The Effect of Google Earth-Assisted Remote Sensing Learning on Students 'Spatial Thinking Ability in Solving Disaster Mitigation Problems

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Abstract. Spatial thinking ability (STA) have an important role in the study of geography which is currently supported by many geospatial technologies. Remote sensing learning has a strategic position to support the formation of student STA. This study aims to (1) test the effectiveness of Google Earth-assisted remote sensing learning on students' spatial thinking skills to solve the disaster mitigation problems, and (2) examine the relationship between STA students and remote sensing learning achievements. This study uses a quasi-experimental design. The subjects in this study were students of the Department of Geography Education. Subjects were treated as remote sensing learning with the help of dynamic imagery in Google Earth. The experimental and control classes used are geography education students who are taking remote sensing courses. Data collection is done by the test method. The test instrument was in the form of multiple-choice questions developed based on the STA concept proposed by Gresmehl & Gresmehl. Data analysis techniques to test hypotheses are t-test and Pearson product-moment correlation. The expected results of the research are Google Earth-assisted remote sensing learning is effective for improving student STA in solving disaster mitigation problems. This can be seen from the test results that show the coefficient t = 30.187 with degrees sig = 0.000. There is a positive and significant relationship between STA students with remote sensing learning achievement. This can be seen from the high significance coefficient.

Keywords: spatial thinking ability, remote sensing, google earth

1. Introduction

Remote sensing is a strategic subject in the Department of Geography Education which is under the auspices of the Higher Education Institutions for Education Personnel or Lembaga Pendidikan Tenaga Kependidikan (LPTK). It is said to be strategic because this course is just no a science and a tool for data collection by almost all geographic branches and an analytical tool that can produce fast accurate multipurpose findings, it can also function as a learning media in schools that enable goals. Learning can be achieved optimally if it used learning media[1]. The media, in addition to explaining learning material, can also increase student motivation and achievement [2]. Remote sensing gives a very big role in the development of geography and various fields related to the spatial aspects of a particular phenomenon.

Remote sensing learning at the university level often experiences problems in terms of image availability and image processing applications. This learning requires a lot of images, both as lecture material and as a learning medium. For learning purposes, images of various spatial resolutions, temporal resolutions, spectral resolutions, multi-sensor, and multi-vehicle images should be available. The price of digital images, which is still expensive, is an obstacle to procurement, so the need for images for learning cannot be adequately fulfilled. There are currently only Landsat 8 and Sent Continental imagery available freely or unpaid, provided by NASA. Landsat 8 imagery is only one type of medium spatial resolution image, so learning that requires high and low spatial resolution images cannot be fulfilled. The powerful image processing application needed also has an expensive price, so learning only uses open-source, free applications, such as ILWIS and QGIS.

The implementation of remote sensing courses is not by the minimum requirements due to the lack of supporting facilities and infrastructure. Learning facilities in the form of images and software are not available adequately. The supporting infrastructure is in the form of a representative
laboratory, the lack of fulfillment of the number of computer units needed for training in digital image processing, the number is not proportional to the number of students, and the specifications of the computer units are not by the software currently available in remote sensing circles, which generally require high specifications.

A very important component of remote sensing learning is the image. Lack of image causes the implementation of learning not to be carried out optimally. In remote sensing learning, including practicum learning, the Geography Education Study Program requires aerial photographs of various scales, but these aerial photographs are not sufficiently available. Satellite images with various spatial resolutions and multiple channels required for learning are also not available adequately. The Geospatial Laboratory of this department does not have sufficient data to carry out adequate learning of geospatial technology. In general, in some LPTK colleges, there is no budget to purchase a new image with various resolutions, which of course costs tens or even hundreds of millions of rupiah. This constraint causes remote sensing learning to be unable to keep up with newness through technological developments. In reality, it only uses less varied images with relatively long image life. The impact is that the accuracy of the results of image interpretation is not as expected, because the objects depicted in the image and the existing relations do not match.

Remote sensing has a wide potential for various applications to solve problems [3]. In addition to applied needs, remote sensing can also be used as a medium in learning, especially to develop students' spatial thinking ability (STA). In the industrial era 4.0, which is accompanied by the proliferation of various information (big data era) today requires learning in various educational institutions to educate students to be able to think and solve problems. One of the important problems that always befall this nation is the problem of natural disasters. STA which is supported by the availability of imagery on Google Earth allows it to be used by education to train students to solve spatial problems around disaster mitigation problems. Google Earth has considerable potential to enhance methods for teaching geography and helping students develop other capabilities [3]. Several problems of disaster mitigation include determining the location of evacuation, determining safe evacuation routes, determining points for assisting, and determining the location of EWS (Early Warning Systems) tools. Google was a powerful application to get spatial information and the features on earth [4]. Therefore many researchers are interested in utilizing this application for various purposes. Some research on the use of Google Erath for mitigation learning [5] [6] [7], is not specific to spatial thinking development. Research only emphasizes how to use Google Earth for mitigation. In other research, Google Earth is used as a source of imagery for mitigation purposes. Some studies use Google Earth only to develop STA, but these were not used to develop disaster mitigation capabilities. Even though the development of this STA can trigger students to solve spatial problems independently. The development of STA is emphasized in this study with the aim that students can solve problems related to Google Earth assisted mitigation.

The main competence of utilizing remote sensing imagery for mitigating natural disasters that are urgently needed is the ability to sort information, analyze, and draw logical conclusions with supporting tools. STA is a type of thinking aimed at the ability to solve spatial problems [8]. Remote sensing learning has not been oriented towards the achievement of increasing students' spatial thinking skills in solving problems. The use of Google Earth, which is very prevalent by various groups, including in learning, has not reached a wider audience. Spatial thinking requires that users ask "what is where" and "why"; the most common virtual globe tasks only include the "what" [9]. What, where, and why are urgent question that related STA. Google Earth could to answer these question and to develop STA[10].

2. Methods

2.1 Research Design

This type of research is experimental, specifically quasi-experiments whose subjects cannot be completely controlled. In this study, the experimental class that was determined was 1 class, and the
control class was also 1 class. The experimental group was not randomly selected. Therefore, the experimental design used was a non-randomized pretest-posttest control group design. This design model uses an experimental group and a control group as samples that are not randomly selected, but requires a minimum of two groups provided that both groups are homogeneous. This design was chosen because in the world of education, especially in learning, the implementation of research does not always allow random selection of subjects. After all, subjects are naturally formed in one whole group (whole groups that are formed naturally), namely class.

2.2. Variables
The variables of this study include the independent and dependent variables. The independent variable in this study is a qualitative variable (fix factor), namely the use of Google Earth. The dependent variable includes 2 variables, namely the variable spatial thinking ability and remote sensing learning achievement. Spatial thinking ability variables include location conditions, connections, comparisons, aura, regions, hierarchies, transitions, analogies, patterns, spatial associations [11]. The ability to think spatial is the ability to think inclusively as an amalgamation of declarative forms, perception of knowledge, and several cognitive operations that can be used to change, combine or operate on this knowledge, where this ability is measured using a set of questions, and the results are expressed with a certain score, from 50 to 100.

Remote sensing learning achievement is the score obtained by students after learning disaster mitigation materials assisted by Google Earth. The Scores were measured through a series of tests and expressed as a number from 0-100.

2.3. Population and Sample
The population of this study was students of the Department of Geography Education, Faculty of Social Sciences, Yogyakarta State University. According to the records of the student affairs subdivision, the number of students in this department is 415 students. The sample of this study were students who were selected to serve as the experimental and control classes, which numbered 87 people (class A and B), respectively (41 and 46 people). The sample was not chosen randomly because if it was chosen randomly it would change the nature of the class.

Sampling was carried out by non-random methods by a quasi-experimental research design or also known as purposive technique (purposive sampling). The sample taken was not an individual student but the sample taken was a class, using quota sampling. Sampling is not done individually, but in a per class manner, it is intended that the experiment can run naturally.

2.4 Data Collection Techniques
There are 2 data collection techniques used in this study, namely tests and observations. The test technique was used to collect data on students’ special thinking skills and remote sensing learning achievement. The test was carried out twice, namely pre-test and post-test. The pretest was carried out before the treatment (treatment) of the research subject was carried out. Post-test was carried out after treatment. Both tests were conducted to measure the effectiveness of the treatment in improving students’ spatial thinking skills. The results of this test are then used for testing with inferential statistics, especially the t-test. Observations are used to collect student activity data while carrying out remote sensing learning with treatment using Google Earth.

2.5 Research Instruments
There are 2 research instruments used for data collection purposes, namely STA test questions and learning achievement test questions. To measure student STA, multiple-choice questions were developed based on the imagery provided by Google Earth. The STA component developed for the preparation of questions is based on a concept developed by Gresmehl & Gresmehl [12]. This instrument has been developed and used for research purposes whose validity and reliability have been tested [13]. The number of questions from this instrument is 35 items.

The questions used to measure remote sensing learning achievement are based on the basic competencies stated in the syllabus, namely the basic competencies in interpreting satellite images and aerial photographs. The number of questions is 40 multiple-choice questions. The number of questions from the two sets of questions is 75 items. The test is carried out in stages, namely in the first stage,
STA test questions are given, then in the second stage questions are given to measure geography learning achievement.

2.6. Data Analysis Techniques
The data analysis techniques used to test the hypothesis are the t-test and Pearson Product Moment Analysis. The t-test is used to (a) determine the differences in the spatial thinking abilities of the experimental class and the control class, (b) to test the differences of the student's spatial thinking abilities of the pre-test and post-test results, (c) to test the differences in spatial thinking abilities between male and female students. Pearson Product Moment Analysis is used to examine the relationship between spatial thinking skills and student remote sensing learning achievement.

3. Result and Discussion
3.1 Ability to Think Spatially
3.1.1 Experiment Class
To find out the score of the spatial thinking ability of the experimental group or students who carry out learning activities using Google Earth media, with a sample of 36 students, a descriptive analysis was carried out. The analysis showed that the average STA score for this group was 66.22, with a standard deviation of 4.776, a median of 69.00, and a mode of 65. The minimum score was 60 and the maximum score was 78, the range of scores obtained was from 60-78. The theoretical range of scores of the instrument is 0-100.

The frequency distribution of students' spatial thinking ability scores treated with Google Earth media is by the following table where the score 76-78 is the score with the highest frequency (27.78%) and the score>78 is the highest score with the lowest frequency, namely 1 or 2.78%. Based on the classification (very low class = 0-20, low = 21-40, medium = 41-60, high = 61-80, and very high = 81-100) it is known that all students in this group have high grade STA, none students who belong to the low and very high class (Fig 1).

![Figure 1. Line graph of STA Score in the Experimental Group](image)

3.1.2 STA of Control Class
The control class or group of students learning to improve spatial thinking skills aided by conventional remote sensing or not using Google Earth media was represented by 42 samples of students. The average score was 63.36 with a standard deviation of 15.693. The minimum score is 45 and the maximum is 75, the median is 65, and the mode is 65 with a variance of 43,388. The achievement of this score shows that in this control class as much as 39.54% of students have STA abilities at the middle to lower level (Fig 2).
3.2. Remote Sensing Learning Achievement

3.2.1. Experimental Class Learning Achievement

Remote sensing learning achievement referred to in this study is limited to learning achievement in the cognitive aspects. Achievements are obtained from the average midterm exam (nd course assignments that have been obtained by the participants. Information regarding learning achievement scores from the experimental group is needed to provide a statistical picture, so that it can understand the logical relationship between the STA position and determine the role of remote sensing learning achievement as an independent variable. Learning achievement (knowledge) is an independent variable that can affect the ability to solve spatial problems, as in the next section of this study which conducts inferential analysis. The discussion of learning achievement includes both groups, namely the achievement of the experimental group in general and according to spatial resolution.

Before discussing the results of the descriptive analysis of the achievement variables according to spatial resolution, first discuss the distribution of the experimental class achievement scores in general. The results of the descriptive analysis of remote sensing learning achievement in general from the experimental group were learning achievement scores ranging from 48-90, average score = 70.20, median and mode = 70, SD = 9.124, and variance = 84.899. Judging from the central distribution, it can be seen that the student achievement scores are relatively even, this can also be seen from the SD score which shows a deviation from the average score of 9.124. The learning achievement score of the experimental group was included in the good category.

3.2.2 Control Class Learning Achievement

The remote sensing learning achievement of the control group showed a varied distribution, namely scores ranging from 48-81. The central tendency scores included the mean = 65.81, median = 65, mode = 65, SD = 9.214, and variance = 31.274. From the graph, it appears that learning achievement is more concentrated in the intervals of 61-65 and 66-70. The largest group is in the interval of 61-65. This learning achievement is classified as a medium class. When compared with the success criteria set by the instructor of this course, namely the achievement of KKM (minimum competency) with a score of 70, the control class average score can be stated as not meeting the standard of success.

3.3 The Effect of Google Earth Assisted Remote Sensing Learning

The use of Google Earth as remote sensing learning media with problem-based learning methods is used to train students to use imagery as a medium and a geospatial technology tool that can help develop spatial thinking skills. Remote sensing learning through the study of geography themes/problems requires students to use images available on Google Earth to solve problems so that their STA can be trained. To determine the effect of Google Earth assisted remote sensing learning on
the experimental class, it requires the control class as a class that does not carry out Google Earth assisted learning. The problems that must be solved in this study are the determination of the location of settlements, the location of the evacuation of people affected by volcanic eruptions, the location of flood prevention facilities, priority for handling hazards and disaster risks, and where is the best route for evacuation and drop aids.

The data obtained from the STA pre-test and post-test results of the experimental group that received treatment with Google Earth-assisted remote sensing learning and the control group who did not receive Google Earth-assisted remote sensing learning were then analyzed inferential statistics. The analysis model used to test this hypothesis is the t-test. Paired t-test analysis was used to determine the difference between the pre-test and post-test scores of the paired groups, namely the pre-test and post-test of the experimental group and the pre-test and post-test of the control group. The independent t-test model was used to test the differences in STA scores between the experimental group and the control group, both between pre-test and pre-test and between post-test and post-test scores.

The hypothesis proposed to test the effect of remote sensing methods assisted by Google Earth on the spatial thinking ability of geography education students is $H_0$ = there is no difference in the average STA score between the experimental group and the control group. $H_1$ = there is a difference in the average STA score between the experimental group and the control group.

To answer the above hypotheses, the analysis was carried out with an independent t-test. Before deciding on the hypothesis, first look at the variance equality in Levene's test as presented in the appendix. In the Equal variances assumed Levene's column, it is known that the coefficient of $F=2.854$ with a value of sig.$=0.092$. The sig number is still $>0.05$, so it can be declared insignificant. Therefore, equal variances are not assumed, from which the value of $t=9.069$ is obtained with sig.$=0.000$.

3.4. Relationship between STA and Learning Achievement

Based on the results of the Pearson Correlation analysis as presented in Table 1, it is known that the coefficient of the relationship between the STA variable and remote sensing learning achievement is $0.489$ with a significant degree of 2 tails of $0.002$. These results justify the hypothesis that nil. which states that there is no relationship between STA and remote sensing learning achievement is rejected. This is based on the results of the analysis which shows that the significant coefficient is below $0.005$. Therefore it can be stated that there is a positive and significant relationship between STA and remote sensing learning achievement.

| Table 1. Results of Analysis of Relationship between STA and Learning Achievement |
|---------------------------------------------------------------|
| STA | Learning Ach of Remote Sensing |
| STA | Pearson Correlation | 1 | .489** |
|     | Sig. (2-tailed) | .002 |
| PresBel_PJ | Pearson Correlation | .489** | 1 |
|     | Sig. (2-tailed) | .002 |
| N   | 36 | 36 |

**. Correlation is significant at the 0.01 level (2-tailed).

4. Discussion

STA is an important factor that must be taught to students majoring in geography education. Geography students have an important task to solve spatial problems based on geospatial technology. Google Earth is a form of geospatial technology that can help students improve STA in solving disaster mitigation problems. The results of this study are in line with what Schwartz have explored regarding the use of big data, including with Google Earth for disaster mapping, particularly for flood mapping and flood vulnerability assessments [14]. But the research [14] did not reveal STA as part of learning outcomes using Google Earth which is useful for solving problems related to mitigation. His research were only for mapping floods and assessing flood vulnerability for disaster decision-making.
Another study using imagery that has been done shows that spatial resolution images can improve students' abilities in solving spatial problems related to disasters. This study strengthens the conclusions from the results of this study which show that Google Earth can be used effectively as a learning medium to train students in solving disaster mitigation problems. This evidence confirms that the nature of Google Earth which has dynamic spatial resolution is in line with the image properties used by Hadi[13].

Disaster mitigation is a part of disaster management that requires in-depth and comprehensive studies. Google earth technology is able to provide the necessary variables for disaster management purposes. Many variables are spatial in the broad study area. For this purpose, Google earth technology alone is not sufficient. He needs someone who has an STA. studies conducted by several researchers [8], [5] for mitigation purposes require a variety of geospatial technologies. This research only uses one geospatial technology, but the human factor is more developed, so that one technology becomes more effective.

The conclusion of this study is also relevant to what has been done by several researchers [15], [8], [11] who use geospatial technology to improve students' spatial abilities and learning achievement. This research is also able to show that students' sensing learning achievement can be improved by utilizing this dynamic image. Research on the use of integrated geospatial technology was carried out by Hyunh [8] which showed that the use of geospatial technology was very effective in improving student achievement and competence. There is an interesting finding in this study, which shows that a Google Earth assisted remote sensing learning does not only improve student STA. But students have increased geographical knowledge to solve problems related to disaster mitigation. Geographical knowledge and the use of Google Earth media in the study and study of remote sensing have an important role in developing spatial thinking skills [16]. Another interesting finding in this study is that the use of dynamic Google Earth to increase spatial thinking encourages increased student interaction with media and interactions between students. This finding is in line with other studies that use virtual globes to hone STA, especially in relation to spatial logic ((the emphasis is on the ability to answer "why" a feature lies there) [9].

5. Conclusion

From the description that has been stated above, it can be concluded that: (1) Remote sensing learning assisted by Google Earth is effective in improving student STA for solving hazards mitigation problems. It can be seen from the test results which show the coefficient t = 30.187 with degrees sig = 0.000. The use of Google Earth can increase student STA, because of its dynamic nature (zoom in and zoom out), provides complete features of the earth's surface, and support attribute information to spatial features. (2) There is a positive and significant relationship between student STA and remote sensing learning achievement. It was evidenced by the high correlation coefficient and the degree of significance = 0.000. STA helps students in image interpretation activities, which require understanding the spatial features of the image. Thus, in the remote sensing learning assessment, students' high STA can obtain high learning achievement. Google Earth is a powerful application for learning geography and remote sensing, including developing spatial thinking skills in disaster mitigation. So, geography teachers must apply this application in learning to train students in discovering various spatial phenomena and attributes.

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References

[1] I. Shah and M. Khan, “Impact of Multimedia-aided Teaching on Students’ Academic Achievement and Attitude at Elementary Level,” US-China Educ. Rev. A, 2015.

[2] J. Lee, L. Lin, and T. Robertson, “The impact of media multitasking on learning,” Learn. Media Technol., 2012, doi: 10.1080/17439884.2010.537664.

[3] T. C. Patterson, “Google earth as a (not just) geography education tool,” J. Geog., 2007, doi: 10.1080/00221340701678032.

[4] O. Mutanga and L. Kumar, “Google earth engine applications,” Remote Sensing. 2019, doi: 10.3390/rs11050591.

[5] J. N. Hird, E. R. DeLancey, G. J. McDermid, and J. Kariyeva, “Google earth engine, open-access satellite data, and machine learning in support of large-area probabilisticwetland mapping,” Remote Sens., 2017, doi: 10.3390/rs9121315.

[6] M. A. Brovelli, Y. Sun, and V. Yordanov, “Monitoring forest change in the amazon using multi-temporal remote sensing data and machine learning classification on Google Earth Engine,” ISPRS Int. J. Geo-Information. 2020, doi: 10.3390/ijgi9100580.

[7] M. Yu, Y. Huang, Q. Xu, P. Guo, and Z. Dai, “Application of virtual earth in 3D terrain modeling to visual analysis of large-scale geological disasters in mountainous areas,” Environ. Earth Sci., 2016, doi: 10.1007/s12665-015-5161-5.

[8] N. T. Huynh and B. Sharpe, “The role of geospatial reasoning in effective gis problem solving: K-16 education levels,” Geomatica, 2009.

[9] J. Schöming, M. Raubal, M. Marsh, B. Hecht, A. Krüger, and M. Rohs, “Improving interaction with virtual globes through spatial thinking: Helping users ask ‘Why?’,” in International Conference on Intelligent User Interfaces, Proceedings IUI, 2008, doi: 10.1145/1378773.1378790.

[10] G. (UNY) Ardyodyanto, “Pemanfaatan Google Earth Dalam Pembelajaran Geografi Untuk Meningkatkan Hasil Belajar Siswa Kelas X Sma Widya Kutoarjo,” Yogyakarta State University, 2014.

[11] R. S. Bednarz and J. Lee, “The components of spatial thinking: Empirical evidence,” in Procedia - Social and Behavioral Sciences. 2011, doi: 10.1016/j.sbspro.2011.07.048.

[12] B. S. Hadi, Penginderaan Jauh Penganter ke Arah Pembelajaran Berpikir Spasial, Fisrt. Yogyakarta: UNY Press, 2019.

[13] B. S. Hadi, “Pengaruh Penggunaan Citra Multiresolusi Spasial Dalam Pembelajaran Penginderaan Jauh Terhadap Kemampuan Berpikir Spasial Mahasiswa Calon Guru Geografi,” 2017.

[14] B. Schwarz et al., “Mapping Floods and Assessing Flood Vulnerability for Disaster Decision-Making: A Case Study Remote Sensing Application in Senegal,” in Earth Observation Open Science and Innovation, 2018.

[15] J. Lee and R. Bednarz, “Effect of GIS learning on spatial thinking,” J. Geogr. High. Educ., 2009, doi: 10.1080/03098260802276714.

[16] Wakabayashi Y, “Role of Geographic Knowledge and Spatial Abilities in Map Reading Process: Implications for Geospatial Thinking,” Geogr. reports Tokyo Metrop. Univ., 2013.