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ANALYSIS OF SPATIAL ABILITY IN MATHEMATICS LEARNING: A SYSTEMATIC LITERATURE REVIEW

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Abstract

The aim of this research is to explore research methods that are often used to research spatial abilities, materials used for spatial abilities and variables related to spatial abilities. This research uses a systematic literature review method with PRISMA steps. The tool used to carry out the prism steps is www.covidence.org with the stages of identification, screening and including. The articles analyzed are articles originating from scopus.com and sciencedirect.com with the keyword's spatial ability and mathematics education. Based on the search results, 138 articles were obtained. In the identification process there were 138 articles that would be screened and the screening results resulted in 72 articles being carried out including. The results included 47 articles for analysis. The results of the analysis show that the research method used to research spatial abilities is a quantitative method. The material that is often used in learning is geometry material

Keywords: spatial ability, Systematic Literature Review

Abstrak

Tujuan dari penelitian ini yaitu menelusuri metode penelitian yang sering digunakan untuk penelitian kemampuan spasial, materi yang digunakan pada kemampuan spasial dan variabel yang berkaitan dengan kemampuan spasial. Penelitian ini menggunakan metode systematic literatur review dengan langkah PRISMA. Alat yang digunakan untuk melakukan langkah prisma yaitu www.covidence.org dengan tahapan *identification, screening* dan *including*. Artikel yang dianalisis merupakan artikel yang berasal dari scopus.com dan sciencedirect.com dengan kata kunci *spatial ability* and *mathematics education*. Berdasarkan hasil penelusuran diperoleh 138 artikel. Pada proses identification terdapat 138 artikel yang akan dilakukan *screening* dan hasil screening menghasil 72 artikel untuk dilakukan including. Hasil including terdapat 47 artikel untuk dilakukan analisis. Hasil analisis diperoleh bahwa metode penelitian yang digunakan untuk penelitian kemampuan spasial yaitu metode kuantitatif. Materi yang sering digunakan dalam pembelajaran yaitu materi geometri.
Kata Kunci: Kemampuan spasial, systematic literature review

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According to McGee (Mcgee, 1979) Spatial ability is the ability to manipulate, rotate, flip, or mentally rotate stimuli that are presented pictorially. Meanwhile, according to David Uttal (Uttal & Cohen, 2012) the scope of spatial ability is to understand objects and space and perform mental rotation of these objects. There are five components of spatial ability according to MCGee (Mcgee, 1979), which divides spatial ability into five components, namely Spatial perception / spatial perception, Spatial visualization / spatial visualization, Mental rotation / rotation ability, Spatial relations / spatial relations, Spatial orientation / spatial orientation. The five components become the dimensions of spatial ability.

Based on this definition, spatial ability is closely related to mathematics achievement in students. When traced bibliometrically, the relationship is very close. On the site www.scopus.com with the keyword spatial ability, 203 documents on spatial ability were obtained. After obtaining articles as data for bibliometric analysis, the data was downloaded in the form of RIS. Then the RIS data is

imported into the Vos viewer application. The results of bibliometric analysis of spatial ability using the Vos viewer application obtained the following visualization.

Figure 1. Bibliometric result analysis of spatial ability

Based on the bibliometric results in Figure 1, there are five clusters related to spatial ability. The main cluster is a red cluster. In the main cluster, it can be seen that spatial abilities are related to education, math achievement, mental rotation, problem solving, gender differences, learning systems, virtual reality, machine learning, augmented reality. So that spatial ability is important to be done more sharply with various research methods.

Based on the relationship of various variables, the statement that spatial ability is closely related to education and math achievement is confirmed. Spatial ability is closely related to variables in other clusters besides the main variable. The relationship with other clusters can be visualized as follows.

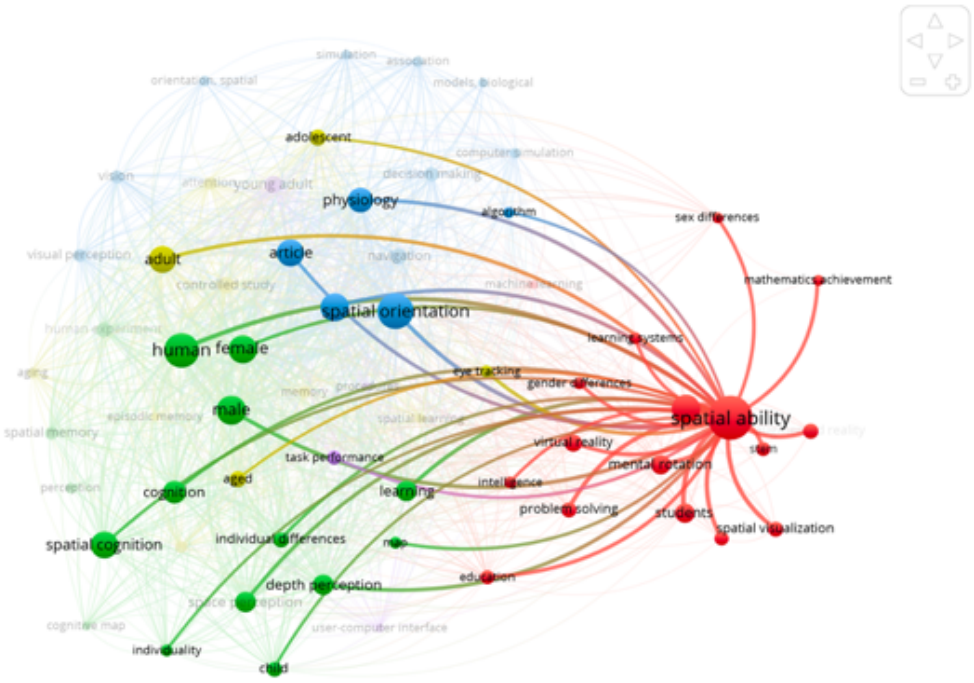

Figure 2. Spatial ability relationship with variables in other clusters

Based on the picture above, it is involved that spatial ability is related to intelligence, physiology, learning, cognition, spatial coginition, tax performance, spatial orientation, female, male, individual differences. All variables related to spatial ability are components in the learning process. So that spatial ability is not only found in the learning process of mathematics but in the learning process in general.

Some articles state that spatial ability is a predictor of student learning success. Wei et al (Wai et al., 2009) mentioned that spatial ability plays an important role in predicting adolescent achievement in STEM careers over quantitative and verbal abilities, and characterized the failure to improve talent identification through spatial ability assessment as “contemporary neglect”.

Based on this analysis, a study of spatial ability is needed. Spatial ability becomes the main thing and becomes a trend of research that is widely done but if we look at the number of articles from spatial ability the number is small, which is around 203. Spatial ability to be developed and improved in students because it is a predictor of student learning success. Therefore, a study was conducted using a systematic literature review to search for research on spatial abilities. Some things that need to be known are research methods to examine spatial abilities and what materials are used to determine students' spatial abilities.

METODE

The research method used is using systematic literature review with PRISMA steps. Before conducting a systematic literature review, articles were searched on the scopus.com and sciencedirect.com websites with the keyword’s spatial ability and mathematics education and the year

were not limited. Subject area is limited to social humanities with the type of article in the journal.

The search results obtained 138 articles consisting of 75 articles from scopus.com and 63 from sciencedirect.com. After obtaining the article, data import is then carried out at the Url address https://app.covidence.org. PRISMA stages consist of 3 stages, namely identification, screen and included. These stages are visualized in the following figure.

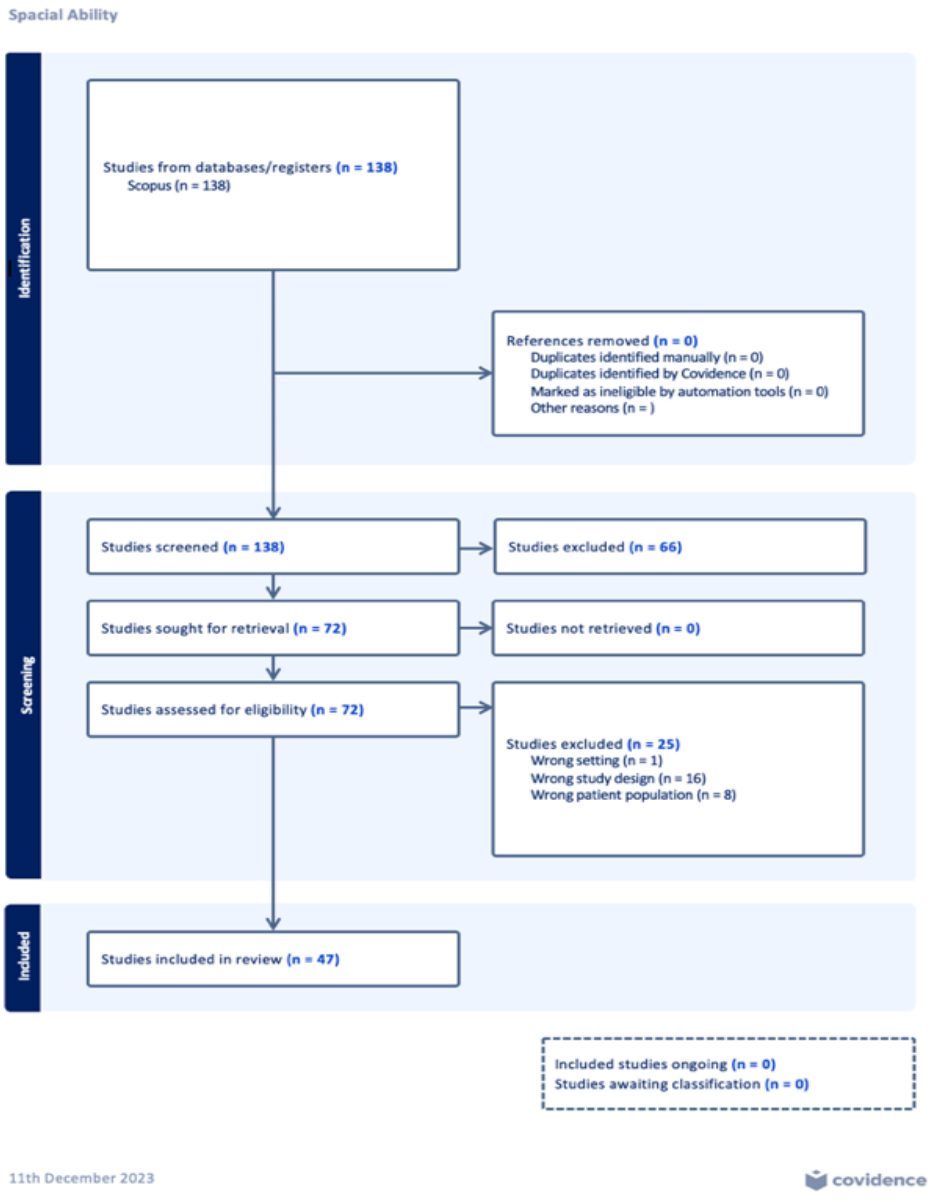

Figure 3. PRISMA's steps

Articles imported into the application in the form of RIS. At the identification stage there are no duplicate articles. So that 138 articles have no duplicates and can be continued at the next stage. The next stage is screening. Screening is done by reading the title and abstract of the imported article. The results of the analysis at the screening stage found 66 articles that were excluded. Articles that were excluded because studies excluded as many as 25 articles, wrong setting as many as 1 article, wrong study design as many as 16 articles and wrong patient population as many as 8 so that there were 72 articles that could be continued at the Included stage. Next, the included stage is carried out. The included stage is to agree between reviewers of articles that will be analyzed. The included results obtained 47 articles that will be analyzed in the study. Based on research conducted by Juandi (Juandi, 2021) states that in the SLR process only articles that are relevant and meet the inclusion criteria will be analyzed.

RESULTS AND DISCUSSION

Based on the search results, 138 articles were obtained from www.scopus.com and www.sciencedirect.com. The search results found spatial abilities starting from 2003. If depicted, the visualization of the obtained meta data is presented as follows.

Table 1. Number of Spatial capability articles per year

TAHUN	JUMLAH
2003	1
2005	1
2006	2
2008	2
2009	2
2010	3
2011	1
2012	2
2014	1
2015	3
2016	2
2017	1
2018	3
2019	3
2020	5
2021	7
2022	4
2023	4
JUMLAH	47

Based on this data, the highest publication was in 2021, namely 7 articles. There are several years that experienced no publications for spatial ability articles, namely in 2024, 207, and 2013. During covid 19, there was a significant increase in publications related to spatial abilities. The urgency of spatial ability as a predictor of success causes spatial ability to be increasingly studied.

Research Methods on spatial ability research and mathematics education Only 47 articles from PRISMA were analyzed. Based on the analysis, the following results are shown.

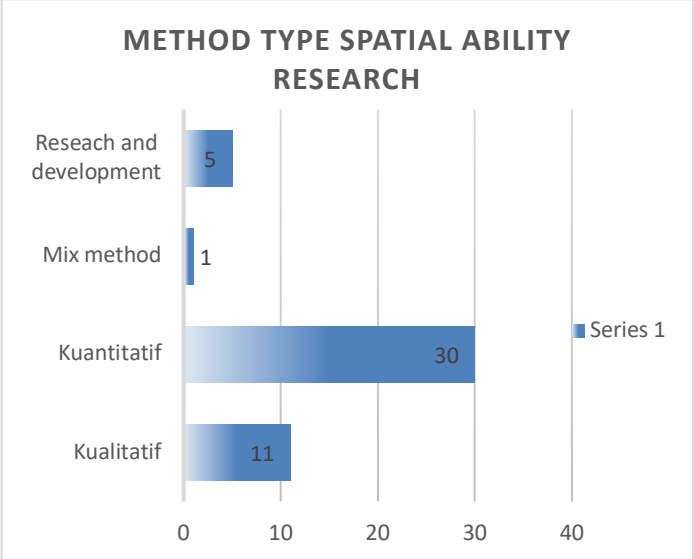

Figure 4. Method Type Spatial ability research

Based on the results of the table above with the analysis of 47 quantitative research articles, quantitative research methods are the most common research methods carried out by researchers. A total of 30 articles were published using quantitative research methods. After the second quantitative research method is the qualitative research method. The third research method used to examine spatial abilities is development research and finally there is 1 article that uses mixed methods.

Research using quantitative methods is divided into two categories, namely using applications and not using applications. If categorized, the following picture is obtained.

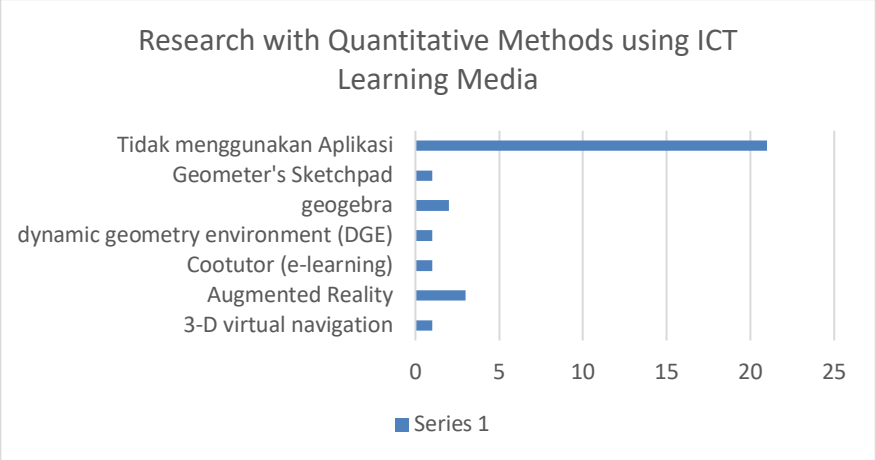

Figure 5. Research with Quantitative Methods using ICT Learning Media

Based on the graph above, it can be seen that 9 studies used quantitative research methods assisted by ICT learning media. The remaining 21 studies did not use ICT learning media.

Based on article searches, mathematics materials that are often used in research with spatial ability study areas are geometry. The following math materials use ICT assistance in the learning process.

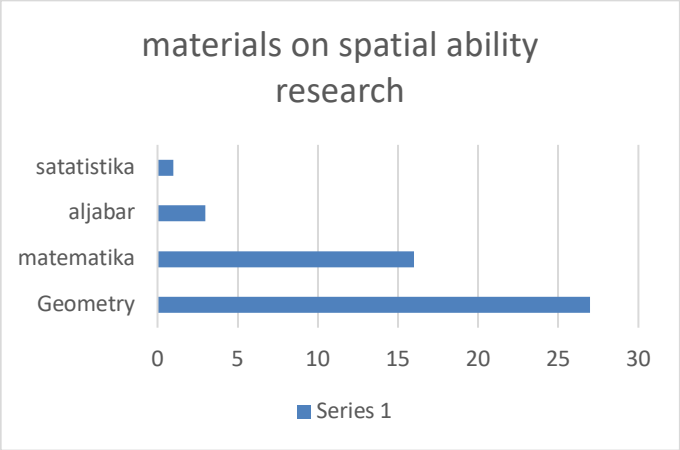

Figure 6. materials on spatial ability research

Based on the data analysis obtained, the material used to determine spatial ability is geometry. After geometry, one of the materials for the spatial ability domain is mathematics, algebra and statistics. Geometry can accommodate the 5 main components of spatial ability. The relationship between geomtery and spatial ability can also be analyzed through bibliometric analysis. Bibliomterically using data from 138 articles if an analysis based on bibliomterics is carried out, it is shown as follows.

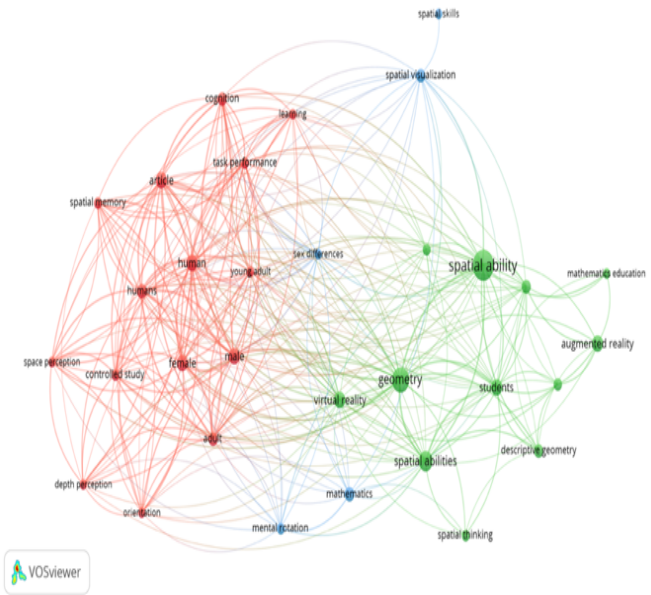

Figure 7. Bibliomteric analysis between geometry material and spatial ability

Based on the bibliometric results of the RIS data of 47 articles, it is known that spatial abilities are closely related to geomtery, virtual reality, students, augmented reality, mathematics education,

descriptive geometry, spatial thinking. It strengthens that in quantitative research the technology used is augmented reality and the material that is closely related to spatial ability is geometry.

Geometry material that is often used in quantitative research is geometry material in 3 dimensions or building space. Quantitative research is divided into two groups. The first group uses research As for some quantitative research including the first study conducted by Hauptman (Hauptman & Cohen, 2011) found that different impacts of virtual environments on students with different modal and personal learning styles. Post-test scores for all students (except audio students on the Talent Profile Test Series - Education) were significantly higher than pre-test scores. The second research result (de Ravé et al., 2016) is that DiedricAR implementation has potential benefits for students' spatial abilities, the relationship between application design and user experience, and software performance on multiple mobile devices.

The third quantitative research by Rohendi and Wihardi (Rohendi & Wihardi, 2020) whose research results revealed that using mobile-based augmented reality can increase students' spatial learning activities. The fourth study (Fikrati et al., 2021)), the results of which showed that there were sex and gender differences and the interaction between sex and gender differences had a significant effect on students' spatial abilities. The fifth research by Baranova (Baranová & Katreničová, 2018), the findings show that descriptive geometry courses have a positive impact on the development of students' spatial skills. The sixth research was conducted by Jelatu S and Made Ardana (Jelatu & Made Ardana, 2018), namely the results showed that 1) the REACT strategy assisted by GeoGebra resulted in higher achievement of students' understanding of geometry concepts when compared to students in the conventional group (expository), and 2) there was no interaction effect between students in the conventional group (expository). Geometry concepts are considered part of the material for spatial abilities. Objective research conducted by (Hannafin et al., 2008) concluded students working with activities in Sketchpad would learn geometry better and that (after controlling for mathematical ability) students' spatial ability would predict success in such an environment more reliably than with a tutorial program.

CONCLUSION

Based on the results of the analysis of research articles with the systematic literature review method, it was found that as many as 63.8297872% of the research methods used for research on spatial abilities in mathematics learning were quantitative research methods. The material used for research on spatial ability is geometry.

Future research can conduct research methods with development research methods. It is based on the study found that development research methods are rarely done for spatial mempuan. Technology tools that can be done are using augmented reality. The material that can be continued is algebra and other mathematical materials this is because the material on geometry has been done a lot of research.

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