaded from https://www.slideshare.net/frilisa/soal-tpa. Spatial ability test and geography skills for high school level were developed by the researchers themselves and have been tested by 40 people. The results of data processing using ANATES version 4.0.2 developed by Karno To and Yudi Wibisono. The ANATES is an open source application and can be downloaded for free. Based on the results of processing, obtained analysis of instrument test with correlation coefficient (x, y) = .58 and test reliability = .73. The test instrument for primary and junior high school is not directly tested but interpolated from high school level instrument. Interpolation process is done by lowering the level of difficulty.

Analysis

Data obtained in this research are in the form of test result score and questionnaire. Data analysis is done by five steps:

1. The test sheets for all levels of education (primary school, junior high school, and senior high school) are divided into three parts: spatial intelligence, spatial ability, and geography skills with the following proportions:

Table 3. The test results of respondents

No	Education Level	Number of Questions	Questions of spatial intelligence (Gf)	Questions of spatial ability (Gc)	Geographical Skill (Geo-s)
1	Primary School	15	5	5	5
2	Junior High School	30	10	10	10
3	Senior High School	39	10	10	10

2. Each section of the problem, given a separate score to obtain spatial intelligence score (Gf), spatial ability (Gc), and geography skills (Geo-s). Score data is tabulated and graphic is made so that the comparison between scores obtained by students of primary school, junior high school and senior high school.
3. Processed with frequency table and graphics techniques. A series of spatial intelligence, spatial abilities, and geographical skills scores are correlated with one another to obtain correlation coefficient data among each other.
4. The analysis of the test results is enriched with data obtained from questionnaires on respondents' trends in interest in learning and games, their likes for drawing, puzzle, painting, watching movies, drawing designs, painting, and the desire to become architects and pilots. Spatial intelligence data is correlated with potential development data obtained from the average score of attitude scales.

Results of Research

The first data processed were the average scores of Spatial Intelligence (Gf), Spatial Ability (Gc), and Geographic Skills (Geo-s). Table 1 displays a recapitulation of the scores obtained by research participants from primary, junior high, to senior high school levels. The column labelled "number of questions" and "mean score" (Gf, Gc, and Geo-s) contains the information about the maximum and average scores. The maximum score is the highest score that can be obtained by participants, while the mean score is the average score achieved by students at the time of the research. The "mastery level" column is the percentage of the mean score that is compared to the maximum score.

To see the tendency of the mastery level of Gf, Gc, and Geo-s, a graph of comparison between the scores achieved by the primary, junior, and senior high school students was made. At the level of primary school, Gf score tended to be low but progressed in the junior high and senior high school levels, whereas Gc score tended to be stable at an average of 45% - 55% of the maximum score that students could gain at the primary, junior, and senior high school levels. In contrast, the score for Geographic Skills (Geo-s) was good at the primary school level but declined at the junior and senior high school levels.

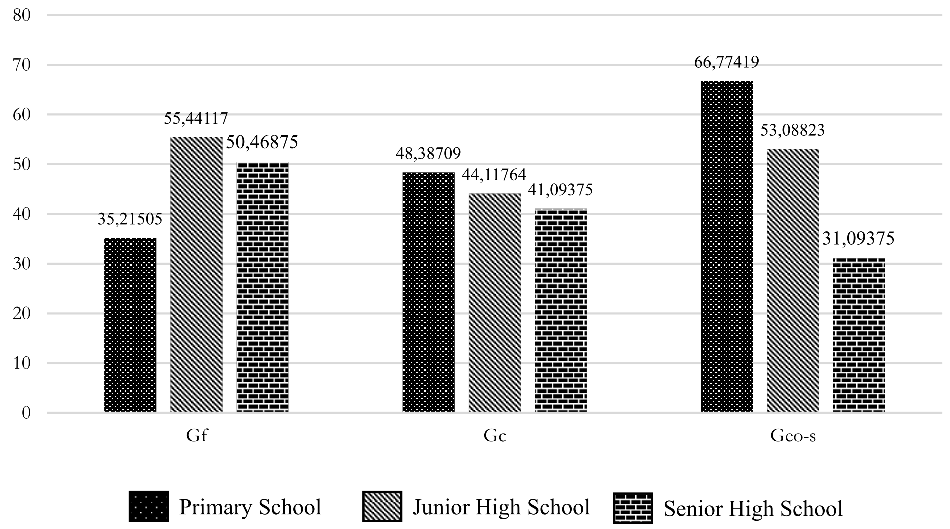

Figure 2. Graph of Mean Scores of Spatial Intelligence (Gf), Spatial Ability (Gc), and Geographic Skills (Geo-s).

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As shown in Figure 2, the researchers tested the correlation coefficients between Gf, Gc, Geo-s, and their development potentials. The potentials for spatial tendency development in this research were derived from the scale of attitudes filled by students consisting of common statements shown by children who have spatial intelligence characteristics, namely their hobbies of drawing, daydreaming, puzzle playing, arranging the space, understanding the map images, summarizing the subject matter by creating charts or concept maps, enjoying paintings or visual art, watching movies or videos, and doodling on textbooks; and the professions they would like to have in the future, such as a painter, architect, photographer, pilot, geographer, and machine engineer. The potentials for spatial intelligence development in this research are coded SID (Spatial Intelligence Development). Table 2 and Figure 3 display the correlation coefficients between spatial intelligence, spatial ability, and geographic skills and their development potentials. The correlation coefficient was obtained by using the Pearson equation.

Table 4. Pearson coefficients of spatial intelligence, spatial ability, geographic skills, and their development potentials.

	Pearson Coefficients					
	Gf - Geo-s	Gf - Gc	Gc – Geo-s	Gf – SID	Gc-SID	Geo-s-SID
Primary Level	0.217261	0.120098	0.359307	-0.02331	0.05644	0.08945
Junior High Level	0.326673	0.054253	0.096848	0.05309	-0.18839	-0.18204
Senior High Level	0.369781	0.445817	0.459315	0.10643	0.18889	0.03863

Notes: Gf = Spatial Intelligence; Gc = Spatial Ability; Geo-s = Geographic Skills
SID = Spatial Intelligence Development Potentials

Based on the data in Table 2 and Figure 3, there are two things to discuss, namely the correlation between spatial intelligence and geographic skills and the correlation between spatial intelligence and the potential for spatial intelligence development. Spatial intelligence (Gf) tended to increase from the level of primary, junior high, to senior high school level, while spatial ability (Gc) and geographic skills tended to decrease. The researchers argue that the increase in Gf at a young age (7 - 18 years) is something reasonable and corresponds to the theory stating that Gf will increase in line with the level of a child's neurological maturity. Gf intelligence will increase until the age of 40 years and tends to decrease afterwards.

Discussion

On a different note, spatial ability and geographic skills are outcomes of learning. In this research, the decrease in spatial ability and geographic skills is assumed to be influenced by two things, i.e. the questions posed were irrelevant to the subject matters (geography) which the students learned in the school, or the questions were too difficult. Thus, further investigation is necessary because there is a difference with the results of previous research. Spatial thinking has an important role in geography learning, as it underlies various skills such as the use of maps, graphs, images, and diagrams visualizations (Carrera & Asensio, 2016). Nevertheless, the researchers still believe that spatial ability and geographic skills can be enhanced through effective learning.

The next question to answer is that "Is there any correlation between Gf and Geo-s?" The answer is, as shown by Table 2, there was a positive and increasing correlation coefficient at the primary (0.217261), junior high school (0.326673), and senior high school levels (0.369781). This means that spatial intelligence in students has the potential to help with the improvement of geographic skills. The correlation between Gc and Geo-s fluctuated as shown by the following scores: primary school (0.359307), junior high school (0.096848), and senior high school (0.459315). With this data, the researchers are confident that Gf and Gc affect geographic skills (Geo-s).

It should be noted that there are important results, i.e. there is a correlation between spatial intelligence with geography skills. Initially researchers do not think that spatial intelligence has a correlation with geography skills. However, the results of the correlation analysis show that these two variables are related and have a significant positive correlation. The results of this research (at least until the current time this article published) reinforce Spearman's opinion. This opinion is in line with the review of Kaya, et al (2015, p.1061). According to Spearman (1904), the general intelligence factor or "G", if coupled with one or more other factors is sufficient to explain a person's performance on intelligence tests. People who have good cognitive aspects will tend to perform well on other field tests because of the dominant role of factor "G". Spearman's opinion was also confirmed by Jensen (1980) and notes the reinforcement that "G" correlates with some life outcomes including scholastic performance, reaction time, job performance, employment status, earned income, and creativity (Rich, et al, 2015, p 1061).

The next question is concerned with the correlation coefficient between spatial intelligence (Gf) and its spatial intelligence development (SID) potentials. Data on the potentials for spatial intelligence development were obtained from the results of attitude scale which show that the respondents had an interest or a "liking" in all the potential characteristics of spatial intelligence. The attitude scale is made in five columns as exemplified by the Likert Scale (Joshi et al., 2015) with selections ranging from "Strongly disagree, Disagree, Neither agree or disagree, Agree, and Strongly agree." The results show that: (a) Spatial intelligence (Gf) had a correlation to the potentials for spatial intelligence development (SID); a negative correlation in the primary school level and positive correlation in the junior and senior high school levels. The researchers are of the opinion that the awareness of the potentials for spatial intelligence started to grow by the time students reached the age of junior high and senior high school; alternatively, the education received during junior and senior high school has influenced the students' career decision and preferences, hence resulting in a positive correlation. This finding reinforces the argument that at school age, spatial intelligence can be enhanced through students' educational processes and experience; (b) The correlation between spatial ability (Gc) and the potential for spatial intelligence development (Geo-s) shows unique symptoms. There was a positive correlation in primary and senior high school levels, while in junior high school level the correlation was negative. This symptom is also found in the correlation between Geographic Skills (Geo-s) and SID, which was found to be negative in the junior high school level. The researchers suspect there was a gap between the learning experience of students (in the form of materials related to Gc and Geo-s) and their potentials or interests. The above data indicate that the students' awareness of their future career expectations (to be designers, artists, architects, and pilots) was strong enough, but there was still room for improvement for spatial ability and geographic skills.

To improve spatial ability and geography skills, researchers recommend following Gardner's (1993) opinion in Diezmann & Watters (2000, p.212) through four stages: stage 1 is to improve the ability to understand patterns related to spatial intelligence such as to appreciate the three-dimensional space. Stage 2 involves the use of a symbol system that provides an initial insight into space. Research on the system of art symbols has been done by Gardner (1993b), mathematics by Tufte (1983) and science by Baigrie (1996). Stage 3 is the use of a notation system that applies to certain domains, such as maps and landforms (geomorphology). Stage 4 is an expression of intelligence in adolescence and adulthood through specific work. For spatial ability and geography skills can be seen from its ability to read and make maps, determine the direction of the compass, determine the point coordinates, and others.

Conclusions

The results show that spatial intelligence (Gf), spatial ability (Gc), and geographic skills (Geo-s) have room for improvement. Spatial intelligence (Gf) can be increased through the fulfillment of food nutrients and other physical needs to support children's neurological growth, whereas spatial ability (Gc) and geographic skills (Geo-s) can be improved through an effective teaching process. The results also indicate that the potentials for spatial intelligence development (SID) as students' awareness of their future career expectations had a correlation to spatial ability (Gc) and geographic skills. Although in junior high school level, the correlation coefficients of Gc and Geo-s to SID were negative, at senior high level the correlations of both were positive. With the results of this research, the researchers conclude good career guidance (especially those directed to careers in the fields of designers, artists, architecture, pilots, geographers, and the like) can help improve students' spatial ability (Gc) and geographic skills. Likewise, if students gain spatial ability (Gc) and geographic skills (Geo-s), they will have a positive perception of and better confidence to choose a career in the future, such as being designers, artists, architects, pilots, geographers, etc. If this conclusion is accepted, geography teachers are expected to participate in improving the spatial ability and geographic intelligence of students and guide them if they have the potentials to pursue careers in the fields related to spatial intelligence.

This research provides guidance to teachers not to ignore the potential of students' spatial intelligence. For primary school teachers, the potential for spatial intelligence can be developed through the concrete things. For instance, teacher can use globes to show the day and night changes. For junior high school teachers, the potential

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of spatial intelligence needs to be developed through simple abstract things. For instance, teacher can use the mind map to explain the hydrological cycle. Then, for high school teachers, the potential of spatial intelligence needs to be developed through high-level order thinking skills in analyzing spatial information. For instance, teacher can assign to the students to analyze the relationship of international trading between countries and the implications for each country.

References

Battista, M. T. (2003). Understanding students' thinking about area and volume measurement. In D. H. Clements & G. Bright (Eds.), *Learning and teaching measurement: 2003 yearbook* (pp. 122–142). Reston, VA: National Council of Teachers of Mathematics.

Bednarz, S.W., Bockenhauer, M.H., & Walk, F.H. (2005). Mentoring: a new approach to geography teacher preparation. *Journal of Geography, 104* (3), 105-112.

Bugg et al. (2006). Age differences in fluid intelligence: contributions of general slowing and frontal decline. *Brain and Cognition, 62*, 9–16.

Carrera, C., & Asensio, L. (2016). Landscape interpretation with augmented reality and maps to improve spatial orientation skill. *Journal of Geography in Higher Education, 41* (1), 119-133. doi: 10.1080/03098265.2016.1260530.

Casey, M. B., Nuttall, R., Pezaris, E., & Benbow, C. P. (1995). The influence of spatial ability on gender differences in mathematics college entrance test scores across diverse samples. *Developmental Psychology, 31*, 697–705. doi: 10.1037/0012-1649.31.4.697.

Chooi, W.T. (2011). Improving intelligence by increasing working memory capacity. *Doctor of Philosophy Dissertation, Department of Psychological Sciences Case, Western Reserve University*. Retrieved from https://etd.ohiolink.edu/rws_etd/document/get/case1301710207/inline

Diezmann, C. M., & Watters, J. J. (2000). Identifying and supporting spatial intelligence in young children. *Contemporary Issues in Early Childhood, 1* (3), 200 – 219.

Gurcay, D., & Ferah, H. O. (2017). The effects of multiple intelligences-based instruction on students' physics achievement and attitudes. *Journal of Baltic Science Education*, *16* (5), 666-677.

Horn, J. L., & Cattell, R. B. (1967). Age differences in fluid and crystallized intelligence. *Acta Psychologia, 26*, 107-129.

Hornby, A. S. (2000). *Oxford advance learner's dictionary*. Oxford: Oxford University Press.

I Putu Artayasa, Susilo, H., Lestari, U., & Sri Endah Indriwati. (2017). The effectiveness of the three levels of inquiry in improving teacher training students' science process skills. *Journal of Baltic Science Education*, *16* (6), 908-918.

Jensen, A. R. (1980). *Bias in mental testing*. New York, NY: Free Press.

Joshi et al. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology, 7* (4), 396-403, doi: 10.9734/BJAST/2015/14975.

Katsioloudis, P., Jovanovic, V., & Jones, M. (2014). A comparative analysis of spatial visualization ability and drafting models for industrial and technology education students. *Journal of Technology Education, 26* (1), 88 – 101.

Kaya, F., Juntune, J., & Stough, L. (2015). Intelligence and its relationship to achievement. *Elementary Education Online, 14* (3), 1060-1078, doi:10.17051/io.2015.25436.

Kayhan, E. B. (2005). Lise öğrencilerinin uzaysal yeteneklerinin incelenmesi [Examination of spatial skills of high school students]. *Ortadoğu Teknik* Üniversitesi*, Orta* Öğretim *Fen ve Matematik Alanları Eğitimi.* Yayınlanmış Yüksek Lisans Tezi [Middle East Technical University, Secondary Education Science and Mathematics Education. Published Graduate Thesis].

Killworth, P. D., & Bernard, H. R. (1982). A technique for comparing mental map. *Social Networks*, *3*, 307 – 312. Lausanne – Netherlands. Elsevier Sequoia S.A.

Mandar, D. S. (2011). Implementing Thurstone method in measuring instrument quality and making instrument proposal for academic aptitude test. *JIEMS-Journal of Industrial Engineering & Management Systems*, *4* (2), 55 -67.

May, T. C., & Smith, P. (1998). Spatial ability: A handbook for teachers. *National Foundation for Educational Research*. The Mere, Upton Park, Slough, Berkshire SL1 2 DQ.

Mc. Kenzie, W. (2005). Multiple intelligences and instructional technology. Second Edition. Washington, DC. Office: 1710 Rhode Island Ave, NW. Suite 900. Washington, DC 20036-3132.

Miller, C. L., & Bertoline, G. R. (1991). Spatial visualization research and theories: Their importance in the development of an engineering and technical design graphics curriculum model. *Engineering Design Graphics Journal, 55* (3), 5–14.

Newcombe, N. S., & Frick, A. (2010). Early education for spatial intelligence: Why, what, and how. *Mind, Brain, and Education*, *4* (3), 102–111.

Postlethwaite, B. E. (2011). Fluid ability, crystallized ability, and performance across multiple domains: a meta-analysis. PhD (Doctor of Philosophy) Dissertation, University of Iowa. http://ir.uiowa.edu/etd/1255.

Rachman, R. (1999). *Introduction of liturgical history*. Tangerang: Bintang Fajar.

Rochmadi, H. (2015). The relationship of spatial and mathematical-logical intellegence with reading ability of engineering drawing of the 11th grade students of mechanical engineering program in 2nd Vocational School Depok. Thesis. Program of Machine Engineering Education, Engineering Faculty, Universitas Negeri Yogyakarta.

Sambodo, E. (2013). Knowledge about maps and compass. Retrieved from: http://gayonusantara.blogspot.co.id/2013/07/pengetahuan-peta-dan-kompas.html.

Seng, S., & Chan, B. (2000). Spatial ability and mathematical performance: gender differences in an elementary school. *National Institute of Education*, Nanyang Technological University, Singapore.

Spearman, C. (1904). General intelligence, objectively determined and measured. *American Journal of Psychology*, *15*, 201-293. doi:10.2307/1412107.

Susantini, E., Faizah, U., Prastiwi, M. S., & Suryanti. (2016). Developing educational video to improve the use of scientific approach in cooperative learning. *Journal of Baltic Science Education, 15* (6), 725-737.

Suyidno, Nur, M., Yuanita, L., Prahani, B. K., & Jatmiko, B. (2018). Effectiveness of Creative Responsibility Based Teaching (CRBT) model on basic physics learning to increase student's scientific creativity and responsibility. *Journal of Baltic Science Education*, *17* (1), 136-151.

Thurstone, L. L. (1950). Some primary abilities in visual thinking. *Proceedings of the American Philosophical Society, 94* (6), 517–521. Retrieved from http://www.jstor.org/stable/3143593.

Van Schaik, L. (2008). *Spatial Intelligence: New futures for architecture*. John Wiley & Son Inc Great Britain. pp 9, 24-26, 186, 142.

Whiley, D., Colvin, B., Arrue, R. A., & Kotir, J. (2017). Enhancing critical thinking skills in first year environmental management students: A tale of curriculum design, application and reflection. *Journal of Geography in Higher Education, 41* (2), doi:10.1080/03098265.2017.1290590.

Wilson, H., Leydon, J., & Wincentak, J. (2016). Fieldwork in geography education: Defining or declining? The state of fieldwork in Canadian undergraduate geography programs. *Journal of Geography in Higher Education, 41* (1), 94-105. doi:10.1080/03098265.2016.1260098.

Yenilmez, K., Kakmaci, O. (2015). Investigation of the relationship between the spatial visualization success and visual/spatial intelligence capabilities of sixth grade students. *International Journal of Instruction*, *8* (1), 189-204. Retrieved from http://e-iji.net/dosyalar/iji_2015_1_14.pdf.

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