Prior Achievement, Self-efficacy, and Mathematical Literacy on Uncertainty and Data Content of Senior High School Students

A Muhazir1, K Hidayati2, H Retnawati3

1,2,3Mathematics Education, Graduate Program, Yogyakarta State University, Indonesia

1Ahmadmuhazir.2018@student.uny.ac.id

**Abstract**. Mathematical literacy as a unity of ability to think critically, creatively, use information, think systematically, communicate, and reflect is an ability that needed in 21st century which is uncertain and rapidly changing. Through mathematical literacy, real world problems can be done by playing the role of mathematics. Belief in ability or self-efficacy is also an important part in problem solving process. Self-efficacy is considered to be able to predict a person's mathematical literacy skills. Apart from self-efficacy, prior achievement can also be a predictor of mathematical literacy. This research is expected to be able to describe mathematical literacy, self-efficacy, and prior achievement of XI grade high school students. The description of the relationship between self-efficacy and prior achievement is also an objective in this study. Based on data collection on 227 students from senior high school in Banjarmasin, the results showed that mathematical literacy was in the low category, self-efficacy in the medium category, and prior achievent students in the high category. There is a correlation between self-efficacy and mathematical literacy with low correlation (.0.3056). There is no correlation between prior achievement and mathematical literacy on uncertainty and data content of XI grade high school.

1. **Introduction**

The change of life in the 21st century towards modern life which is supported by the rapid development of technology has created an increasingly erratic, uncertain, complex, and even ambiguous flow of life. As a provision to be able to keep pace with the world, education and skills are important in responding to every challenge. Through education, a person's way of thinking and perspective on a challenge can change, whether he accepts and faces challenges or allows himself to be defeated by these challenges[1].

The implementation of a good education is the obligation of the state in forming citizens who have the knowledge and skills needed to become full citizens. However, the knowledge obtained in formal education is not all knowledge that can be directly applied in the real world. Not infrequently there are gaps or boundaries between what is obtained through formal education and what happens in the realities of life, especially related to mathematical knowledge. However, education remains an important part of honing skills.

The skills acquired can bridge the knowledge obtained through formal education so that they can reach problems in the real world in order to obtain a solution. So that in the process, mathematics is no longer seen as a separate part of life, not just writing formulas without knowing the benefits of life through critical thinking skills, creative, information use, systematic thinking, communication, and reflection. These skills are part of mathematical literacy..

Mathematical literacy is better known as the identity of the program implemented by the OECD, namely PISA. Although mathematical literacy has been introduced for a long time [2]. Mathematical literacy in the PISA framework used in half a decade (2012, 2015, and 2018) is an individual's ability to formulate, use, and interpret mathematics in various contexts. This includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. Mathematical literacy helps individuals to recognize the role that mathematics plays in the world and to make reasoned judgments and decisions that are needed by citizens who are constructive, actively engaged and reflective [3].

In the 2021 PISA framework, mathematical literacy promotes mathematical reasoning and is supported by individual abilities in formulating, using, and interpreting mathematics in solving problems tailored to the needs of the 21st century. Mathematical literacy is the individual's ability to reason mathematically and to formulate, use, and interpreting mathematics to solve problems in a variety of real-world contexts. It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It helps individuals to know the role mathematics plays in the world and to make reasoned judgments and decisions that are needed by 21st century citizens who are constructive, engaged, and reflective[4].

Turning back, in the period 2000-2009, mathematical literacy is the ability to identify the role that mathematics plays in the world to make reasoned judgments using and involving mathematics with measures that meet the needs of individuals as constructive, caring, and reflective citizens [5, 6, 7, 8]. Of all the definitions put forward by the OECD through PISA, mathematical literacy is a skill to understand and identify the role of mathematics in making rational decisions in solving problems in real life. The problem is not purely a mathematical problem, but is placed in a kind of mathematical situation

[9].

Mathematical literacy is something that is related to real problems, these problems are not purely mathematical problems, but are placed in a kind of mathematical situation [9]. ]. In placing a real problem into a mathematical situation, there is an activity to formulate by making structures, concepts, assumptions or modeling and interpreting mathematics which includes what and how to determine the results of a mathematical problem related to the original (real) problem and determine and carry out the proper way of solving it. This activity is called mathematisation [10].

Mathematics is one of the seven basic skills used in PISA mathematical literacy framework besides communication, representation, reasoning and argumentation, designing strategies to solve problems, using symbols, formal and technical language, and operations, and using mathematical tools [3]. The seven basic abilities are closely related to mathematical literacy in the process domain, namely employ, formulate, and interpret.

The domains of mathematical literacy introduced by PISA include the process domain, content domain, and context domain. The process domain consists of employ, formulate, and interpret. Employ is using mathematical concepts, facts, procedures, and reasoning. Formulating what is meant is formulating a real situation or problem into a mathematical form. Meanwhile, interpret is interpreting, applying, and evaluating mathematical outcomes. The content domain contains mathematical content, namely quantity, changes and relationships, space and form, as well as uncertainty and data. Regarding content in mathematical literacy, in some countries, mathematical literacy is considered to have similarities with numeracy and quantitative literacy [11]. ]. Numerical literacy and quantitave literacy are also considered as a whole of mathematical literacy together with spatial literacy [12].

As content in mathematical literacy, uncertainty is a phenomenon at the heart of the mathematical analysis of many problem situations, and probability and statistical theory and data representation and description techniques are a constant in overcoming uncertainty. Uncertainty always appears in science, technology, and everyday life [3].

Real problems related to uncertainty can be solved with mathematical literacy. However, how someone believes in their ability or self-efficacy is also an important part of solving problems []. The higher a person's self-efficacy, the greater the effort, persistence, and willingness to endure difficult problems and make them a challenge to master rather than avoid them [13].

Bandura introduces the dimension of self-efficacy into three parts: 1) the level of difficulty that is believed to be able to be overcome; 2) strength and endurance in facing problems; and 3) generality or variety of situations that are believed to be able to be overcome [14]. Belief in the ability to be able to do something is able to provide adequate performance in certain situations [15]. Belief in what can be done is not the same as knowing what to do [16].

As a skill, a person's mathematical literacy can be predicted based on their self-efficacy [17]. There are reports that at high math literacy scores, self-efficacy is also high [18]. Apart from self-efficacy, students' prior achievement is also a predictor of student achievement in mathematics [19]. The impact of previous achievements has been widely discussed about its impact on student achievement. This factor is worth considering because several previous studies have succeeded in predicting student achievement and academic achievement [20]

Based on the explanation above, self-efficacy and prior achievement can be predictors of mathematical literacy. This study is expected to provide information related to mathematical literacy, self-efficacy and prior achievement of high school students, especially in Banjarmasin. This study also aims to provide an overview of the relationship between self-efficacy and mathematical literacy and the relationship between prior achievement and mathematical literacy.

1. **Method**

This type of this study was a survey. The purpose of this study was to describe the relationship between prior achievement and self-efficacy with mathematics literacy skills of class XI high school students in Banjarmasin. The population in this study were all class XI high school students in the city of Banjarmasin with a sample of 227 students. Determination of the sample size using the Krejcie and Morgan formula [21].

Data were collected by observation, giving written tests and questionnaires. Observations were made in order to obtain student National Examination data when they were junior high school students as a prior achievement. The written test is prepared based on the PISA framework which includes process domains, content and context with a focus on uncertainty and data content. The self-efficacy questionnaire was developed based on Albert Bandura's dimension of self-efficacy, namely the level of problems that are believed to be able to be faced, the strength and persistence in dealing with problems, and generality the belief one has to be able to face the problem [22].

1. **Result and Discussion**

The purpose of this study was to describe the relationship between prior achievement and self-efficacy with the mathematics literacy of high school students in Banjarmasin. Based on the data collection conducted on the students 'national exam scores while in junior high school, it was found that the students' prior achievement was in the high category. More detailed information can be seen in table 1 and table 2

.**Table 1.** Prior Achievement Scores Based on National Examination

|  |  |
| --- | --- |
| Description | Result |
| Highest Possible Score  Lowest Possible Score  Highest Score Achieved  Lowest Score Achieved  Average | 100 0  35,375 98,375 61,62478 |
| Criteria | **High** |

**Table 2.** Prior Achievement Distribution

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Very High | High | Medium | Low | Very Low | Total |
| frequency  Percentage | 27  11,9% | 77  33,9% | 118  52% | 5  2,2% | 0 0% | 227  100% |

**Table 3.** Self-Efficacy Scores

|  |  |
| --- | --- |
| Description | Result |
| Highest Possible Score  Lowest Possible Score  Highest Score Achieved  Lowest Score Achieved  Average | 120 24  115 36  75,87665 |
| Criteria | **Medium** |

**Table 4.** Self-efficacy Distribution

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Very High | High | Medium | Low | Very Low | Total |
| frequency  Percentage | 16  7% | 52  22,9% | 129  56,8% | 29  12,8% | 1 0,4% | 227  100% |

Table 3 and table 4 show that the student self-efficacy has an average of 75.88. This illustrates that the belief of XI grade high school students in the city of Banjarmasin is in the medium category. This means that students have self-confidence who are not too sure of their abilities but are also not pessimistic about their ability to understand and solve mathematical problems, resilience and tenacity in mastering mathematics and dealing with mathematical problems, and confidence in their abilities in mathematics in certain situations and conditions. Students' assessment of their abilities has an important role in dealing with a problem, when students have the belief that they are able to solve problems, this belief can predict the student's ability to solve problems [23].

As for the acquisition of mathematical literacy on uncertainty and data content is in the low category. This result is not much different from the results of PISA 2018 where only 1% of students reached level 5 or above in mathematical literacy. In this case, only a few students can mathematically model complex situations, and can select, compare, and evaluate appropriate problem-solving strategies to deal with them [24]. These results indicate that at least students can solve problems in complex situations. This can happen because most students are not familiar with problems that require higher mathematical reasoning [25]. in another perspective, this is because students rarely solve context-based problems as in PISA. Most students still tend to be involved in routine problems [26].

**Table 5.** Student’s Senior High School Mathematical Literacy

|  |  |
| --- | --- |
| Description | Result |
| Highest Possible Score  Lowest Possible Score  Highest Score Achieved  Lowest Score Achieved  Average | 10 0  10 0  2,638767 |
| Criteria | **Low** |

**Table 6.** Distribution of Student’s Senior High School Mathematical Literacy Scores

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Very High | High | Medium | Low | Very Low | Total |
| frequency  Percentage | 18  7,9% | 13  5,7% | 118  11% | 5  16,7% | 0 58,6% | 227  100% |

In correlation with mathematical literacy, self-efficacy has a correlation with mathematical literacy (p-value = 2.707e-06). The correlation is in the low category (cor = 0.306). Based on these results, students who have high self-efficacy will tend to have high mathematical literacy as well.These results continue the finding that self-efficacy is seen to have a positive correlation in seeing mathematics aptitude and student achievement in high school to [27]. When compared to other types of self-confidence, such as self-esteem, self-concept, and interests, self-efficacy is a very strong predictor and is above it [28].

In the process, self-efficacy predicts the value of student achievement in the future through motivation with self-efficacy that affects performance [29]. Students who have high self-efficacy tend to be able to survive every problem. The high motivation that comes from self-efficacy will provide better effort and performance to overcome challenges. In difficult situations, students with low self-efficacy tend to give up easily [30].

Prior achievement and mathematical literacy in class XI high school students did not show any correlation (p-value = 0.8444). In contrast to several findings which state that prior achievement has a correlation with mathematics achievement and achievement. Prior achievement comes from the national exam when they were in junior high school so there is a gap of about 1 year from the achievement of mathematical literacy. Referring to the findings of Watts et al. [31], the relationship between mathematics prior achievement and subsequent achievement decreases with increasing time between measurement. This shows the difference in the growth of each individual's mathematics achievement over time. The existence of a relationship between self-efficacy and mathematical literacy compared to prior achievement is also strengthened by the results of Kriegbaum's [32] research that motivational builders such as self-efficacy predict mathematics achievement over and above prior achievement.

1. **Conclusion**

Based on the results and discussions, the students' prior achievement was in high category. Student self-efficacy is in medium category, and mathematics literacy on the uncertainty content and data of class XI high school students is in low category. Students tend to experience difficulties when facing complex mathematical situations. The relationship between prior achievement and mathematical literacy on uncertainty content and data has no correlation, where students who have high prior achievement do not necessarily have high mathematical literacy. The time interval between the prior achievement and the next achievement also affects the predicted value. As for self-efficacy and mathematical literacy on uncertainty and data content. As for self-efficacy and mathematical literacy on uncertainty and data content, both have a positive correlation and the correlation coefficient is in a low category. This indicates that students who have high self-efficacy tend to have high mathematical literacy as well. In predicting student mathematics achievement, self-efficacy is above the prior achievement.

**References**

[1] OECD, 2018 The Future of Education and Skills: Education 2030 *OECD Educ. Work. Pap.* p. 23.

[2] National Council of Teachers of Mathematics (NCTM), 1989 *Curriculum and Evaluation Standards for School Mathe matics* Reston, VA: The Council.

[3] OECD, 2019 *PISA 2018 Assessment and Analytical Framework* Paris: OECD Publishing.

[4] OECD, 2018 *PISA 2021 Mathematics Framework (Second Draft)* OECD Publishing.

[5] OECD, 2000, The PISA 2000 Assessment of Reading , Mathematical and Scientific Literacy, in *2000*, .

[6] OECD, 2004 *The PISA 2003 Assessment Framework* .

[7] OECD, 2006 *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006* France: OECD Publishing.

[8] OECD, 2009 *PISA 2009 Assessment Framework – Key Competencies in Reading, Mathematics and Science* France: OECD Publishing.

[9] J. D L, 2006 Mathematical literacy for living from OECD-PIA perspective *Tsukuba J. Educ. Study Math.* **25** p. 13.

[10] OECD, 2014 *PISA 2012 Results in Focus: What 15-year-olds know and what they can do with what they know* France: OECD Publishing.

[11] Stacey K, 2011 The PISA view of mathematical literacy in Indonesia *J. Math. Educ.*

[12] Lange J de, 2003, Mathematics for Literacy, in *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges*, .

[13] Pajares F, 2004, Gender differences in mathematics self-efficacy beliefs, in *Gender Differences in Mathematics: An Integrative Psychological Approach*, .

[14] Bandura A, 1978 Self-efficacy: Toward a unifying theory of behavioral change *Adv. Behav. Res. Ther.*

[15] Gibson J L Ivancevich J M Donnelly, Jr. J H and Konopaske R, 2011 *Organizations: Behavior, Structure, Processes, Fourteenth Edition* New York: McGraw-Hill.

[16] Schunk D H, 2012 *Learning Theorities an educational perspective (6th ed.)* 6th ed., **71**, 1–4 Boston: MA: Pearson Education, Inc.

[17] Carmichael C Callingham R Hay I and Watson J, 2010 Statistical literacy in the middle school: The relationship between interest, self-efficacy and prior mathematics achievement *Aust. J. Educ. Dev. Psychol.*

[18] Tutkun O F and Erdogan D G, 2014 Levels of Visual Mathematics Literacy Self-Efficacy Perception of the Secondary School Students 8 p. 19–27.

[19] Hemmings B Grootenboer P and Kay R, 2011 Predicting mathematics achievement: The influence of prior achievement and attitudes *Int. J. Sci. Math. Educ.*

[20] Manganelli S Cavicchiolo E Mallia L Biasi V Lucidi F and Alivernini F, 2019 The interplay between self-determined motivation, self-regulated cognitive strategies, and prior achievement in predicting academic performance *Educ. Psychol.*

[21] Krejcie R V and Morgan D W, Sep. 1970 Determining Sample Size for Research Activities *Educ. Psychol. Meas.* **30**, 3 p. 607–610.

[22] Bandura A, 1997 *Self-efficacy: The Exercise of Self-Control* .

[23] Pajares F and Miller M D, 1994 Role of Self-Efficacy and Self-Concept Beliefs in Mathematical Problem Solving: A Path Analysis *J. Educ. Psychol.*

[24] OECD, 2019 *Indonesia - Country Note - PISA 2018 Results* Paris: PISA, OECD Publishing.

[25] Fointuna D W Kaluge A H and Fernandez A J, 2020 An analysis of mathematical literacy of state junior high school students in Kupang *J. Phys. Conf. Ser.* **1422**, 012025.

[26] Permatasari R Putri, R I I and Zulkardi, 2018 Uncertainty and data content in bowling: Task design *J. Phys. Conf. Ser.* **1088**, 012010.

[27] Tossavainen T Rensaa R J and Johansson M, 2019 Swedish first-year engineering students ’ views of mathematics , self-efficacy and motivation and their effect on task performance *Int. J. Math. Educ. Sci. Technol.* **0**, 0 p. 1–16.

[28] Cleary T J and Kitsantas A, 2017 Motivation and self-regulated learning influences on middle school mathematics achievement *School Psych. Rev.*

[29] Skaalvik E M Federici R A and Klassen R M, 2015 Mathematics achievement and self-efficacy: Relations with motivation for mathematics *Int. J. Educ. Res.*

[30] Kurniawati N D L and Mahmudi A, 2019 Analysis of mathematical literacy skills and mathematics self-efficacy of junior high school students *J. Phys. Conf. Ser.* **1320**, 012053.

[31] Watts T W Duncan G J Siegler R S and Davis-Kean P E, 2014 What’s Past Is Prologue: Relations Between Early Mathematics Knowledge and High School Achievement *Educ. Res.*

[32] Kriegbaum K Jansen M and Spinath B, 2014 Motivation: A predictor of PISA’s mathematical competence beyond intelligence and prior test achievement *Learn. Individ. Differ.*