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Spatial Reasoning: A Survey on the 8th Grader Students' Gain in Online Learning

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Abstract

Coronaviruses disease (Covid-19) pandemic forces schools to implement schools from home through online learning. This study aims to describe online mathematics learning, examine differences in aspects of spatial reasoning, and observe spatial reasoning based on gender. We conducted a survey method on 140 participants in one private junior high school in Yogyakarta. Data collection is using a spatial reasoning test via Google Form consist of nine questions and a direct interview with a teacher through video conference. Data analysis uses descriptive and inferential statistics. The results showed that online mathematics learning using the Google Form platform could assist students with limited facilities in the learning process. The research finding showed no difference in spatial reasoning ability between male and female students, including in each aspect of spatial reasoning. In addition, other findings indicate that the aspect of spatial reasoning that students master the most is spatial visualization, while the aspect of spatial reasoning that is the least mastered by students is spatial relations.

Keywords: gender, online learning, spatial reasoning

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INTRODUCTION

Coronavirus (COVID-19) pandemic has changed the order of human life, including education. Many countries affected by COVID-19 have implemented school closures or online learning through learning from home (Basilaia & Kvavadze, 2020; Favale et al., 2020; Radwan & Radwan, 2020; Sintema, 2020; Viner et al., 2020; Zayapragassarazan, 2020; Zhang et al., 2020) as physical distancing efforts to prevent COVID-19 transmission. In Indonesia, through BNPB (*Badan Nasional Penanggulangan Bencana*-The National Disaster Management Authority), the government has set an emergency response period of COVID-19 since February 29, 2020. This setting has an impact on the implementation of social distancing and physical distancing. Responding to the National Disaster Management Authority circular, the Ministry of Education and Culture issued a circular containing learning recommendations carried out from home through online learning. During the implementation of online learning, the Minister of Education and Culture emphasized school from home through online learning to provide meaningful learning experiences for students (Circular Letter No. 4 of 2020). However, this circular received various reception from the schools.

The COVID-19 Pandemic has forced various fields to optimize the use of Information Technology (IT) as an Industrial Revolution 4.0 implementation that can meet the needs during the COVID-19 crisis (Javaid et al., 2020). Conducting online learning can use many platforms such as Edmodo, Zoom, Meetme, Google Meet, and Google Classroom. Ministry of Education and Culture has collaborated with several

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learning platforms such as Rumah Belajar, Meja Kita, IndonesiaX, Google Education, Smart Classroom, Microsoft 365, Ruang Guru, Sekolahmu, Zenius, Cisco Webex. All of these platforms can facilitate students' school from home. Unfortunately, most of these platforms require a large internet quota and smartphone facilities with an operating system version of Android 8.0 and more. For schools with adequate IT facilities and supported by good parents' social-economic conditions, online learning is certainly not a significant problem. Students have received support facilities to take part in online learning. It will be different for schools with limited IT facilities and middle-low-income parents' socio-economic conditions in the region. Students may not obtain laptop/computer or smartphone facilities that support their participation in online learning.

For schools with limited student facilities, the learning can be conducted by implementing online learning that utilizes a low internet quota platform and can be accessed by students even with a smartphone equipped with the Android 8.0 operating system version and below. One of them is the application released by Google: Google Form. Through this platform, teachers can send students material and questions through asynchronous mode access.

One of the expected competencies after students learn mathematics at the high school level is students can do mathematical reasoning (MOEC, 2018). Geometry, as a branch of mathematics, is closely related to shape and space. Therefore, the reasoning skills needed in learning geometry become more specific, namely spatial reasoning abilities. This ability helps students understand geometric concepts and solve everyday problems involving the application of geometric concepts.

The importance of geometry in life is not in line with the achievement of geometry learning outcomes for junior high school students on the national exams in the last five years, namely 2015-2019. In that span of years, junior high school students' average geometry learning outcomes were still low, namely 46,28. Meanwhile, the geometry material being tested on the junior high school national exam includes 2D and 3D geometry. It means that junior high school student's mastery of 2D and 3D geometry is still low. 3D geometry material is closely related to spatial reasoning abilities (Pittalis & Christou, 2010). It indicates that junior high school students' spatial reasoning skills are still lacking.

During the school from home period, 3D geometry was one of the materials taught online by the eighth-grader students of junior high school. The study results found that there were still students' misconceptions about 3D geometry (Özerem, 2012; Tan Sisman & Aksu, 2016) even though learning was carried out regularly. Their misconceptions are even worse when the teaching process is delivered in online mode.

Psychologically, there are two individual tendencies, namely masculine and feminine. Boys tend to build masculinity while girls tend to femininity. Legewie, J., & DiPrete, T. A. (2012) stated that boys tend to be dominant when they are in school, especially in subjects that are considered masculines, such as sports and mathematics, so that they create differences in mathematics learning outcomes.

Spatial reasoning ability becomes one of the essential skills possessed by students (Buckley et al., 2018; Harris & Lowrie, 2018; Hawes et al., 2017; Lowrie et al., 2016, 2019; Mulligan et al., 2018). The majority of research on spatial reasoning is conducted in typical learning situations (Gagnier et al., 2017; Hartatiana et al., 2017; Hawes et al., 2017; Septia et al., 2018). Students' spatial reasoning in online learning during the COVID-19 Pandemic is interesting to study because online 3D geometry learning forces students to independently learn and use all their spatial abilities to

understand the material presented. Also, it is essential to study gender issues in spatial reasoning to determine whether there are differences in their abilities. This study's results are expected to provide information to mathematics teachers about gender differences in students' spatial reasoning abilities so that teachers can design learning geometry by paying attention to these differences.

This study aims to describe online mathematics learning during the COVID-19 Pandemic, examine differences in spatial reasoning aspects, and examine differences of spatial reasoning in terms of gender. The finding of this study will add to our understanding of online learning amid COVID-19 outbreaks in junior high schools with limited facilities in developing countries. To answer this goal, the research questions raised in this study are (1) What is the description of online mathematics learning during the COVID-19 outbreak in junior high school? (2) Are there significant differences between each aspect of spatial reasoning? and (3) Are there significant differences in spatial reasoning skills in terms of gender?

RESEARCH METHOD

In this study, a quantitative approach with a cross-sectional survey method (Creswell, 2015) was chosen to describe online mathematics learning, examine different aspects of students' spatial reasoning, and examine differences in spatial reasoning based on gender in online learning COVID-19 Pandemic. A brief survey was followed by 140 of 154 students from one private junior high school in Sleman-Yogyakarta on spatial reasoning, including visualization, mental orientation, and spatial relations.

Participants in this study were the 8^{th}-grade students (74 boys, 66 girls) with 14-15 years old. All participants were registered in a private junior high school located in one of the subdistricts in Sleman Regency adjacent to the red zone district COVID-19 in Bantul Regency, Yogyakarta. Participants came from families with middle socio-economic conditions - lower in the border area between Sleman and Bantul. There are 7.14% of participants living in dorms around the school—the whole Javanese descent and Javanese language as their primary speech-language at home. More than 90% of the participants are facilitated smartphones by their family or relatives so that they can participate in online learning during the COVID-19 Pandemic. However, most smartphones still use the Android operating system in version 8.0 or earlier.

The test used multiple-choice spatial reasoning questions consisting of nine questions measuring three aspects of spatial reasoning, namely five visualization questions, two mental orientation questions, and two spatial relation questions adapted from Ramful et al. (2017). Interviews with mathematics teachers were conducted to explore information about the implementation of online mathematics learning during the COVID-19 outbreak.

The online test was used to collect data. This method was chosen because the schools have implemented online learning during the Pandemic. Furthermore, online questionnaires can collect extensive data quickly (Creswell, 2015). During the Pandemic period, online learning for each subject was scheduled once a week. For mathematics lessons, online learning schedules were held every Monday from 07.00-09.00. The link of the test in google form was then given at the mathematics lesson schedule to students via WhatsApp group. The students were asked to work for 45 minutes on that day.

The data were analyzed descriptively using inferential statistics. Descriptive statistics contain the average of the participant's spatial reasoning. In contrast,

inferential statistics use ANOVA to reveal different aspects of spatial reasoning and participant spatial reasoning differences based on gender.

RESULTS AND DISCUSSION

Results

The school did not have a learning management system yet, so it used existing applications to support online learning during the COVID-19 Pandemic. Before introducing learning from home during the COVID-19 Pandemic, the school had invited information technology experts to provide training for teachers in online learning preparation. Some online learning platforms that become training material are Zoom and Google Classroom. Unfortunately, students' smartphone facilities' limitations are an obstacle to implementing online learning with a synchronous model. To maintain the continuity of learning during the Pandemic, the principal and the teachers' council finally decided to use the Google Form platform for online learning. The Google Form Platform was used is because it can be accessed by students with limited student facilities in terms of memory capacity and operating system.

The 3D geometry material was given during three online meetings, with each meeting's duration is 2 hours. Through the Google Form platform, the teacher submitted the material in writing at session 1. While in the next session, the students were asked questions as training material on material that has been studied independently. The questions given are around 10-16 multiple-choice questions. The students were allowed to answer questions on Google Form individually.

The duration of students answering questions, including sending their answers in Google Form, is limited to 21:00. Because after that, the teacher will check and evaluate students' responses. Teachers' obstacle during online learning is that some students are late sending their answers via Google Form. The results of interviews with mathematics teachers are likely due to the limitations of smartphone facilities for students. Some students come from families with middle-low socio-economy status; in one family, only fathers have smartphones and are taken to work during the day. Children can only access the material and questions on the google form at night after their father comes home. If this is not the case, several children whose families do not have a smartphone to learn have to borrow a smartphone from their relatives or neighbors. This condition became one of the obstacles to student learning during the COVID-19 outbreak.

Besides students taking part in online learning, students also have a textbook for independent learning materials. To anticipate the material that students do not yet understand, the teacher opens a Question and Answer service using the WhatsApp application. However, only about 5% of students actively ask questions. Students who have a high interest in learning and are active during face-to-face learning, even though they are held online learning during the Pandemic, still actively ask for a not yet understood material.

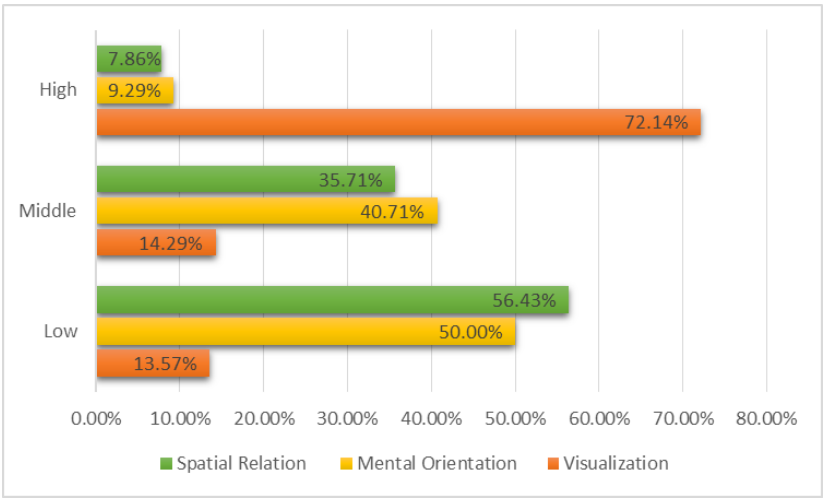

Figure 1. The number of students in each aspect of spatial reasoning

Figure 1 reports the survey results relating to the number of participants who correctly answered each spatial reasoning aspect, namely visualization, mental orientation, and spatial relations. By dividing the range of 0 - 100 into three parts, each labeled high (score equal to or greater than 65), moderate (40 <score <65), and low (score equal to or less than 40), it can be obtained that the percentage of participants in each aspect of spatial reasoning is different. Most participants, 72.14%, were in the high category for visualization aspects. Whereas in the other two factors, mental orientation and spatial relations, 50% and more participants were in a low type. Only less than 10% of participants are in the high category.

Table 1. Description of the results of spatial reasoning

Construct	N	Mean	St Dev
The aspect of spatial reasoning			
Visualization	140	73.29	19.13
Mental orientation	140	29.64	32.79
Spatial relation	140	25.71	32.01
Gender			
Boy	73	52.66	15.05
Girl	67	53.40	15.98
Spatial reasoning	140	53.02	15.45

The spatial reasoning test results in Table 1 show that the most challenging aspect for participants is spatial relations (mean = 25.71), followed by elements of mental orientation (mean = 29.64). Furthermore, the highest factor for participants is visualization (mean = 73.29). Additionally, when viewed from gender, both groups of boy participants (mean = 52.66) and women (mean = 53.40) show that it is not much different. It is reinforced by the ANOVA results shown in Table 2.

Table 2. The summary of one-way ANOVA analysis results

Spatial Reasoning	Result
Aspect	Mean (visualization = 73.29; mental orientation = 29.64; spatial relation = 25.71), Sig. = .000, df between group = 2, df within group 417, F = 118.735
Gender	Mean (boy = 52.66; girl = 53.40), Sig. = .780, df between group = 1, df within group = 138, F = .079
Visualization	Mean (boy = 72.05; girl = 74.63), Sig. = .429, df between group = 1, df within group = 138, F = .630
Mental orientation	Mean (boy = 34.93; girl = 23.88), Sig. = .567, df between group= 1, df within group = 138, F = 4.054
Spatial relation	Mean (boy = 21.92, girl = 29.85), Sig. = .144, df between group =1, df within group = 138, F = 2.164

Table 2 results show significant differences in participants' ability in each aspect of spatial reasoning, as demonstrated by one-way ANOVA (F (2, 417) = 118.735, p = .000). The post hoc test results in Table 3 show that there are significant differences in the average score of participants between aspects of spatial visualization and mental orientation, where the average visualization score is better than the average score of mental orientation. The same is true for the comparison of mean visualization scores and spatial relations. The participant scores indicate that the intermediate visualization is better than spatial relations. The post hoc test results showed that the two did not show any significant differences in contrast to the average score comparison of mental orientation and spatial relations. Thus, questions regarding visualization become the most straightforward problem for participants.

Table 3. The summary of Post Hoc Test Results

Comparison between aspects of spatial reasoning	Results
Visualization vs. Mental orientation	Mean difference = 43.64, Sig. = .000
Visualization vs. Spatial relation	Mean difference = 47.57, Sig. = .000
Mental orientation vs. Spatial relation	Mean difference = 3.929, Sig. = .486

The mean difference is significant at the 0.05 level.

ANOVA one-way test results in Table 2 show no significant difference between the spatial reasoning abilities of male and female participants (F (1,138) = .079, p = .780). This result is strengthened by testing the differences in participants' knowledge in each aspect of spatial reasoning in terms of gender. In the visualization, ANOVA results showed no significant difference between male and female participants (F (1,138) = .630, p = .429). While in the aspect of mental orientation, as shown in table 2, there was no difference between the mean scores of male and female participants (F (1,138) = 4,054, p = .567). Likewise, the results show no significant difference in the mean score of spatial relations between male and female participants (F (1,138) = 2,164, p = .144).

Discussion

This study aims to describe online mathematics learning during the COVID-19 Pandemic, examine differences in aspects of spatial reasoning, and differences in spatial reasoning aspects in terms of gender. The findings show that there are three crucial things to discuss.

First, this research describes the implementation of online mathematics learning using the Google form platform. With the Asynchronous model, it is easier for students to access Google forms at any time, given that personal smartphones do not facilitate some students. Nevertheless, there are weaknesses, namely the opportunity for students to work together and even cheat their friends' answers. Teaching 3D geometry material, especially with the Google form platform, becomes a challenge for mathematics teachers. The google form platform has been used to survey affective aspects (Habibi et al., 2018; Sutherland, 2018). Even though it also accommodates users to upload images. Excellent spatial reasoning skills are needed to master 3D geometry concepts to their geometrical abilities (Sinclair & Bruce, 2014) and their mathematical achievements (Newcombe et al., 2019). Moreover, spatial reasoning can be developed early and is easily forged from time to time (Mulligan, 2015; Uttal et al., 2013). Therefore, the integration of spatial reasoning content into formal learning is essential because it improves spatial functionalities in general and reduces differences concerning gender and socio-economic status that might hinder full participation in technological societies (Newcombe, NS, & Frick, A., 2010).

Second, this study shows significant differences between the ability of visualization, mental orientation, and participants' spatial relation. Furthermore, most of the participants were able to solve visualization problems. These findings indicate that participants are more knowledgeable about reconstructing 3D objects than 2D objects, including when the 2D object mesh is designed complex by adding some ornaments to the area. These findings indicate that participants can remember and rotate the representation of 2D objects into 3D mentally. It is undoubtedly not so surprising because students in learning often encounter or learn about breaking down a 3D shape into a mesh or otherwise constructing a 3D shape from the mesh. However, it becomes a challenge for students for mental orientation because it involves mental activity to understand objects' positions even if the item is changed in place. This skill is rarely practiced in class through written questions and exams, for example. Students often experience this skill in real life and games (Carbonell Carrera et al., 2018). No different from mental orientation, aspects of spatial relations are also less mastered by students by showing the average student score is relatively low. This aspect requires students to imagine the transformation of 2D and 3D objects mentally as a whole. Again, sometimes these skills are less noticed in learning mathematics in class. Students in their daily lives need this skill.

The last research result shows no significant differences between the spatial reasoning of boy and girl participants. Other findings, in every aspect of spatial reasoning, also showed no significant differences. Boy and girl participants' ability in visualization, mental orientation, and spatial relationships tends to be the same. Whereas other research shows, there are differences in spatial reasoning ability based on gender (Newcombe, 2010). Furthermore, several studies report that boys have more cogent spatial reasoning than girls (Maeda & Yoon, 2013; Reilly & Neumann, 2013; Zancada-Menendez et al., 2016). Some even report the opposite (Newcombe, 2010).

CONCLUSION

During the COVID-19 Pandemic, for schools with limited student smartphone conditions, one alternative to continuing to carry out online learning is to use the asynchronous platform model, Google Form. The material is presented in writing and is equipped with exercises to find out student understanding. Spatial reasoning test results show significant differences between each aspect of the participant's facilitator's equipment. While in terms of gender, the results of the study showed no significant differences in the spatial reasoning of boys and girls. The same results also in each aspect of spatial reasoning, namely visualization, mental orientation, and spatial relations.

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