Systematic Literature Review: Improving Creative Thinking Ability and Curiosity in Learning Geometry GeoGebra assistance

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Abstract

In the process of learning geometry, high curiosity is needed to be able to support learning success. In addition, it also takes the ability to think creatively in solving problems. An attitude of curiosity and the ability to think creatively can be grown in the application of GeoGebra-assisted geometry learning. This study aims to examine whether GeoGebra-assisted geometry learning can improve students' curiosity and creative thinking abilities in learning geometry and what learning model is appropriate to increase students' curiosity and creative thinking skills in learning geometry. This research was conducted using the SLR method for articles published in 2016-2023 about improving creative thinking ability and curiosity in learning geometry. There are 26 national or international articles obtained from Google Scholar and ResearchGate databases. The results of this study concluded that to investigate the impact of using Geogebra software on creative thinking ability and curiosity in geometry learning. It was found that Geogebra had a positive effect on improving creative thinking ability in geometry learning, and while it also had a positive effect on curiosity, this area could potentially be further explored as a research topic. The second finding from a research study conducted between 2016 and 2023, focused on improving creative thinking and curiosity in geometry learning with the assistance of Geogebra software, showed that the Problem Based Learning model was commonly used. Thirdly, the study found that research on enhancing creative thinking and curiosity in geometry learning with Geogebra is primarily conducted with junior high school students.

Keywords: Mathematical Creative Thinking Ability, Curiosity, Geometry, Geogebra

1. Introduction

Education is one of the most important things in life. In life, education certainly has a very important role, namely helping each individual to develop. Not only formally, but education can also take place anywhere. Education is one thing in society that has been going on for a long time. Many things happen in the educational process, one of which is the learning process. The learning process is an important aspect of education that can affect the quality of education. In Indonesia, in the learning process in schools there are various subjects taught, one of which is mathematics.

Mathematics learning has a role to develop students' creative abilities in everyday life, so that soon students will be able to apply mathematics in contexts that are useful for students, both in their world of life and in the world of work in the future. In addition, studying mathematics can accustom someone to think critically, logically, and can improve their creativity. Creative mathematics learning will also have implications for students' creative thinking ability which involve curiosity, the ability to find, explore, seek certainty and enthusiasm, all of which are very large qualities found in students, especially in the field of mathematics.

To determine the level of ability to think creatively in a lesson, an assessment is needed. Teachers can find out how students are developing in various aspects through

assessment (Mohzana et al., 2021) . Assessment in the learning process is divided into three aspects, namely cognitive, psychomotor, and affective. The affective aspect of learning consists of students' attitudes during learning. One of the attitudes or characters that are assessed in the learning process is student activity. This is in line with Kraiger's opinion in (Yanuarti & Sobandi, 2016) that a learning process that involves students' active participation in it can develop optimal learning outcomes. To assess student creativity, it can be done by measuring their curiosity. Student curiosity is very important because with curiosity, students are able to do learning by themselves. In addition, Harty & Bell also stated that curiosity is an important characteristic and is an influential factor in the individual learning process (Özkan & Topsakal, 2020).

Curiosity triggers someone to find out more and dig deeper on a particular topic. Meanwhile, the ability to think creatively mathematically involves a person's ability to solve mathematical problems in an original and innovative way. In this case, when students have a strong curiosity, they tend to be more enthusiastic and continue to find out about mathematics, and they will try to solve mathematical problems in a more creative and innovative way. Likewise, when students have strong mathematical creative thinking abilities, they will tend to have a greater curiosity about mathematics and will always look for new ways to solve mathematical problems in a more creative way.

In addition to the affective aspect, in the explanation above it has also been stated that there is a cognitive aspect in an assessment. Students are certainly expected to have qualified knowledge after the implementation of learning activities. One of them in learning mathematics is the ability to think creatively. The ability to think creatively is one of the important abilities for the 21st century, students must acquire and use it. The ability to think creatively is one of the higher order thinking abilities, namely the process of thinking that is not just memorizing and reciting known information. The ability to think creatively is a process used when bringing in/bringing up a new idea. It incorporates ideas that haven't been done before. In general, creative thinking is triggered by challenging problems.

Creative thinking is the ability to think that begins with the emergence of sensitivity to a problem that must be solved. This ability arises from student creativity which is the ability to create something or a new idea in dealing with a problem (Mandari et al., n.d.). Sri Hastuti Noer in (Haifatudzikroh, 2019)explains that the ability to think creatively is one of the higher-order thinking ability in learning mathematics which is currently receiving less attention from teachers. The ability to think creatively is an ability in learning mathematics which includes fluency, flexibility, originality and elaboration (Risqi, 2012; Wijaya et al., 2016).

The ability to think creatively is needed in geometry. In viewing and solving geometric problems, students need to think creatively to find innovative and effective solutions. In addition, they also need to use imagination and creativity to visualize geometric objects and explain geometric concepts intuitively. So, in learning geometry, strengthening creative thinking skills will help students to become more skilled and successful in understanding and applying geometric concepts. Based on the characteristics, it is owned by learning geometry. Geometry requires the ability to think abstractly and visually, as well as how to apply geometric principles and concepts to solve problems. Therefore, students who have the ability to think creatively can more easily understand and solve geometric problems. Geometry is a field of study in school mathematics material which has a large portion to be studied by students at school. Geometry is a field in mathematics that studies points, lines, planes and space as well as

their properties, measurements and their relationship to one another (Nur'aini et al., 2017). Geometry is a field of study in mathematics that gets a larger portion to be studied by students at school compared to other subjects such as algebra, numbers, statistics, and probability. This is because of the many concepts contained in geometry and its abstract nature, so that in teaching geometry the teacher needs to plan it well so that it can be understood by students.

In addition, related to improving students' creative thinking ability, it is also necessary to study students' mastery of computers. According to research conducted by (Lai & Cheung, 2019) entitled "The effects of a creativity training program on creativity and critical thinking among primary school students in Hong Kong", it was found that systematically structured creativity training can help improve creative thinking skills and critical in elementary school students in Hong Kong. Meanwhile, according to research conducted by (Csikszentmihalyi & Wolfe, 2014) entitled "New Approaches to Creativity Training: A Social-Psychological Approach", it was found that mastering the use of information and communication technology, including computers, can help improve students' creative thinking skills. In conclusion, creativity training and mastery of information and communication technology, including computers, can help improve students' creative thinking skills. The low ability to think creatively mathematically can be caused by learning at school which generally only trains convergent thinking processes, limited to verbal reasoning and logical thinking. So that students will be accustomed to convergent thinking and when faced with problems, students will have difficulty solving problems creatively and will provide an uninteresting learning experience, especially in learning mathematics. So, to overcome these problems, the help of *software* that stimulates creativity is needed which can improve student curiosity to solve various mathematical problems in learning geometry in the classroom, so that all students are involved in the learning. This *software* does not rule out the possibility of using the GeoGebra application. Nur (2016) revealed that there are three uses of geogebra in learning mathematics, namely mathematics learning media, tools for making mathematics teaching materials, and tools for solving math problems.

GeoGebra can be used as a medium for learning mathematics, especially related to geometry. GeoGebra was developed by Markus Hohenwarter, which is a dynamic and free application that can be used by anyone, including students. GeoGebra is very useful for demonstrating and visualizing mathematical concepts, especially geometric objects. (Mahmudi, 2011). The use of learning media such as Geogebra is also important in improving students' creative thinking ability because the use of learning media can build understanding and mastery of learning objects. Geogebra is a mathematical software that combines geometry, algebra, and calculus. In addition, Geogebra can associate variables with numbers, vectors, and points, find derivatives and integrate functions, and provide commands to find extreme points or roots.

Geogebra is a mathematical software that can help students understand mathematical concepts in an interactive way. By using Geogebra, students can explore and experiment on their own to learn mathematical concepts, so as to arouse students' curiosity about mathematics. Geogebra also allows students to visualize abstract mathematical concepts, so that they can help students understand these concepts better. Thus, Geogebra can help increase students' interest and motivation in learning mathematics. According to (Sari et al., 2016), GeoGebra is a dynamic geometry system software that can construct points, vectors, line segments, lines, conic sections, and functions and then change them dynamically. By using this program, abstract geometric

objects can be made more concrete so that dots, lines and planes can be displayed more attractively and clearly. Mahmudi (2011) said that geogebra can be used as a medium for learning mathematics, especially geometry, to demonstrate or visualize geometric concepts and as a tool for constructing geometric concepts.

The purpose of writing this article is to find out whether the use of GeoGebra can direct and foster students' creative thinking ability and curiosity in learning geometry. Thus, the purpose of this literature study is to examine learning geometry, creative thinking abilities, and students' curiosity as well as reviewing how geogebra can direct and enhance students' creative thinking ability as well as students' curiosity in learning geometry and what learning model is appropriate to increase students' curiosity and creative thinking skills in learning geometry.

2. Methodology

The method used in this study is to use the Systematic Literature Review (SLR) method. This method is a systematic, explicit, and reproducible method that aims to identify, study, evaluate, and interpret existing research results and ideas. In this study, a series of review and identification processes were carried out on articles that were relevant to the keywords in this study in a structured manner. The research was structured by following the steps (Triandini et al., 2019) in (Niar et al., 2022), including the following. First, namely by compiling research questions or Research Questions (RQ) or problem formulation. The RQ in this study includes: 1) What are the types and research designs used in articles about improving creative thinking ability and curiosity in geogebra-assisted geometry learning in 2016-2023; 2) What are the selected learning models in improving creative thinking ability and curiosity in Geogebra-assisted geometry learning 2016-2023; and 3) How is the research trend of learning geometry on the ability to think creatively and curiosity in 2016-2023.

The next step, second step is the Search Process or the search process used to obtain relevant sources and used to answer the formulation of the problem or research question. The search process is used to obtain relevant data to answer research questions. The process was carried out using the Google Scholar and ResearchGate databases with the keywords geometry, creative thinking ability, curiosity, GeoGebra, geometry, mathematical creativity ability, curiosity.

The third step is inclusion and exclusion criteria (see **Table 2. 1**). Inclusion and exclusion criteria were used to determine whether the data obtained could be used in this study or not. Inclusion criteria include:

Table 2. 1 Inclusion and Exclusion Criteria

Inclusion	Exclusion
National or international articles that are relevant to learning geometry to improve mathematical creative thinking ability and curiosity with the help of GeoGebra.	National or international articles that are not relevant to learning geometry to improve mathematical creative thinking ability and curiosity with the help of GeoGebra.

National or international articles in accordance with the title and research topic.	National or international articles that do not match the title and research topic.
Articles published in 2016-2023.	Articles published before 2016.
The language used is Indonesian or English.	The language used is other than Indonesian or English.

Fourth, namely, Quality Assessment (QA). The data obtained is then evaluated according to the following assessment criteria. The QA in this study is (QA1) Was the article published in 2016-2023?; (QA2) Does the article indicate the type of research, or research design used?; and (QA3) Does the article write down the learning model used? The fifth is data collection. The data collected for study in this study is primary data, namely data collected through interviews, observations, surveys, or according to needs. Next, data analysis. The data that has been collected is then analyzed according to the RQ. The last step is deviation from protocol. During the research there was a change that was to refine our equivalents for keywords in the database.

3. Result and Discussions

A literature search was conducted in February 2023, articles obtained based on the year of publication within the 2016-2023 timeframe using the keywords "creative thinking ability", "curiosity", and "geometry" obtained 26 articles relevant to the keywords used. The research data related to this article are documented as shown in **Table 3. 1.**

Table 3. 1 Documentation of Research Results

Source	Author, Year	Journal Category	Research result
Google Scholar	(Saputra, 2016)	Pythagoras: Journal of Mathematics Education	Geogebra-assisted geometry learning is more effective than Cabri-assisted geometry learning in terms of the aspects of mathematics learning achievement, creative thinking and student self-efficacy.
Google Scholar	(Yullah et al., 2022)	Axiom: Journal of Mathematics Education Study Program Volume	Teaching and learning activities with the GeoGebra-assisted discovery model make students' creative thinking abilities improve in reflection geometry transformation material.

Google Scholar	(Asri et al., 2020)	Vygotsky: Journal of Mathematics and Mathematics Education	GeoGebra class students are more active in learning activities than puzzle class students. Geogebra class students explore so that they can come up with new ideas without any size limit. So that there is an improve in students' creative thinking abilities.
Google Scholar	(Niar et al., 2022)	ProSandika (Proceedings of the National Mathematics Education Seminar)	The effectiveness of geogebra applications in ethnomathematics learning by applying mathematical creative thinking abilities and curiosity characters has improved in spatial geometry material.
Google Scholar	(Saironi & Sukestiyarno, 2017)	Unnes Journal of Mathematics Education Research	There is a positive influence of the character of students' curiosity on students' mathematical creative thinking abilities, as well as an improve in students' curiosity characters, the ability of students' mathematical creative thinking processes using learning with OEL strategies.
ResearchGate	(Tambunan, 2016)	Journal of Formative Scientific Education MIPA	The learning strategy chosen by the teacher will have a major influence on the level of achievement of learning objectives that focus on students' mathematical creative thinking abilities. In creative thinking students are able to solve math problems from various different perspectives
ResearchGate	(Aminy et al., 2021)	Malikussaleh Mathematics Education Journal	Problem Based Learning learning model is better than students' mathematical

			creative thinking abilities through a scientific approach.
ResearchGate	(Fajriadi et al., 2022)	Theorems: UNIGAL Mathematical Theory and Research	GeoGebra can be used as a tool to help create digital math textbooks or materials and can be used as online student worksheets to solve math problems in three-dimensional material to improve creative thinking ability and curiosity.
ResearchGate	(Pianda & Rahmiati, 2020)	Al Khwarizmi: Journal of Mathematics Education and Learning	Learning by applying the Google Classroom approach as a digital class with the GeoGebra Application, the creativity in learning mathematics for class X students has improved.
ResearchGate	(Majerek, 2017)	Advances in Science and Technology Research Journal	Utilization of the introduction of dynamic mathematical applications in the learning process is going well. Current trends in science teaching call for the use of visualization techniques, and GeoGebra fits right in with this trend.
Google Scholar	(Muryaningsih, 2020)	Scholar: Professional Journal of Academics of Elementary School Teacher Education Study Program	Realistic mathematics learning model (PMR) can improve the attitude of curiosity and student achievement on the material circumference and area of flat shapes on the improve in student curiosity occurs from sufficient criteria to good criteria. During the learning process, improving students' curiosity is inseparable from the activities of the teacher who always provides guidance, motivation, and guides students during the learning process.

Google Scholar	(Purba & Harahap, 2021)	Scholar's Journal: Journal of Mathematics Education	Cooperative script learning model assisted by the GeoGebra application has a greater influence on students' mathematical creative thinking abilities than conventional learning methods.
ResearchGate	(Khairunnisa et al., 2021)	Imaginary: Journal of Mathematics and Mathematics Education	Improving students' creative thinking ability is done by the teacher having to make the learning design as attractive as possible so that students can explore the problems given, so that many solutions emerge from students.
Google Scholar	(Sariningsih & Kadarisma, 2016)	Scientific Journal of UPT P2M STKIP Siliwangi	There is an achievement of students' mathematical creative thinking abilities by using ethnomathematics-based learning.
ResearchGate	(Rizal Usman & Humairah Halim, 2018)	Journal of Majamath UNIM	Geogebra has a better influence on developing students' mathematical creative thinking abilities.
Google Scholar	(Shoit & Masrukan, 2021)	PRISMA: Proceedings of the National Mathematics Seminar	Learning problem posing based on open ended problems with performance assessment is effective for students' mathematical creative thinking abilities, students with high curiosity meet the indicators of fluency, flexibility, and novelty.
Google Scholar	(Dewi et al., 2022)	PRISMA: Proceedings of the National Mathematics Seminar	The use of blended learning learning models can improve students' curiosity and creative thinking ability in learning.
Scopus	(Yanty Putri Nasution et al., 2020)	Journal of Physics: Conference Series	There is a significant improve in the relationship between students' creative thinking abilities and students' creative

			thinking dispositions through an open-ended learning approach on area and volume problems.
Scopus	(Selvy et al., 2020)	Journal of Physics: Conference Series	Students' mathematical creative thinking ability improved taught using the PBL model with GeoGebra was higher than those who taught using the PBL model without software. GeoGebra to build mathematical concepts such as geometry and make a positive contribution to improving mathematical creative thinking ability because it shifts learning mathematics to be more fun and interesting.
Scopus	(T. Wijaya et al., 2021)	Journal of Physics: Conference Series	Each student's level of creative thinking has different categories based on fluency, flexibility, and novelty and based on each student's van Hiele ability level.
Google Scholar	(Nurhanifah, 2022)	Journal of Mathematics Learning Innovation: PowerMathEdu (PME)	The ability to think creatively mathematically is still low because the learning carried out by the teacher is not suitable to be able to develop students' mathematical creative thinking abilities which are less varied and less enjoyable which in turn results in low enthusiasm for learning, enthusiasm, and enthusiasm for student learning so that it can hinder the process of receiving learning.

Google Scholar	(Simatupang, 2020)	Medan State University	The application of the Problem Based Learning learning model with the Scientific Learning approach assisted by Geogebra media to students in class VIII can improve students' mathematical creative thinking abilities.
Google Scholar	(Haifatudzikroh, 2019)	Education National Seminar, FKIP UNMA	The use of the discovery learning model has a positive effect on the ability to think creatively mathematically and students' curiosity. Because this model transforms information so that it finds new information that can support indicators of mathematical creative thinking.
Google Scholar	(Solehuzain & Dwidayati, 2017)	Unnes Journal of Mathematics Education Research	Problem-based learning with open ended problems is effective for students' mathematical creative thinking abilities and curiosity. There is a significant influence of students' curiosity on the ability to think creatively mathematically.
Google Scholar	(Octaviyani et al., 2020)	Journal on Mathematics Education Research	The ability to think creatively mathematically after the application of the Project-Based Learning model with the STEM approach has improved compared to before applying learning in the high category
Google Scholar	(Kurnia & Tasman, 2022)	Journal of Mathematics Education and Research	The use of Geogebra Classroom is categorized as quite effective and can improve creative thinking ability on quadrilaterals and triangles for class VII SMP.

Research trends for the last seven years were obtained from the results of bibliometric data processing using VOSviewer as shown in **Figure 3. 1** The same color indicates the same cluster, and the circle size indicates the popularity of the keywords. The larger the circle size, the more popular the topics covered in the 26 articles. The connecting lines between the circles mark the direct relationship between the keywords.

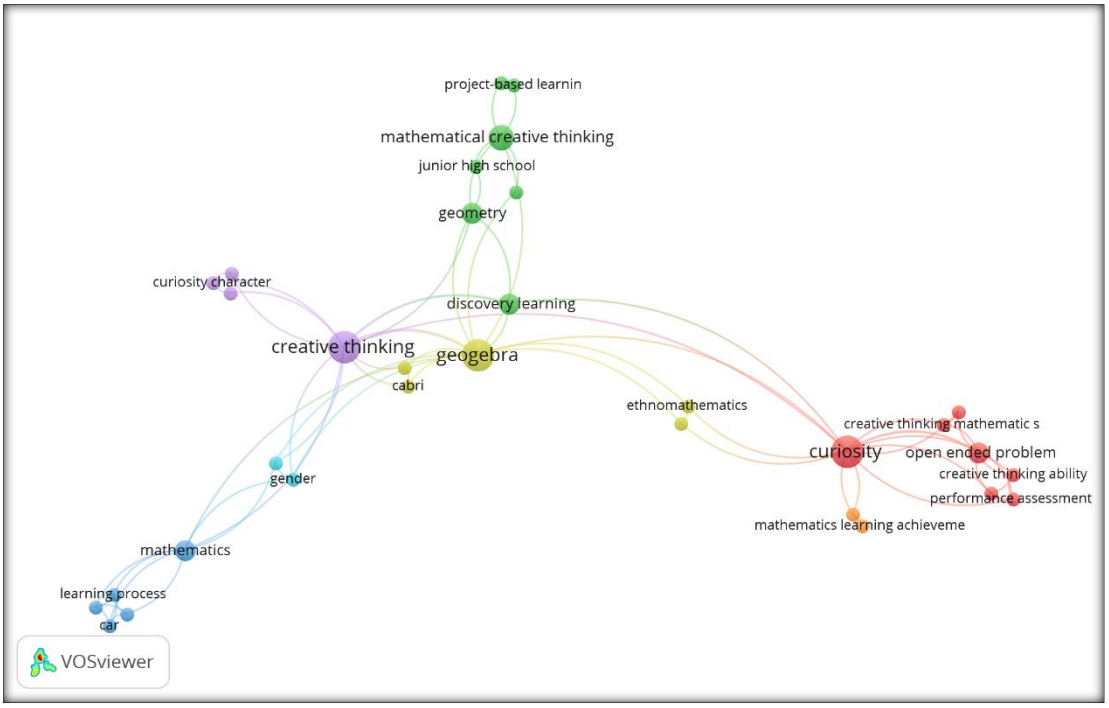

Figure 3. 1 The Keyword Network Visualization of 26 Articles

The size of the circle for each keyword (**Figure 3. 1**) shows the level of popularity of the 26 research titles processed. The larger the circle size, the greater the use of keywords in research. This indicates that the variable has previously been studied extensively. The direct relationship between the keywords 'creative thinking' and 'creative thinking mathematically' with other keywords is presented in **Figure 3. 2**.

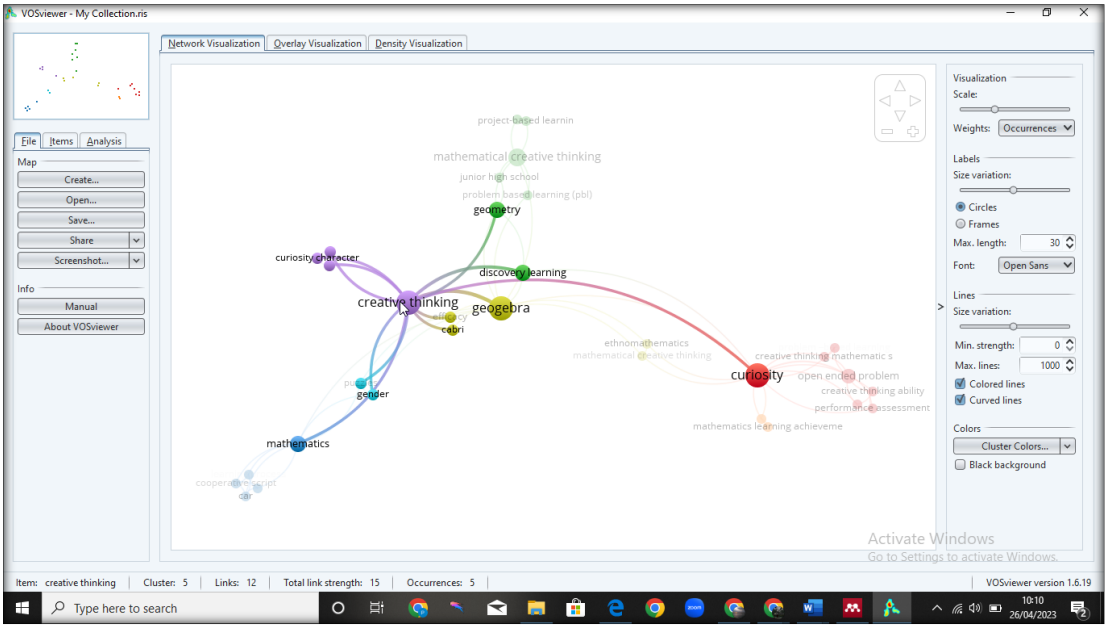

Figure 3. 2(a) The Relationship of 'Creative Thinking' with Other Keywords

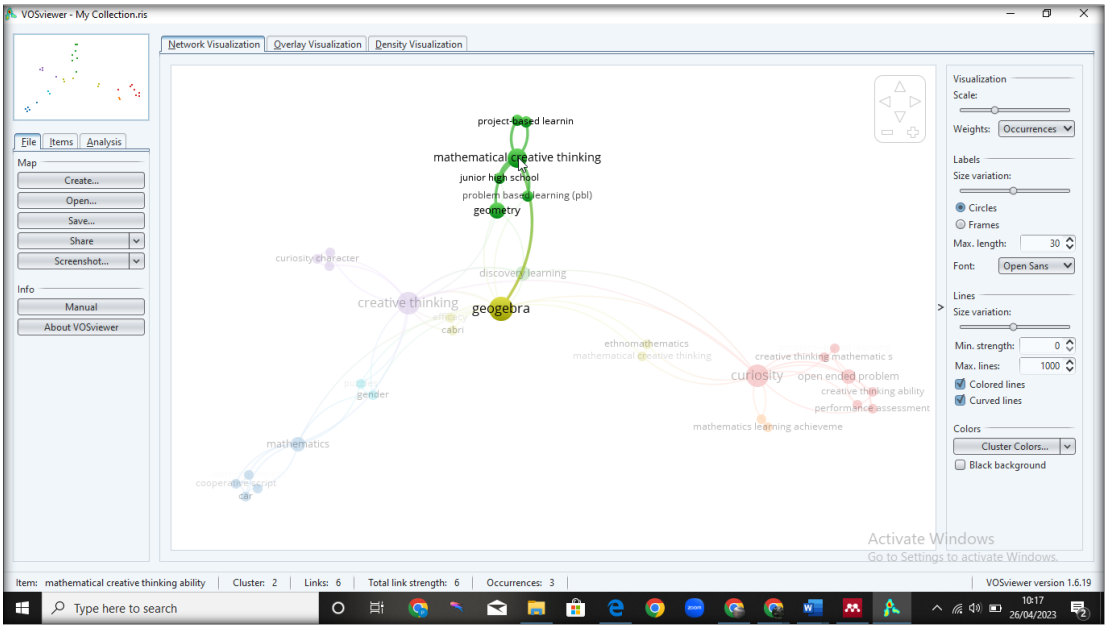

Figure 3. 2(b) The Relationship of 'Mathematical Creative Thinking' with Other Keywords

Figure 3. 2(a) informs that the keyword 'creative thinking' is included in cluster 5 with 12 links and **Figure 3. 2(b)** informs that the keyword 'mathematical creative thinking' is included in cluster 2 with 6 links. Popular keywords related to 'creative thinking' are curiosity, geogebra, geometry. These keywords are in three different clusters, namely those in clusters 1 (red), 4 (yellow), and 2 (green). Then, popular keywords related to 'mathematical creative thinking' are geometry, geogebra, problem-based learning. These keywords are in three different clusters, namely those in clusters 2

(green), 2 (green) and 4 (yellow). This can be interpreted that of the 36 studies conducted, the keywords in the six clusters are most likely to be topics in one research title.

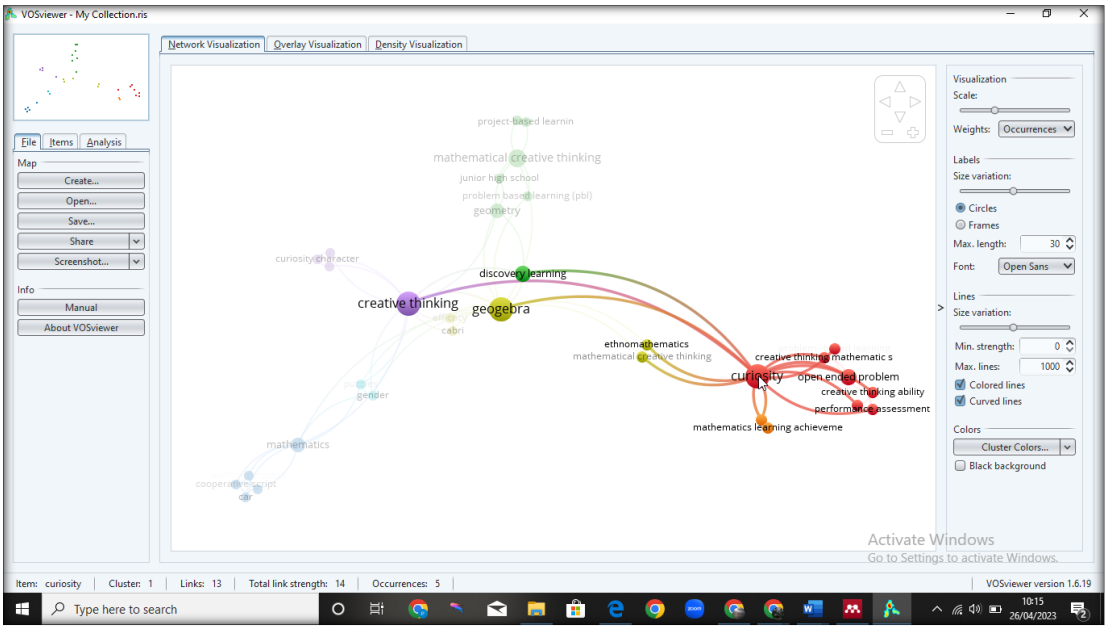

Figure 3. 3(a) The Relationship of 'Curiosity' with Other Keywords

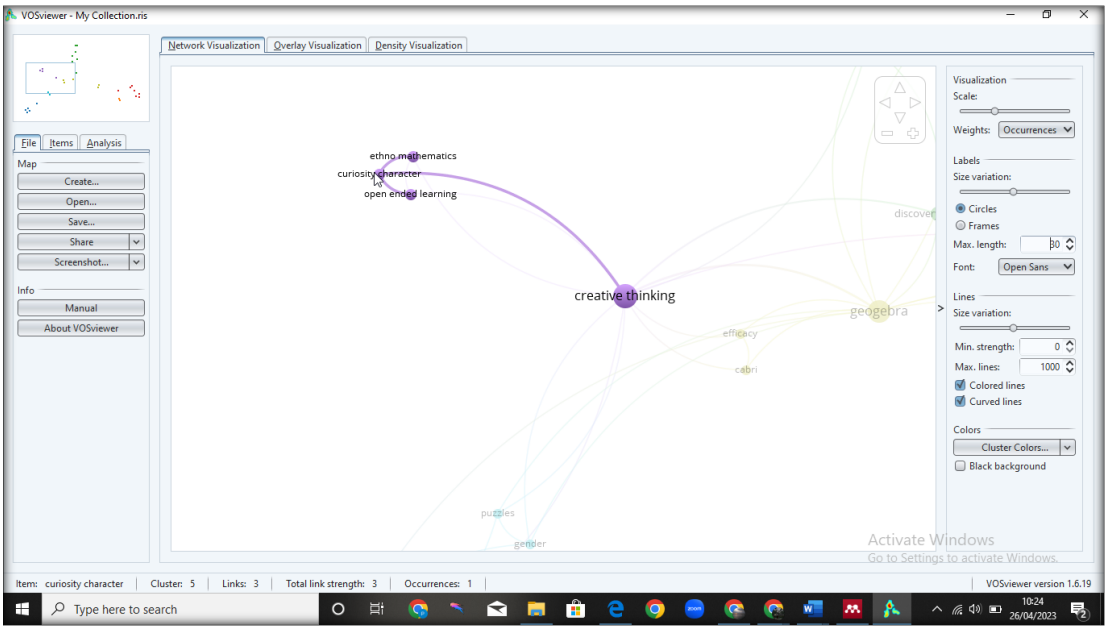

Figure 3. 3(b) The Relationship of 'Character of Curiosity' with Other Keywords

Figure 3. 3(a) informs that the keyword 'curiosity' is included in cluster 1 with 13 links and **Figure 3. 3(b)** informs that the keyword 'character of curiosity' is included in cluster 5 with 3 links. This can be interpreted that of the 26 studies conducted, keywords that are related to links and have large circle sizes are most likely to be topics in one research title.

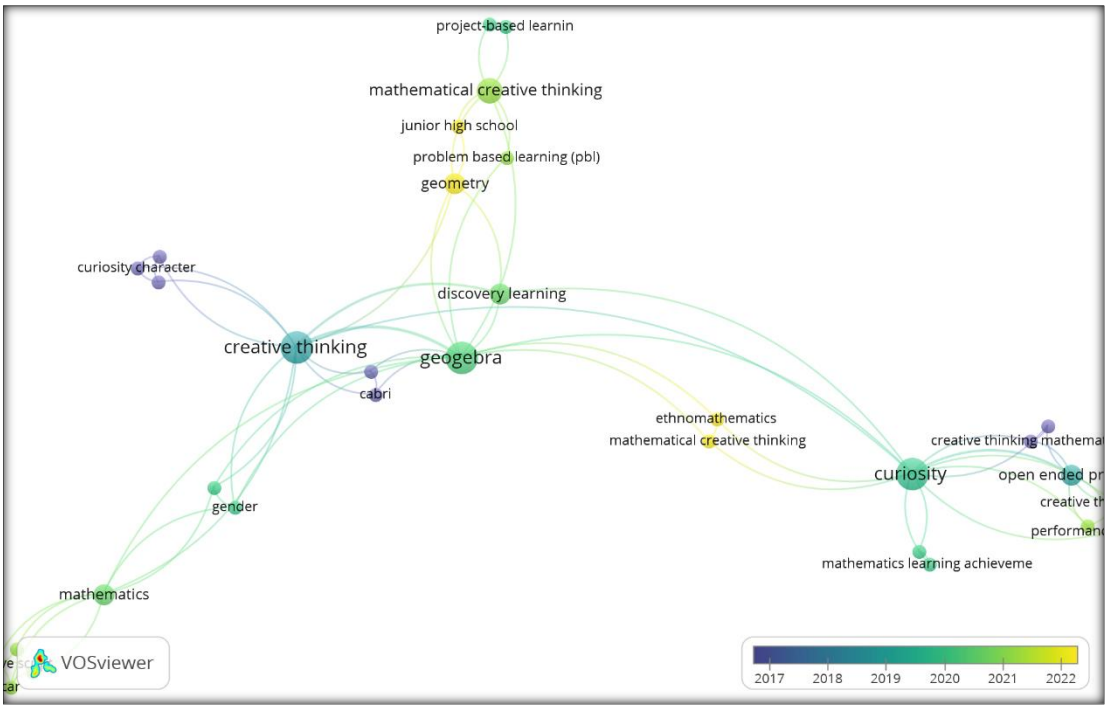

Figure 3. 4 Publication Trends from 2017 to 2022

These trends, as shown in **Figure 3. 4**, are indicated by color, with lighter markings indicating more recent publications. Recent publications, denoted in yellow, indicate that the trend includes keywords such as junior high school, geometry, ethnomathematics and mathematical creative thinking. For researchers, information about topic novelty is important to show the current state of research conducted in accordance with the times.

Of the 26 articles that have been reviewed, the authors come from Indonesia, and outside Indonesia. This research in Indonesia can be developed on learning media, learning models and approaches.

1. **What Types, and Research Designs are Used in Articles on Improving Creative Thinking Ability and Curiosity in Geometry Learning GeoGebra Assisted from 2016-2023?**

In **Figure 3. 5** shows 26 articles, there are 5 types of research used in learning geometry to improve mathematical creative thinking ability and geogebra-assisted curiosity characters published in 2016-2023. Quasi-experimental research illustrates that this type of research tends to be used more in research on learning geometry to improve mathematical creative thinking ability and curiosity with the help of geogebra.

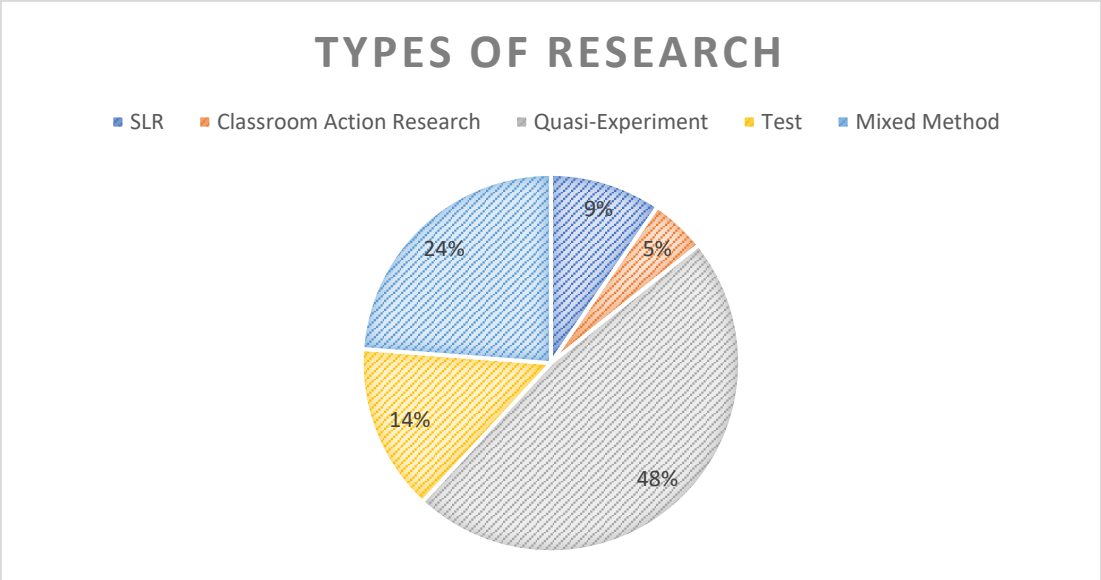

Figure 3. 5 Types of Research

Then in **Figure 3. 6**, provides an overview of the research design used to determine the improve in mathematical creative thinking ability and the character of curiosity in geogebra-assisted geometry learning in 2016-2023. It can be seen that the pretest-posttest control group design tends to be used in research on improving geometry learning on mathematical creative thinking abilities and geogebra-assisted curiosity characters.

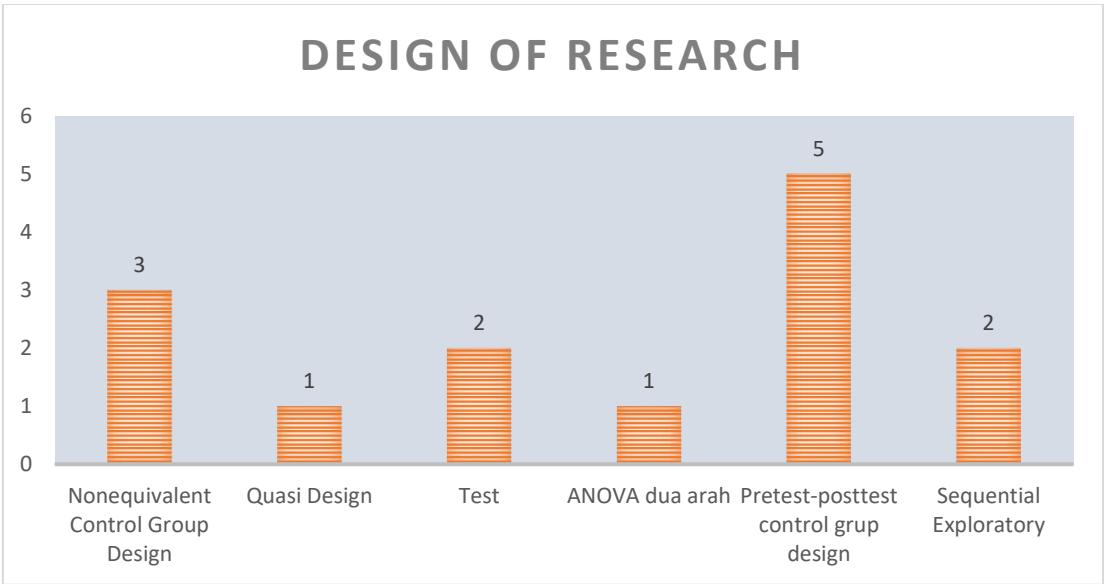

Figure 3. 6 Research Design

2. What are the learning models chosen in the article on Improving Creative Thinking Ability and Curiosity in Geometry Learning GeoGebra Assisted from 2016-2023?

Figure 3. 7 illustrates the learning model used in research on geometry learning to improve mathematical creative thinking abilities and geogebra-assisted curiosity characters in 2016-2023. The figure shows that the Problem Based Learning learning model tends to be used in this study which was published in 2016-2023.

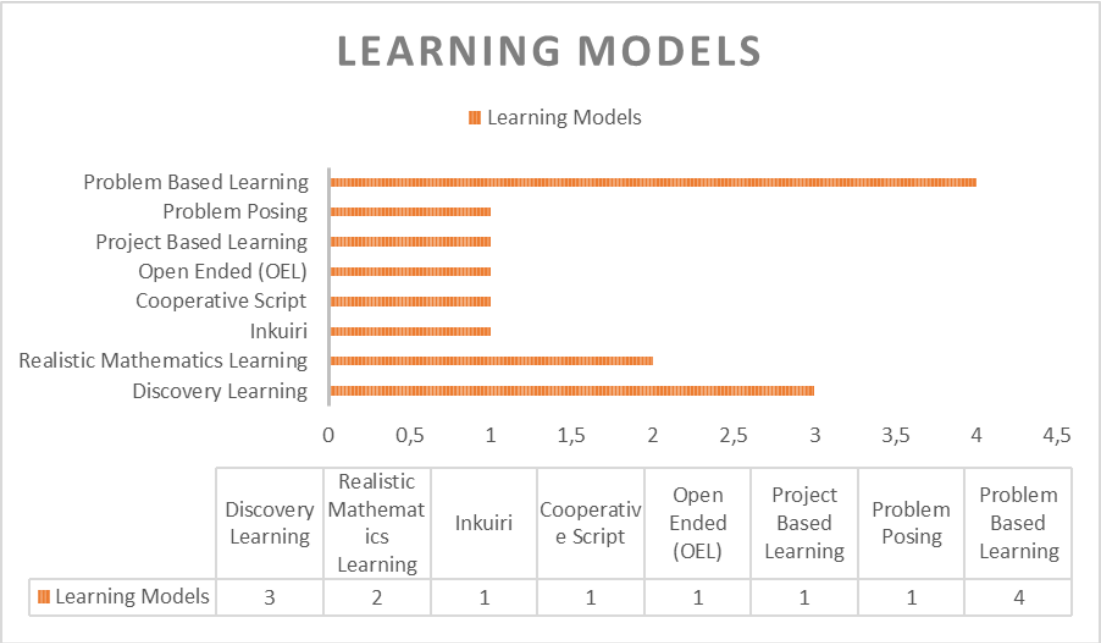

Figure 3. 7 Learning Models

3. What is the research trend of Improving Creative Thinking Ability and Curiosity in Geometry Learning GeoGebra Assisted in 2016-2023?

Figure 3. 8 shows that research regarding learning geometry on improving the ability to think creatively mathematically and the character of curiosity in 2016-2020 3 . Research at the elementary level shows a percentage of 9% , SMP/MTs 50%, SMA/MA 27% and SMK 14% . It can be concluded that research on improving creative thinking ability and curiosity in learning geometry tends to be conducted in junior high schools .

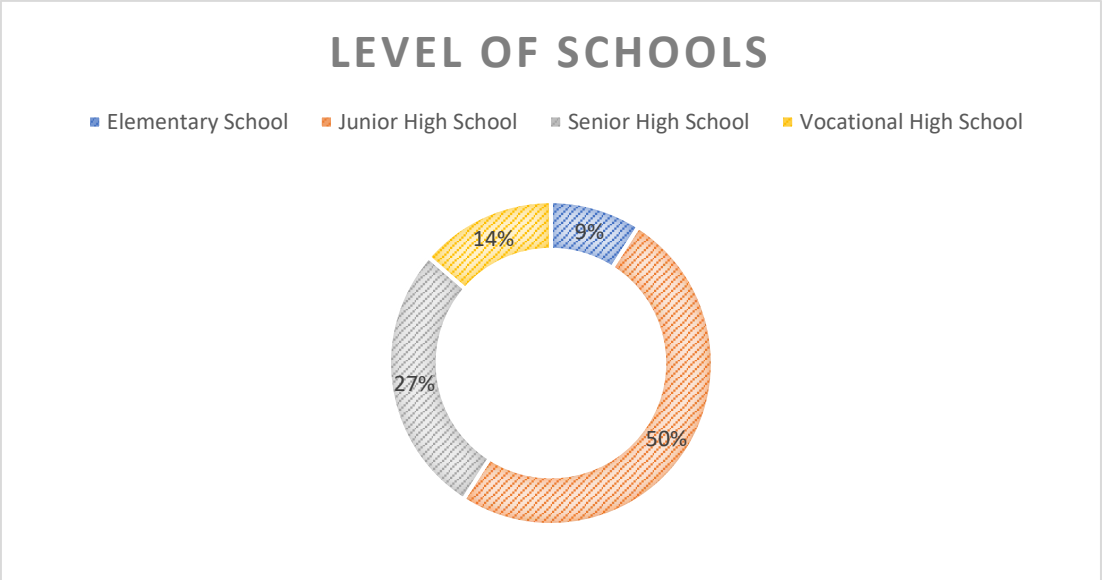

Figure 3. 8 Educational Level

4. Conclusion

Based on the results and discussion of the literature review of 26 articles published in 2016-2023, it can be concluded that. First, research on creative thinking ability and curiosity in geogebra-assisted geometry learning was found to have a tendency to test the effectiveness of geogebra to improving creative thinking ability in geometry learning, while the effectiveness of geogebra to improve the character of curiosity in geometry learning is in second place and can be an alternative research focus that can be developed again. Then the next trend is the use of quasi-experimental research types, as well as the tendency to choose a pretest-posttest control group design. Second, in research on improving creative thinking ability and curiosity in geometry learning geogebra-assisted published in 2016-2023 it was found that they tend to use the Problem Based Learning learning model. Third, research on improving the ability to think creatively and curiosity in learning geometry with the help of geogebra is more often done in junior high school students.

Then from the results and trends obtained, future research is still relevant to be carried out regarding the effectiveness of mathematical creative thinking abilities and curiosity in relevant methods or models.

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