Research Article

Mathematics Proficiency -- A Systematic Literature Review

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Abstract.
There have been a significant number of studies on mathematical proficiency; however, there are no classifications on research related to it. This study aims to gather and analyze previous studies on mathematical proficiency based on its publication year, research subject, methods, and results. This research is a survey-based descriptive study using the SLR method. The survey was conducted with secondary data in the form of research articles on mathematical proficiency at all educational levels, teachers and students were also included from 2010 to 2020. The steps included in this research were data collection, data analysis, and conclusion. Collected data were in the form of research articles published in international journals and proceedings indexed in Scopus and other trusted databases, such as Thomson, Google Scholar, Science Direct, and Eric databases. The results show that the majority of research on mathematical proficiency was the ones performed in the year 2019 with percentages of 20% and 16%, and the most significant subject were junior high school students with 21%. Results on mathematical proficiency were based on the level of proficiency, positive and negative correlations between mathematical proficiency and other variables, efforts in improving mathematical proficiency, and the assessment of mathematical proficiency. The results suggest that this research could support further studies on mathematical proficiency.

Keywords: mathematics proficiency, systematic literature review.

1. INTRODUCTION

The shift from Industrial Revolution 4.0 to Society 5.0 affects all aspects of life, especially in the technology and informational system [1]. During this transition, communities can access information instantly as it reaches even the remotest area in the world. Such effect presents challenges to students, as they have to manage, sort, and respond to the information to take its full benefit and apply it to their own lives [2]. To do so, they have to possess the ability to think creatively, logically, systematically, and critically. The ability to think creatively, logically, systematically, and critically is ideally nurtured in the classroom, specifically during math lessons [3]. Mathematics is a compulsory

course at all levels of education. Learning mathematics is deemed a success if students can solve mathematical problems, or in other words, possess mathematical proficiency. Mathematical proficiency is the ability to comprehend mathematics functions as a whole. Mathematical proficiency consists of five components – conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. These mathematical proficiencies need to be developed in each individual. Mathematical proficiency is able to develop the process of understanding concepts so that students have a conceptual understanding of mathematics that can help students in solving problems in daily life. Therefore, mathematical proficiency is an indispensable ability in the transition era of the industrial revolution 4.0 to the era of society.

Several kinds of research have been conducted on mathematical proficiency [4], concluded that their research subjects have moderate mathematical proficiency [5], in her study stated that their high school students possessed adequate proficiency. Similar results are shown in [6], in which the high school students' mathematical proficiency is quite significant, [7] reported that proficiency can be improved using the multi representation approach, further emphasized that the use of ICT also improves proficiency. Various studies have been conducted on mathematical proficiency, and they mostly focused on strands of mathematical proficiency and how to improve them. However, there is no research that explains and classifies how the development of research on this mathematical proficiency has been conducted. This concept is fundamental in this Systematic Literature Review. This Systematic Literature Review on mathematical proficiency aims to see an overview of research developments over the last 10 years (2010-2020). Thus, through this SLR previous research on mathematical proficiency' can be collected and analyzed. The analysis can be done by classifying the articles of the research based on the year of publication, subject, methodology, and the results of their research. The results will describe the development of previous research and can also direct the further research needed on this mathematical proficiency. In other words, SLR can also be used as a benchmark for developing other research related to mathematical proficiency. Based on the collected data, relevant research questions are as follows:

1. How do the studies describe mathematical proficiency in relation to their publication year?

2. How do the studies describe mathematical proficiency in relation to their research subject?

3. How do the studies describe mathematical proficiency in relation to their research methodology?

4. How do the studies describe mathematical proficiency in relation to their research results?

2. RESEARCH METHOD

This study is descriptive research based on SLR (systematic literature review) method. The SLR was conducted on secondary data in the form of research articles on mathematical proficiency on each educational level, teachers and students included. The steps included in this research are data collection, data analysis, and conclusion. Data were collected in the form of research articles published in international journals and proceedings indexed in Scopus, and other trusted databases such as Thomson, Google Scholar, Science Direct, Taylor and Fancis, Sage and Eric databases. The studies are activated; only those that follow the inclusion criteria are used. The inclusion criteria are as follows: (1) The article is a study on mathematics education. (2) The published year is between 2010 – 2020. (3) The article is related to mathematical proficiency

The population in this study were all the research articles on mathematical proficiency. The search query results in 100 sample articles that follow the inclusion criteria. After the articles are found, the authors classify the categories. To make this classification process easy, a table is used. his paper aims to conduct a comprehensive study of the research carried out during the mathematical course, the author also comprehensively analyzes, categorizes, compares. The research instrument was in the form of an observation sheet that connects the inclusion criteria to the exclusion criteria classified based on the articles' published year, duration of the experiment, education level, and the sample size. In each section, we report by percentage for each category. In the last section, the author writes in the form of a table about a resume regarding the research on mathematical skills from 10 years ago (2010-2020).

3. RESULT AND DISCUSSION

This study found 100 articles that follow the inclusion criteria. These articles were from Scopus indexed databases, including Thompson, Google Scholar, Science Direct, and Eric databases. The articles were then classified based on their publication year, research subject, methods, learning materials, and other variables related to other studies. The discussion is as follows:

3.1. Publication year

The research articles classified in this study are from the year 2010 to 2020. The range of publication year is shown in Figure 1 below.
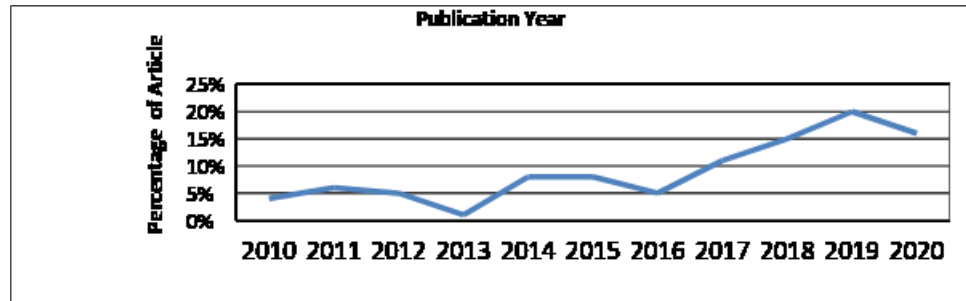

Figure 1: The classification based on publication year.

Based on Figure 1, research on mathematical proficiency tends to increase each year, especially in the year 2010 and 2020. Researchers performed studies mostly in the year 2019 and 2020 with a percentage of 20% and 16%, and the trends of mathematical proficiency reached their peak in 2010 until today. Meanwhile, research on mathematical proficiency was at least carried out in 2013 with a percentage of 1%. As a result, there is a possibility that more research will come out in the future.

3.2. Research subject

The next classification is based on the research subject. Research subjects consist of students, as in nursery/kindergarten, elementary school, junior high school, senior high school, college students; and teachers, such as elementary school, junior high school, senior high school, general education teachers, and university professors. The results of the research subject classification are shown in Figure 2 below.

Figure 2: The classification based on research subject.

Figure 2 shows that the majority of research on mathematical proficiency is conducted on junior high school students with a percentage of 21%. Furthermore, at the elementary school level, this research has also been carried out with a percentage of 19%. While the

least research is done on lecturers and professors with a percentage of 2%. The figure also shows that studies on proficiency are not only performed in formal institutions. It can be seen that research was also conducted in early childhood education, which further proves that research on mathematical proficiency is possible at the nursery/kindergarten level. This finding is in line with related theories on mathematics education that support the application of maths in daily life. It also supports the notion that mathematics should be taught even at the earliest level of education. Furthermore, research on mathematical proficiency was also conducted on teachers and university professors. In short, the proficiency needs to be improved on teachers and university professors as well. Teachers and professors are the central components that could help elevate their students' mathematical proficiency; thus, teachers and university professors should be proficient in the first place.

3.3. Research Method

A research methodology is a primary indicator of research. Good research follows the procedure mentioned in its research methods. The research methods in this study are classified into the quantitative, qualitative method, developmental research, and mixed-method research. The results of the classification are shown in the diagram below.
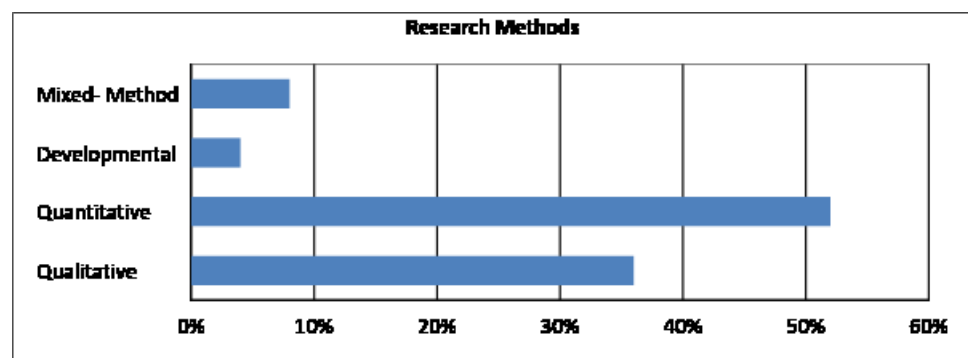

Figure 3: The classification based on the research method.

Figure 3 shows that the majority of the research was quantitative research with a percentage of 52%. As such, studies on mathematical proficiency yield accurate results of interactions between mathematical proficiency and other variables. The diagram also shows that research on proficiency is also conducted in qualitative with a percentage of 36%, developmental of 4%, and mixed-method research of 8%. It is evident that various methods are applicable to research on mathematical proficiency.

3.4. Other studies related to mathematical proficiency

Mathematical proficiency is the ability to comprehend mathematics functions through conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Proficiency becomes a trend in the last decade due to the reform in mathematical education, as it stresses the importance of both individual mathematical competency and an encompassing understanding of math. This study found various kinds of research results related to mathematical proficiency. Based on the classification and the analysis of the research articles, the researchers concluded the data below. The first classification is on the level of mathematical proficiency. This survey found one research article that states the variety of elementary students' mathematical proficiency [8] One study states that the students displayed a sophisticated range of mathematical reasoning while another article mentioned that the students' proficiency is below average [9] conducted a study on a sample size of 30, while [9]conducted the study on a national scale. Based on the disparity and the sample size, the elementary school students' proficiency is still below average. Also, six articles on the mathematical proficiency of junior high school students show that students are quite proficient. One article reported that junior high school students displayed low proficiency [10]. Thus, this suggests that junior high school students are proficient. At the high school student level, there was one article that stated that high school students displayed proficient mathematical reasoning [11]. Other studies report that the students' mathematical proficiency was below average [12]. These findings suggest that the high school students' mathematical proficiency is still below average. The survey also found two articles in which college students possessed an adequate level of proficiency [13]. These studies suggest that students at the university level are proficient.

Another finding revealed that two articles mentioned that teachers are moderately proficient [14], while six articles described teachers' mathematical proficiency as low. One study also mentioned that teachers often have misconceptions about mathematics learning process [15]. Besides, one article also states that teachers have low motivation to teach. These findings suggest that teachers' mathematical proficiency needs to be improved. The next category is that mathematical proficiency has a positive correlation with various other variables. A positive correlation is a direct relationship between variables. If one variable increases, the other variable also increases, or vice versa. Mathematical proficiency has a positive correlation with brain structure, socioeconomic level[16][16][16] [1-16] computational thinking skills [2-17][17][17][17] language proficiency,

conceptual understanding**,** motor skills, critical thinking skills, self-concept, spatial abilities, motivation, learning methods, attitudes, writing skills, skills attitudes functions, learning achievement cowan, ICT skills [3-18][18][18][18], knowledge and attitudes [1-16][16][16][16], as well as reading skills [4-19][19][19][19].

In conclusion, the researchers found that the most common correlation was between language skills and mathematical skills. This result suggests that the higher an individual's language skills, the higher their mathematical skills. Language skills possessed by students allow them to understand problems in mathematics. Twenty-nine articles reported correlations between mathematical proficiency and other skills. This finding suggests that research related to mathematical proficiency is associated with many abilities. In addition to positive correlation, other studies also yield negative correlation. A negative correlation is a relationship between two variables in which one variable increases as the other variable decreases and vice versa. The survey found three negative correlations of mathematical proficiency: learning anxiety, math anxiety [20][20][20][5-20] and learning attitudes [21]. The results suggest that the lower the students' level of general anxiety, mathematics anxiety, and students' attitudes, the higher their mathematical proficiency, and vice versa. This negative correlation suggests that the mathematical proficiency variables can also have opposite results. In addition to positive and negative correlations, this study also found several variables that have no relationship with mathematical proficiency. The variables that do not correlate include language proficiency, gender, study program, [6]-[22] and [23] learning method, representation and reading skill [23]**.** Thus, not all variables have a relationship with mathematical proficiency.

Furthermore, this study also classified articles based on the process of developing mathematical proficiency. Several factors affect mathematical proficiency, one of which is the learning strategy. The learning strategy is instructional plans made by the teacher to achieve learning objectives. Several learning strategies that are proven to improve mathematical proficiency are the ball game method, ICT-based learning [24], multi-representational approach, learning outside the classroom, web-based learning [25], problem-based learning, learning with games activity-based learning and blended learning [26]**.** These findings suggest that the development of mathematical proficiency is mainly through the learning process. This study also found research related to the assessment of mathematical proficiency. Results related to the assessment of mathematical proficiency include one article in 2012, in which there was no assessment of mathematical proficiency [27] and one article in 2018 where there was no standardized mathematical proficiency assessment me**.** A study in 2019 reported the

development of assessment indicators and in 2020, two articles presented a mathematical proficiency assessment and the development of a digital diagnostic tool for mathematical proficiency[24, 25, 28]. These findings suggest that there has been a development in the assessment of mathematical proficiency. Assessment is an essential element in measuring one's proficiency. In conclusion, there are four main categories of research articles in mathematical proficiency, namely research results that state the level of mathematical proficiency, positive and negative correlation between mathematical proficiency and other variables, efforts to improve mathematical proficiency, and the process of assessing proficiency. The findings suggest that mathematical proficiency has been developed in the teaching and learning of mathematics.

4. CONCLUSION

Based on the 100 articles reviewed on this SLR by year of publication, subject, methodology, and research results, it was concluded that: 1) the mathematical proficiency research process most often occurred in 2019 and 2020, 2) research was often carried out on junior high school students, 3) research that mostly consists of quantitative research, 4) results of research related to mathematical proficiency in the form of research results stating the level of mathematical proficiency, positive and negative correlations of mathematical proficiency, efforts to improve mathematical proficiency and the process of assessing mathematical proficiency. The subjects of the research on mathematical proficiency were mostly junior high school students, followed by high school and elementary school students. Meanwhile, research on mathematical proficiency in lecturers and professors is the least carried out. We encourage researchers to conduct further research on this mathematical proficiency, not only at the elementary and secondary levels, but also at the higher education level.

Acknowledgments

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