Analysis Of Differential Equation Problem Solving Abilities In Terms Of Mathematical Literacy Skills

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Abstract

This study analyzes students' mathematical literacy skills, which aims to obtain steps to solve mathematical problems in the Differential Equation material for final year students based on students' literacy skills. The research design used descriptive qualitative by describing students' literacy skills in solving problems. Differential equations based on students' literacy skills. Data analysis was carried out retrospectively by combining literature review, observations, answer sheets, interviews, and field notes. Furthermore, concerning the concept of Literacy and mathematical problem-solving theory. The data from the results of the analysis showed that in question number 1. In the initial step of the reading and thinking stage, there were 20% of the subjects had made mistakes in understanding the questions/problems. then only 5% can complete until the final stage because students are not able to apply basic mathematics to differential equations. As for question number 2, given a differential equation application problem and only 10% of students were able to pass step 1 (students were unable to read and understand the problem in this matter due to the low literacy skills of students, so they could not proceed to the next step.

Keywords-Differential Equation, Mathematical Literacy.

I   Introduction

In general, students' mathematical abilities can overcome difficulties in everyday life (Wardono et al., 2016) and one of the mathematical abilities that must be possessed by a student is literacy ability. Literacy ability is a person's ability to read and write. According to (OECD, 2018) and (Stacey, 2011), Mathematical literacy is a person's ability to formulate and use and interpret mathematics in various contexts. Thus students' literacy skills are considered capable of

helping in solving any mathematical problems. Mathematical literacy is also referred to as a science that can improve the quality of thinking of an individual (Brewley & College, 2012).

Mathematical literacy is a combination of spatial literacy, numeracy, and quantitative literacy (Adams, 2020). Mathematical concepts that can be used are not only limited to spatial abilities, arithmetic, or quantitative field abilities (Sopyan & Supiarmo, 2022). The mathematical concepts contained in literacy include all three. Thus, mathematical literacy includes all concepts, procedures, facts, and mathematical tools both in terms of calculations, numbers, and spaces. In terms of language, the word literacy (in English literacy) provides a formal definition of mathematical literacy, namely:

Mathematical literacy is defined as students' capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain and predict phenomena. It assists individuals in recognizing the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged, and reflective citizens(OECD, 2016).

In this article based on the definition above, it can be seen that the basic concepts of Literacy itself about mathematical problems are 1. the ability of students to understand and formulate mathematical problems, 2. The ability to explain and predict mathematical phenomena or problems and 3. The ability to use mathematics in problem-solving (Luna et al., 2000).

The ability of a student's literacy is considered to be an important component in solving mathematical problems, especially questions that are included in the category of high difficulty levels (Megawati & Sutarto, 2021). In the tertiary institution itself, several final semester courses require the ability to be literate in solving questions related to the course. One of them is the subject of differential equations. To program this course requires the basic abilities of several previous courses. The differential equation itself is the basis for studying applied mathematics. Furthermore, differential equations have a very important role in modern technology to connect and solve various routine or daily life problems. Several approaches and teaching

techniques have been developed and more developed to make solving the problem of differential equations more effective (Aisha, 2017). This is expected that differential equations are easily understood by students. From the results of research conducted by (Valcarce & Díaz, 2008) on students who take the subject of differential equations, it is stated that students cannot apply the concept of derivative functions correctly. While the concept of the derivative function is the basic element of the differential equation. Therefore, to understand the concept of differential equations, students are expected to have a clear scheme construction of the concept of a function. In line with what was stated by (Suhandri, 2016) that students, in general, have not been able to link mathematical material that is likely caused by the knowledge possessed by students is still very low,

Differential equations have a very important role in mathematics and remain an important course in calculus for centuries. The concept of differential equations is used to model and understand real-life problems. (Aisha et al., 2017).

In solving differential equation problems, a student must be able to analyze and read carefully before solving the differential equation problem, because each type of question has its way of solving it. So if a person is wrong in reading and understanding or interpreting the problem from the beginning, the next step of completion will be fatal. Furthermore, the author uses an indicator of mathematical literacy assessment expressed by (Utami et al., 2020), namely: (1) formulating problems, (2) using mathematics in problem-solving, (3) interpreting solutions in problem-solving, and (4) evaluating solutions In solving problems and approaches to solving problems raised by previous experts, one of which is the problem-solving step raised by Krulik and Rudnik (Kusdinar et al., 2017). The steps of the problem consist of 5 steps in solving mathematical problems without having to be done sequentially. The five steps are: (1) reading and thinking: identifying facts, identifying questions, visualizing the situation, explaining the settings, and determining further action; (2) Explore and planning: Set information, find out whether there is information according to/necessary, finding whether there is information unnecessary, drawing/describing the problem model, and making charts, tables, or pictures; (3) Select Strategy: Find/Make Patterns, Work Reverse, Try and Do, Simulation or

Experiment, Simplification or Expansion, Create Sequence List, Logical Deduction, and Divide or Categorize Problems into Simple Management; (4) Find an answer: predict, use counting, using algebra skills,

use geometric capabilities, and use a calculator if necessary; (5) contemplate and extend: recheck the answers, determine alternative solutions, develop answers to other situations, develop responses (generalizations or conceptualizations), discuss answers, and cause various problems that are the source of the problem.

Furthermore, there are modified Polya steps that can be used to solve mathematical problems. In this case, there are five steps, namely: 1) Understanding the problem; 2) Prepare a plan; 3) Carry out a plan; 4) review; and 5) draw conclusions. (Hayyulbathin et al., 2011).

Based on observations made by researchers when teaching the subject of differential equations it was found that the ability of students in solving differential equation questions is very low. And the literature search researchers conducted an in-depth investigation by giving a test of differential equations to students who have learned differential equations to analyze students' abilities in literate and cross-check the problems faced by students in reading, understanding, and interpreting the differential equation questions followed by the interview and analyze the problems faced by students in solving differential equations.

Furthermore, by adopting the problem-solving steps from these experts modified from the results of the analysis of the ability of students in the differential equation. Researchers carry out problem-solving construction that can improve student literacy capabilities so that they can easily solve differential equation problems

2   Research Methodology

Research design

The design in this study is a descriptive qualitative research design by describes the ability of student literacy in solving differential equation questions based on student literacy capabilities. This study aims to obtain a problem-solving step in final year students based on the ability of student literacy.

Samples and data collection

This study took data from the 5th semester of Mathematics Education at Khairun University in Ter-

nate City, Indonesia. Students selected are students who have learned differential equation material. Researchers involved 25 students as a research sample.

Furthermore, the researcher chose 3 research subjects with purposive sampling techniques from the twenty-five of research samples. The purposive sampling technique is a sampling technique from data sources with certain considerations (Sukestyarno, 2020). The focus of researchers in this study is to choose samples with criteria with high, medium, and low literacy capabilities. The research subject (informant) was given a code (student a = ma, student b = MB, student c = mc) to facilitate analyzing data. Development of test instruments and interview guidelines to obtain student literacy capabilities refer to the indicator of mathematical literacy assessment expressed by ((Utami et al., 2020), namely: (1) formulating problems, (2) using mathematics in problem-solving, (3) interpreting solutions in problem-solving, and (4) evaluating solutions in problem-solving that are adjusted to the objectives. The instrument of the validated test by experts is declared feasible to be used to obtain data by objectives. Then the researcher conducted a limited trial of the research instrument. Validation

test results show that the differential equation questions used are valid and reliable. Furthermore, validation is carried out by experts in the field of psychology, and expert assessments in the field of psychology validate interview guidelines and self-efficacy questionnaires.

Data analysis

Data analysis uses descriptive analysis methods, namely analyzing data by describing the data obtained to obtain a problem-solving step that can improve the ability of student literacy in solving mathematical problems in teaching materials for differential equations. Data collection is done by conducting literature and observation studies. Furthermore, the research subjects were given a test using the validated differential equation questions. The test results from the selected informants are used as a basis for conducting in-depth interviews. The data analysis step is done using the results of tests and in-depth interviews to be grouped, reduced, presented, and hypothesized (Sukestiyarno, 2020). Data credibility test using triangulation tests by comparing data from the results of literature studies and observations, test results, and in - depth interviews.

3   Result and Discussion

4. 1 Result

Based on the mathematical literacy assessment indicator expressed by (Utami et al., 2020), namely: (1) formulating problems, (2) using mathematics in problem-solving, (3) interpreting solutions in problem-solving, and (4) evaluating solutions in solving solutions problem. The researcher conducted a test on 25 students who had learned differential equations obtained as follows.

Tabel 1 Frequency of Student Literacy Ability

No	Indikator Penilaian	Frekuensi	Presentasi
1.	Formulate problems in solving problems	20	80%
2.	Using mathematics in problem solving	10	40%
3.	Interpreting solutions in problem solving	10	40%
4.	Evaluate solutions in problem solving	10	40%

From the data above the researcher obtained information that of the 25 students who took the test there were 20. Students who could formulate problems with 80% presentations, 10 students who could use mathematics in solving problems with 40% presentations., and 10 students who could interpret solutions in problem-solving with a 40% presentation. And 10. students who can evaluate solutions in problem-solving with presentations.

From this data, the researcher concludes that the ability of student literacy is one of the causes of the difficulty of students in solving differential equation questions. Furthermore, the results were obtained that most students had difficulty in solving mathematical problems in indicators using mathematics in solving problems so researchers conducted cross-check by conducting interviews with students who are difficulty using mathematics in solving mathematical problems, namely differential equations.

For more in-depth crossed results than researchers' differential equation questions given to students, can be seen the ability of students in solving differential

equation questions about the initial requirements and boundary conditions. From the work of students, 3 student work was selected with 3 different categories, namely low categories, medium categories, and high categories, the following analyzed student work by selecting 3 samples of each low category, medium category, and low category. Furthermore, interviews were conducted with the three students to find out the obstacles obtained in solving differential equation questions.
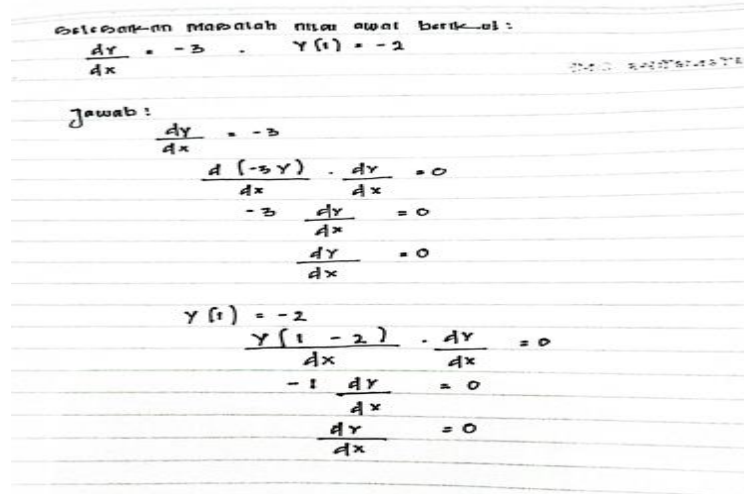
Picture 1 Student Work Results Low -ability category

In Figure 1 above it can be seen that student A can not at all in formulating problems, cannot use mathematics, and interpret problem-solving solutions. So that it is wrong in evaluating solutions. It can be seen that the student does not read well the questions given. So that it immediately substitutes the initial requirements to the differential equation given. To find out the problems faced by the student, along with an interview with student (S1).

P : What are your obstacles in solving differential equation problems?

S1 : There are too many ways to settle and each model of the problem is different, confused about what way to use.

P   : I look at your answer, ordinary derivatives are still wrong in completing it.

S1   : I was a bit forgotten if I'm not mistaken, it was a calculus lesson. I need to learn calculus again

P   : Do you have to repeat the material related to the differential equation? Like calculus and algebra.

S1   : Right. Need to read the previous material.

Furthermore, the work of student B students represented students with the medium ability.

Figure 2 Student Work Results Category with Medium Ability

In Figure 2 it can be seen that students B can formulate the masalh and interpret solutions but are not appropriate to use mathematics in solving mathematical problems. The following excerpts interview with students (S2)

P : What are your obstacles in solving differential equation problems?

S2 : I forgot how to solve it. Forget the derivative rules.

P : Do you think there needs to be a refreshment of basic mathematical material before entering the differential equation material?

S2 : Very necessary.

The following is chosen the work of students of students (S2) who represent high -capable students.
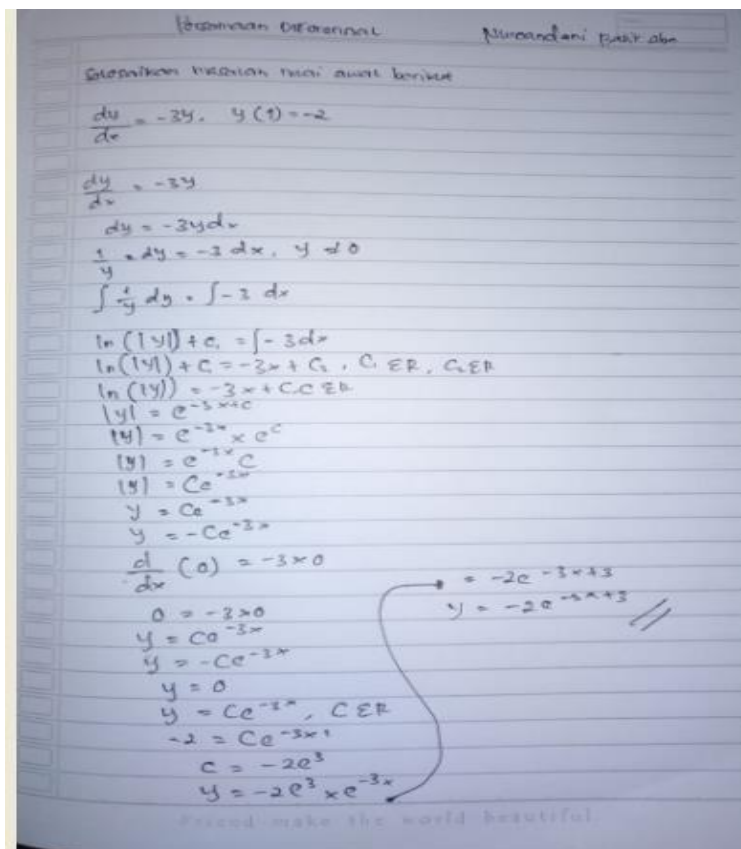

Figure 3. Student Work Results High Ability Category

In Figure 4 it can be seen that students (S3) can formulate problems, use mathematics and interpret solutions to problem-solving and can evaluate solutions obtained, along with interview quotations with students (S3):

P   : What are your ob-
        stacles in solving dif-
        ferential   equation
        problems

MC   : In general there are
        no problems.

P   : Are there any sug-
        gestions or input to
        other friends so they
        can easily solve dif-
        ferential   equation
        problems?

MC   : To be able to solve
        differential equation
        problems, we must
        master basic mathe-
        matics.

P   : Do you think you
        need to be given a
        brief review of basic
        mathematics   before
        entering the material
        of   the   differential
        equation?

MC   : Very necessary

4. 2. Discussion

In this study, one of the different factors of previous devices is to improve the ability to solve mathematical problems is to solve problems by focusing on increasing the ability of mathematical literacy on differential equation material, within the scope of final semester students. But differential equations are important material in mathematics as well as in science and social sciences. Thus, the material of differential equations has been included in the compulsory course program in various departments in higher education. The importance of differential equations has attracted the attention of many researchers who generally focus on the contents and instructions of differential equations. However, differential equations are materials that have complex problems that may be difficult for students to understand (Arslan, 2010). Remembering the importance of differential equation problems, it is important for a student to have a good understanding of periphency and solutions. As mentioned earlier, a study of a study of teaching approaches is needed, with more focus on the ability of students to read and understand the basic concepts of differential equations of understanding in this case the ability of students to read and understand students' problems or abilities in literacy. Therefore, there is a need to learn the understanding of students' difficulties related to differential equations and the solutions to the differential equations themselves.

Mathematical literacy ability is an ability that must be possessed by students in solving mathematical

problems in this case solving differential equation problems. The ability to solve mathematical problems students are influenced by several factors both directly and indirectly this is closely related to motivation, self -efficacy and models used by the teacher (Pimta et al., 2009). Furthermore, according to (Sophonyranrak et al., 2015) The main factor in solving the problem is 1) Understanding challenges, 2) producing ideas, 3) Preparing actions, 4) Planning yourself approaches.

4   Conclussion

From the results of the research above the researcher can conclude that based on the results of the literacy analysis before entering the learning activities or provision of differential equation materials to students, it is necessary for a Previous or brief explanation that researchers called a connection that is connecting the previous material with the material of the differential equation to be taught.

Referring to the steps in solving the problem raised by Krukik and Rudnik literacy analysis. Researchers construct a problem-solving step as follows: 1) Reading and thinking (read and think), 2) Remembering and connecting previous material with material to be

studied (Remember and Connection), 3) Exploring and planning (Explore and Plan), 4) Select a strategy (select a strategy), 5) Find an answer (find the answer), 6) Review and discuss (reflect and extend).

5   Acknowledgment

6   References

1.   Adams, T. L. (2020). Mathematical Literacy. Mathematics Teacher: Learning and Teaching PK-12, 113(4), 262–263. https://doi.org/10.5951/mtlt.2019.0397

2.   Aisha, B. (2017). Teaching and Learning of Differential Equation: A Critical Review to Explore Potential Area for Reform Movement. International Journal For Innovative Research In Multidisciplinary Field, 3(6).

3.   Aisha, B., Norulakmar, S., Zamri, S., & Abdallah, N.

(2017). Factors Affecting Differential Equation Problem Solving Ability of Students at Pre-University Level: A Conceptual Model. Malaysian Online Journal of Educational Sciences, 5(4), 13–24.

4. Arslan, S. (2010). Do students really understand what an ordinary differential equation is? International Journal of Mathematical Education in Science and Technology, 41(7), 873–888. https://doi.org/10.1080/0020 739X.2010.486448

5. Brewley, D. N., & College, G. G. (2012). College Mathematics Literacy Workers of the Young People's Project Chicago : A Community of Practice. 5(1), 44–54.

6. Hayyulbathin, I., Winarni, R., & Murwaningsih, T. (2011). Modification of Polya's Step to Solve Math Story Problem. 5th ICRIEMS Proceedings, 119–126. http://seminar.uny.ac.id/icri ems/sites/seminar.uny.ac.id. icriems/files/proceeding201 8/ME16_Isfa Hayyulbathin.pdf

7. Kusdinar, U., Sukestiyarno,

S., Isnarto, I., & Istiandaru, A. (2017). Krulik and Rudnik Model Heuristic Strategy in Mathematics Problem Solving. International Journal on Emerging Mathematics Education, 1(2), 205. https://doi.org/10.12928/ije me.v1i2.5708

8. Luna, C., Solsken, J., & Kutz, E. (2000). Defining Literacy. Journal of Teacher Education, 51(4), 276–288. https://doi.org/10.1177/0022 487100051004003

9. Megawati, L. A., & Sutarto, H. (2021). Analysis numeracy literacy skills in terms of standardized math problem on a minimum competency assessment. … Journal of Mathematics Education, 10(2), 155–165. https://doi.org/10.15294/ujm e.v10i2.49540

10. OECD. (2016). Results from PISA 2015: Indonesia. OECD Publishing, 1–8. https://www.oecd.org/pisa/P ISA-2015-Indonesia.pdf

11. OECD. (2018). PISA 2018 Assessment and Analytical Framework. OECD Publishing. https://doi.org/10.1787/b25e fab8-en

12. Pimta, S., Tayruakham, S.,

& Nuangchale, P. (2009). Factors Influencing Mathematic Problem-Solving Ability of Sixth Grade Students. Journal of Social Sciences, 5(4), 381–385. https://doi.org/10.3844/jssp.2009.381.385

13. Sophonhiranrak, S., Suwannatthachote, P., & Ngudgratoke, S. (2015). Factors Affecting Creative Problem Solving in the Blended Learning Environment: A Review of the Literature. Procedia - Social and Behavioral Sciences, 174(1982), 2130–2136. https://doi.org/10.1016/j.sbspro.2015.02.012

14. Sopyan, D., & Supiarmo, M. G. (2022). The Effect of Spatial Ability on the Mastery of Mathematical Concepts for Class VIII MTs Nahdlatul Mujahidin NW Jempong. Jurnal Cendekia: Jurnal Pendidikan Matematika, 06(01), 1184–1194.

15. Stacey, K. (2011). The PISA view of mathematical literacy in Indonesia. Journal on Mathematics Education, 2(2), 95–126. https://doi.org/10.22342/jme.2.2.746.95-126

16. Suhandri. (2016). Meningkatkan Kemampuan Pemahaman Matematis Siswa SMP/MTs. 9(2).

17. Sukestiyarno, Y. (2020). Research Educational Methode (1st ed). In UNNES Press.

18. Utami, N., Sukestiyarno, Y. L., & Hidayah, I. (2020). Kemampuan Literasi dalam Menyelesaikan Soal Cerita Siswa Kelas IX A. Prisma, Prosiding Seminar Nasional Matematika, 3, 626–633.

19. Valcarce, M., & Díaz, J. (2008). Initial Diagnostic Assessment To Support Learning. Cerme8.Metu.Edu.Tr. http://cerme8.metu.edu.tr/wgpapers/WG14/WG14_Codes_Valcarce.pdf

20. Wardono, Waluya, S. B., Mariani, S., & Candra, S. D. (2016). Mathematics Literacy on Problem Based Learning with Indonesian Realistic Mathematics Education Approach Assisted E-Learning Edmodo. Journal of Physics: Conference Series, 693(1). https://doi.org/10.1088/1742-6596/693/1/01201