Building Numerical Literacy for Prospective Mathematics Teachers Through Analogical Reasoning

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Abstract. The purpose of this study is to analyze how analogical reasoning as one of the reasoning in mathematics can build the numeracy literacy of prospective mathematics teachers. Qualitative methodology was used in this recent study. Data collection techniques in this study are test, observation, interview, and documentation. Meanwhile, data analysis was processed by reducing data, presenting data, and drawing conclusions. Analogous reasoning is one way that can be used in learning to build numeracy literacy because, with analogical reasoning, students will try to find problems that are similar to the questions given and then learn them by reading and understanding the information it provides. However, analogous reasoning in research can only be done by students with high abilities, while students with low abilities have not been able to use this reasoning. Nowadays, reasoning is very mandatory to use in literacy-based learning because literacy requires reasoning, without reasoning, it will be difficult for students and prospective teachers to be able to solve numeracy literacy questions.

Key words: analogical reasoning; numeracy literasy; prospective mathematics teacher.

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INTRODUCTION

Today, we are in the 21st century. The life of the 21st century demands learning where students must have various skills or skills that later after graduating from school can bring them into the world of work and can achieve success. In this century there has been a significant shift from consuming services to services that emphasize information and knowledge (Scott, 2015a.). Bernie Trilling and Charles Fadel (2009) argue that there are three skills in the 21st century that need to be possessed, namely: 1) life and career skills; 2) learning and innovation skills, and: 3) information media and technology skills. The competencies possessed in life and career skills include: 1) flexibility and adaptability; 2) have initiative and be able to self-regulate; 3) social and inter-cultural interactions; 4) productivity and accountability, and: 5) leadership and responsibility. The competencies possessed by learning and innovation skills consist of 1) critical thinking; 2) communication and collaboration, and: 3) creativity and innovation. Meanwhile, the competencies possessed by information media and technology skills consist of 1) information literacy; 2) media literacy; and 3) ICT literacy. The US-based Partnership for 21st Century Skills (P21), identified these learning and innovation skills into four competencies, namely: 1) critical thinking skills; 2) creative thinking skills; 3) communication skills, and 4) collaboration skills as required competencies in the 21st century. These competencies are then called the 4C 'skills (Zubaidah, 2018).

4C skills can be mastered by students as the nation's successors, one of which through education. Education is a place for students to be able to prepare themselves to face the 21st century because of increasingly fierce competition in the current era of globalization. (Pacific Policy Research Center, 2010) also explained that through education it is expected to be able to develop students to think creatively, be flexible, solve problems, collaborate, and be innovative skills needed to succeed in work and life. Education is also expected to be able to equip students with the ability to apply their knowledge in everyday life. Therefore, the government continued to improve the education curriculum until the presence of Curriculum 13. In Curriculum 13, it has been emphasized that student's skills are needed to be able to play a role in the era of globalization and answer challenges in the future. Curriculum 13 has a goal to develop the talents, interests, and potential of students to be characterized, competent, and literate so that to be able to achieve these goals, a paradigm of learning is needed in learning and not teaching. Therefore, this then becomes our joint task,

especially the school which consists of elements of teachers and students to be able to carry out learning oriented to 21st-century learning.

Teachers as facilitators in the classroom have a very large role in creating learning in the 21st century. In addition, teachers as agents of change are also expected to shape future generations who are literate, creating conditions in the classroom that can foster students' motivation, enjoyment, and interest in reading.

Literate is a language that is now being widely used in the world of education. In the English Dictionary, literate is defined as literate or educated which then develops into literacy. The term literacy itself has many definitions and defining it is not as simple as we think. Literacy covers various disciplines such as education, psychology, sociology, anthropology, politics to linguistics. (*Webster's New World Dictionary of American English*, 1988) defines literacy (n) as "the state or quality of being literate". More specifically, literacy is defined as 1) the ability to read and write; 2) knowledgeability or capability. While the word literate (adj) is defined as 1) able to read and write (able to read and write); 2) well-educated; having or showing extensive knowledge, learning or culture (well-educated; having or showing extensive knowledge, learning or culture; 3) knowledgeable or capable (knowledgeable or capable). Thus, we can distinguish between the definition of literate and literacy, namely, literacy is a noun that has the definition of the ability to be able to read and write while literate is an adjective that means capable or knowledgeable. As for being literate by the mandate of Curriculum 13, we must master literacy.

To increase competitiveness and fighting power in facing the challenges of the 21st century, Indonesian people must master six basic literacies, namely: 1) language literacy; 2) numeracy literacy; 3) scientific literacy); 4) digital literacy; 5) financial literacy; and 6) cultural literacy and citizenship. As for mastering these six literacy skills, it needs to be balanced with 4C skills, namely communication, collaboration, critical thinking in problem-solving, and creativity. The problem-solving in question is not only limited to solving routine problems but also finding solutions to contextual problems that are faced daily and require reasoning. To have good literacy, good reasoning is also needed which is one of the basic abilities in numeracy literacy. Apart from being one of the basic skills in numeracy literacy, reasoning is also one of the five NCTM process standards, namely problem solving, communication, connection, and representation standards (NCTM, 2000).

Reasoning has an important role in mathematics because it is used as the foundation for other standard processes. In addition, reasoning and mathematics cannot be separated from each other because solving mathematical problems requires reasoning while reasoning abilities can be trained by learning mathematics (Kusumawardani et al., 2018).

The reasoning is defined as a thought process, especially logical thinking or problem-solving thinking. Keraf also explains that reasoning can be interpreted as a thought process that tries to connect known facts or evidence to a conclusion. Furthermore, it is defined that reasoning is an activity, a process, or a thinking activity to draw conclusions or make a new statement that is true based on several statements whose truth has been proven or assumed previously (Shadiq, 2004). From these definitions, it can be seen that reasoning activities focus on efforts to formulate conclusions based on several statements that are considered true. If this conclusion often pays attention to the similarity of a feature or more of the object being observed, then this reasoning process is said to be analogous reasoning. In the process of learning mathematics, students are often required to think or reason in looking for similarities or similarities or linkages of the nature of a particular concept to another concept through comparison. It is not only required in learning mathematics, but also in everyday life. Therefore, analogical reasoning is very important in forming perceptions and finding solutions to problems (Kristayulita et al., 2019).

Sulaiman, (2010) also explains that reasoning can be defined as a thought process, in this case, namely divergent thinking. Divergent thinking in question is thinking that aims to produce many possible answers to the same question. Divergent thinking often results in variability. Therefore, if students use analogical reasoning in solving the problem, these students may also be able to find possible answers to the same questions. This is by the opinion that reasoning includes creative thinking processes, critical thinking, and basic thinking. Reasoning is part of thinking, but often thinking and reasoning are used synonymously. Based on the thinking hierarchy, it can be concluded that reasoning is part of the thinking process. If someone is reasoning, it can be said that the person is also thinking, but if someone is thinking, it is not necessarily that someone can be

said to be reasoning (Lailiyah et al., 2015).

Analogous reasoning can solve problems that are unclear, new, and complex (Melis and Gentner in (Kristayulita et al., 2019)). Analogous reasoning is a process of obtaining conclusions using the similarity of the nature of the structure of the relationship between a known problem (source problem) and a new problem (target problem). Novick (English, 1999) says the use of analogy in solving mathematical problems involves the source problem and the target problem. Source problems can help students solve target problems. This can happen if students in solving the target problem pay attention to the source problem and apply the source problem structure to the target problem.

According to Reed, Ackinclose, & Voss, the target problem has the same structure as the source problem but is more inclusive, that is, the target problem contains all the necessary information such as solving the source problem, plus some additional information. This means students have to adapt or extend the source problem-solving procedure to use it in solving the target problem (English, 2004).

Characteristics of the source problem are 1) given before the target problem; 2) in the form of easy and medium problems, and: 3) can help solve the target problem or as initial knowledge in solving the target problem. While the characteristics of the target problem are 1) in the form of a modified or expanded source problem; 2) the target problem structure is related to the source problem structure; and 3) in the form of complex problems (English, 1999).

The use of analogies in solving mathematical problems can be done by giving the source and target problems to students. Students are asked to solve source problems, after students can solve and understand source problems well, students are given a target problem. The target problem contains more complex math problems. Usually in solving source problems, students will use known strategies, the concepts they have, while in solving target problems students will make the source problems that have been solved as initial knowledge for the target problems to be solved. Furthermore, (English, 2004) explains that analogous reasoning is a process of concluding known source problems by using similar properties and related structures to be applied to the target problem. Thus, in analogical reasoning, one must recognize the similarity of the structural relationship between the known problem and the new problem. This is what then always becomes a difficulty for students and even students as prospective teachers in solving math problems if they have to use reasoning. However, this reasoning must continue to be improved. In mathematical literacy, students' and students' reasoning is needed to solve problems related to everyday life. Mathematical literacy prioritizes processes and conceptualization, not only using formulas and only counting. A person's ability to use reasoning is then called numeracy literacy as stated by (Abidin, et al., 2017). According to him, reasoning means analyzing and understanding a statement through mathematical activities, namely manipulating mathematical symbols and language found in everyday life which are then expressed in writing. This is in line with the definition of numeracy literacy that is being popularized today, namely (1) knowledge and skills to acquire, interpret, use, and communicate various kinds of numbers and mathematical symbols to solve practical problems in various life contexts; (2) analyze the information displayed in various forms (graphs, tables, charts, etc.) to make decisions (Tim GLN, 2017a). Numeracy literacy requires reasoning. Reasoning in mathematics consists of three types including inductive reasoning, deductive reasoning, and analogical reasoning (Mofidi, & Parvaneh A., 2012; Woo, et al., 2007). However, this analogical reasoning has a significant role in solving mathematical problems, the ability to use known problems (source problems or basic problems) which have identical structures in solving new problems (target problems) which can then improve problem-solving abilities (English, 2004). Analogous reasoning also aims to apply the similarity of relationships in helping to understand new mathematical problems or concepts through the ability of previous mathematical material.

Thus, based on the explanation of the background problems that have been stated above, the researcher wants to build the numeracy literacy of prospective mathematics teachers, namely students through analogical reasoning. Numerical literacy is part of mathematics, so the components in the implementation of numeracy literacy later cannot be separated from the material in mathematics. Through analogical reasoning, students as prospective teachers are expected to be able to build numeracy literacy by reading a lot and thinking about finding the source problem which then the strategy can be used as initial knowledge to solve the target problem. Teachers and prospective teachers must

have good mathematical literacy skills to educate students to have good mathematical literacy skills (Hendroanto, et al., 2018; Prasetyani, & Suparman, 2018). One of the good students' mathematical literacy is influenced by the teacher's mathematical literacy. Furthermore, a teacher needs to have good mathematical literacy (Yavuz, et al., 2013).

The purpose of this study is to analyze how analogical reasoning as one of the reasoning in mathematics can build the numeracy literacy of prospective mathematics teachers.

LITERATURE REVIEW

Numeracy Literacy

Traditionally we think of literacy as the skill of reading and writing, but understanding literacy includes much more than that. Literacy includes the ability to read, understand, and critically appreciate various forms of communication including spoken language, written language, broadcast media, and digital media. However, literacy referred to here is a broader understanding of skills, including speaking and listening, as well as communication that uses not only writing and print but also digital media. While numeracy is not limited to the ability to use numbers, add, subtract, multiply, and divide. But it also includes the ability to use mathematical understanding and skills to solve problems and meet the demands of everyday life in complex social settings (Department of Education and Skills, 2011). So then if we define numeracy literacy, it can be concluded that numeracy literacy is the ability to use, solve, and apply mathematical skills in everyday life.

In simple terms, numeracy literacy can be defined as the ability to: 1) apply number concepts and arithmetic operations skills in everyday life; 2) interpreting quantitative information that is around and; 3) appreciate and understand information expressed mathematically, such as graphs, charts, diagrams, and tables. There are three basic principles of numeracy literacy, namely 1) contextual, by geographical and socio-cultural conditions; 2) aligned with the scope of mathematics in the 2013 curriculum; and 3) interdependence and enrich other elements of literacy (Tim GLN, 2017b).

In addition, if it is associated with reasoning, numeracy literacy can be interpreted as a person's ability to use reasoning. The focus of literacy skills includes formulating, applying, and interpreting mathematics into various contexts that include mathematical reasoning, mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena in everyday life (Ekowati et al., 2019). Mathematical numeracy literacy is very important in everyday life because it can help someone to understand the role or use of mathematics (Putra, et al., 2016).

Analogical Reasoning

There are five competencies in learning mathematics, namely: mathematical problem solving, mathematical communication, mathematical reasoning, mathematical connection, and mathematical representation. The ability that includes the five competencies is mathematical literacy ability (Fathani, 2016).

Reasoning comes from the word "reason". The reason is the power of thinking, and the intellectual thought process to solve problems. Reasoning is defined as a way (thing) that uses reason; the thing that develops or controls something by reason and not by feeling (Chaplin, 1989).

Reasoning is a thinking process that has certain characteristics, namely: a logical or analytical thinking pattern. A logical thinking pattern means using certain logic, while analytical is a consequence of certain thinking patterns. In addition, reasoning can also be interpreted as a creative, critical, and higher-order thinking process (Lailiyah et al., 2015).

The indicators of ability that are categorized as mathematical reasoning abilities include: making analogies and generalizations, providing explanations using models, using patterns and relationships to analyze situations, mathematics, compiling and testing conjectures, checking the validity of arguments, compiling direct proofs, compiling indirect proofs, gives an example of a disclaimer, following the rules of inference (Sumarmo., 2002).

An analogy is the similarity of the nature of a new thing with a previously known thing that is different. According to (Orgill & Bodner, 2006), an analogy is a comparison between two elements that are not similar or completely different which is used to introduce a transfer system of relations between elements in analog sources that are familiar to foreign target elements. The same opinion is also expressed by (Gentner, 1989) that analogy is a knowledge mapping between two objects so that objects that are on an analog target will be mapped on an analog source object.

An analogy is part of inductive reasoning, namely the process of reasoning from one phenomenon to another similar phenomenon and then it is concluded that what happened to the first phenomenon will also occur in other phenomena (Mundiri, 2014). Analogies are made by comparing the similarities of one thing with another, according to the same domain

or a different domain (Vamvakoussi, 2019), then a conclusion is drawn which concludes based on similarity (Soekadijo, 2003). Analogy thinking processes include *encoding, inferring, mapping, and applying* (Hendriana, et al., 2017); (Kristayulita & et al, 2018). *Encoding* is the ability to identify the characteristics of the source domain and target domain. Encoding seen from the definition stated by (Lailiyah, et al., 2018) and (Kristayulita et al., 2019) is a structuring analogy. *Inferring* is the ability to find a relationship between the source domain and the target domain. *Mapping* is the ability to conclude from the similarity of the relationship between the source domain and the target domain, and *applying* is to choose the appropriate answer (Vamvakoussi, 2019).

While, analogical reasoning indicators according to (Ruppert, 2013) consist of four components, namely *Structuring*, where the subject can identify any forms that exist in the source problem by coding its attributes or characteristics and draw conclusions from identical relationships in the code of all source problems; *Mapping*, the subject can look for identical relationships between the source problem and the target problem than build conclusions from the similarity/identical relationship between the source problem and the target problem; *Applying*, the subject can apply the conclusions from the source problem to the target problem to solve the target problem; and *Verifying*, re-checking the correctness of the target problem solving by checking the suitability of the target problem with the source problem.

Analogous reasoning is a central point in the formation of higher-order thinking skills (Vamvakoussi, 2019); (Richland, & Begolli, 2016) and as an indicator of the achievement of mathematical abilities (NCTM, 2000); (As'ari, et al., 2017). In solving problems in TIMMS, analogical reasoning also becomes an important domain (Setiadi, et al., 2012). So is PISA.

Characteristics of analogy problems used in research can give different results. That is, the stages of analogical reasoning depend on the given analogy problem (Kristayulita & et al, 2018). In this research, using Ruppert model analogy thinking process which consists of structuring, mapping, applying, and verifying.

RESULT AND DISCUSSION

Purpura (2009) explains that numeracy consists of three aspects, namely numeracy relations, counting, and arithmetic operations (Ayuningtyas & Sukriyah, 2020). These three aspects have been given from an early age because they are basic abilities that children must have from an early age. However, along with the development of knowledge and the demands of PISA in international competition, it developed into four aspects, namely numbers, measurement and geometry, algebra and uncertainty and data. In the PISA 2012 framework, these four aspects are known as change and relationship (arithmetic and algebraic functions), shape and space (geometry and measurement), quantity (number concept), and uncertainty and data (statistics and data) which are then referred to as literacy content (OECD, 2013). This study uses literacy questions with change and relationship content (arithmetic and algebraic functions) with the topic of the application of derivative functions in everyday life.

Question:

Towards the celebration of Eid al-Fitr or the implementation of a wedding, people are busy preparing many snacks to welcome Eid or the implementation a wedding. This food from Sumatra is no exception, namely *lemang*. This food made from glutinous rice, sweet potato, or sago is cooked using a piece of bamboo covered with rolled banana leaves. The process of making *lemang* is carried out for quite a long time and requires the energy of many people in the process. In Aceh, the making of *lemang* is often done by mothers or women. (*modification from source: https://www.acehtrend.com/2019/06/03/process-buat-lemang-to-meets-perayaan-hari-besar-islam/*).

If during the Eid celebrations, mothers want to produce *lemang* that can contain 0.628 kg of sticky rice in one bamboo, then determine the minimum dimensions of the bamboo that must be made to accommodate sticky rice!

If the five *lemang* bamboos have been burnt and ready to be cut, as shown in the following picture. How many pieces of *lemang* are delicious for Eid guests to enjoy? Source: *https://sumut.idntimes.com/food/dining-guide/doni-hermawan-1/camilan-traditional-medan-c1c2-regional-sumut/5*

The questions given in this study were compiled by the researchers themselves and then

validated by expert validators using content validators. The number of questions is only one question by adapting questions about derivative applications which are then linked to everyday life. In line with the meaning of numeration itself, it is not only being able to carry out procedures in solving mathematical problems but also utilizing mathematics in everyday life (Aningsih, 2018).

Furthermore, this question is given to prospective mathematics teachers, namely sixth-semester mathematicians who have taken differential calculus courses using zoom meetings. Students are given a long time to solve this problem because the researcher allows students to find as many references as possible related to solving the derivative of this function. Participants may use books or try searching on the internet as a first step to motivate them to find a solution to the problem. Previously, in the beginning, the researcher also conducted interviews and found that students were not familiar with the word literacy and numeracy. They don't know what numeracy literacy is like and how to solve it. Then, the researcher gave a briefing on what numeracy literacy was and explained to them that they were free to use any method and argument to solve it. Then, they read the problem and then reflect, thinking about how to solve the problem by using what method. This took a long time until finally, the researcher gave directions for solving the problem by using analogical reasoning, namely looking for similarities like a new thing with something that was previously known which was different.

After the question is done, the researcher then selects the participants' answers by purposive sampling, which is based on certain considerations. The answers of the selected participants are students who are of high ability in the class. In line with the results of research conducted by (Hidayati et al., 2020) that high-ability teacher candidates can meet all the indicators of mathematical literacy that exist in the problem. Likewise in this study, considering that students with initial SF are students who have high abilities in class which is indicated by their high differential calculus scores, they are selected as samples in this study. There are three numerical indicators used, namely: 1) being able to use various kinds of numbers or symbols related to mathematics in solving problems of daily life; 2) able to analyze the information displayed in various forms (graphs, tables, charts, diagrams and so on); and 3) interpret the results of the analysis to predict and make decisions. SF as the sample of this study has met the three indicators. In addition, SF is also able to use analogous reasoning in solving numeracy problems.

At first, SF looked for questions or references related to the application of derivative functions, then SF chose questions that were similar to the questions given by the researcher. SF found a similar problem as a source problem as shown in the figure, which is a problem related to the application of derivative functions on the surface area of a geometric figure. In this problem, you are asked to determine the maximum size (length, width, height) of the size of the shape so that you can make a box from a piece of cardboard if you know the volume is $4m^3$. Then, SF solves the problem by using the derivative of the surface area of the box without the lid, namely by taking the derivative of the surface area to 0 so that one of the dimensions of the size of the shape is obtained, namely the height of the box.

Likewise with solving the target problem, SF did the same reasoning as the source problem, namely determining the minimum dimensions of bamboo that must be made to be able to accommodate sticky rice using the maximum surface area. Here's a picture of the problem solving by SF:

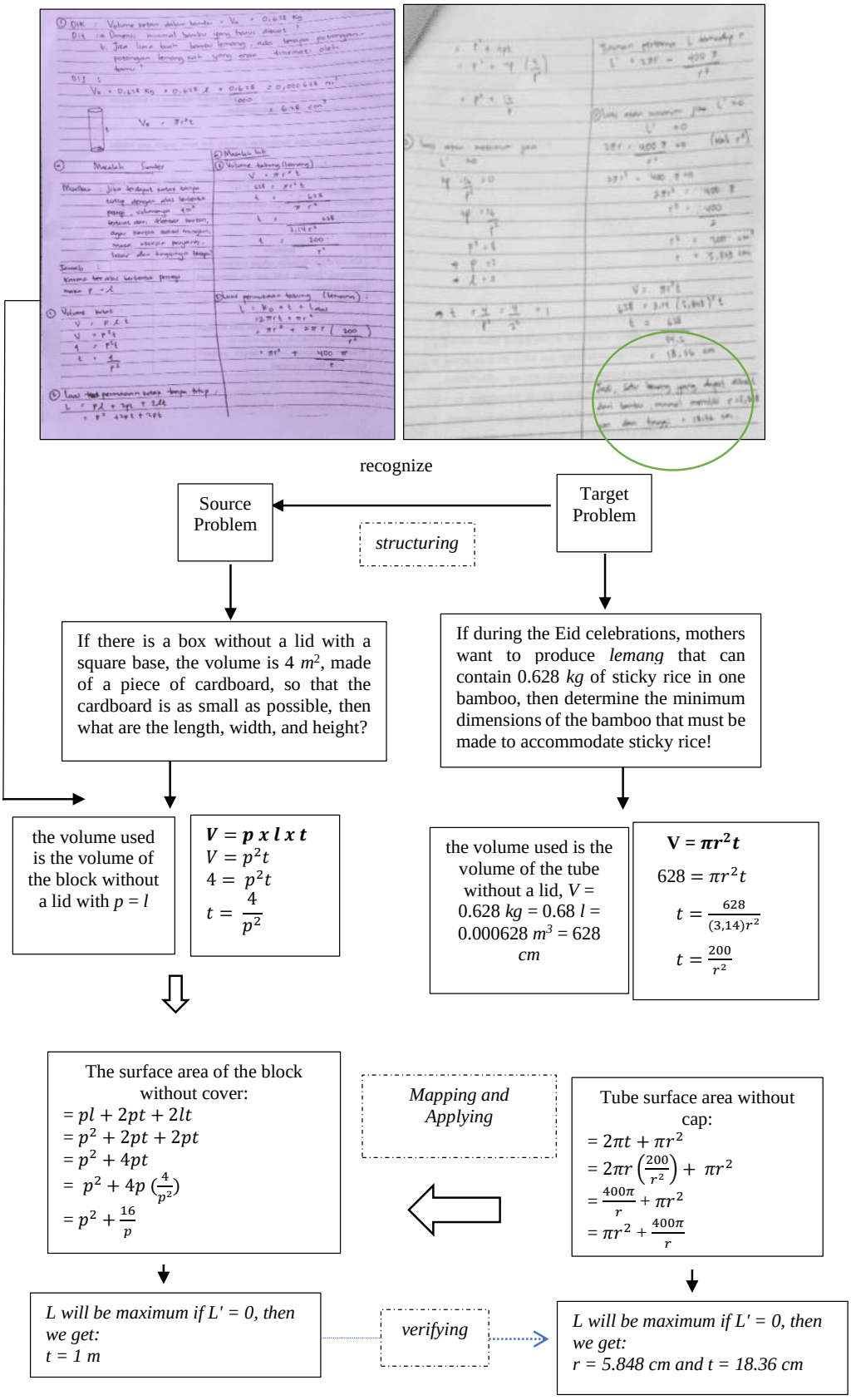

Figure.1. Solving the SF Numerical Literacy Problem using the Analogy Stage

From the results of the settlement shown by the figure, it is also seen that SF has met the three numeric indicators, namely:

Table 1. Description of Solving Problems of Numerical Literacy

Indicator	Description
Able to use various kinds of numbers or symbols related to mathematics in solving daily life problems;	SF can use various numbers or symbols in solving problems of making lemang starting from the structuring stage to verifying. However, at the end of the settlement, SF made a number calculation error, namely when calculating the t value. Supposedly, the t obtained was t ≈ 5.95 cm, while SF obtained t = 18.36 cm. This error is caused by SF's forgetfulness and inaccuracy in dividing the value of phi (π). The value is not divided.
Able to analyze information displayed in various forms (graphs, tables, charts, diagrams, and so on);	SF can analyze the information displayed in the form of daily life questions and then convert it into mathematical form. In this question, do not use questions in the form of graphs, tables, charts, or diagrams, and so on.
Interpret the results of the analysis to predict and make decisions	SF has been able to conclude but has not been able to make a decision on the results obtained. SF makes a decision, the final result obtained is the result that is not rounded up r = 5.848 cm and t = 18.36 cm, when in fact if SF can make decisions and can provide arguments, the values of r and t can be rounded to r = 5.8 cm or r = 5.9 cm or r = 6 cm and t = 18 cm.

Based on the results of the analysis of solving numerical problems carried out by SF, it can then be explained that SF has understood and used analogical reasoning even though SF has not been able to write down the stages perfectly and SF has also been able to solve numeracy literacy problems using analogical reasoning. Not only solving problems related to literacy, indirectly, SF has done literacy by reading, finding out about how to solve the problem, especially since SF rarely does this question, maybe he has found it but has not realized it. Therefore, the habituation of numeracy literacy questions needs to be done continuously. In line with Pangesti's opinion in his research that the habit of solving HOTS questions in mathematics learning needs to be done consistently and continuously so that students can improve their numeracy literacy (Pangesti, 2018). Numeracy literacy questions are of course questions with a high level of ability and are related to everyday life. In solving it, analogical reasoning is one way that can be used in learning to build numeracy literacy because, with analogical reasoning, students will try to find problems that are similar to the questions given and then learn them by reading and understanding the information it provides. However, it should be realized that not all students can use analogous reasoning. This will become increasingly difficult for students with low abilities, even though higher-order reasoning and thinking are needed in numeracy literacy.

The errors that are often found in analogical reasoning include not paying attention to the structure that underlies the two analog problems. Students transfer the general structure of the source to the target without first analyzing whether the general structure of the source can be applied or not. In addition, the low relational and conditional knowledge of students can also be one of the causes. Students do not have a strong understanding of the structure underlying mathematical concepts (Ahmad et al., 2020). These errors can be overcome by continuing to familiarize students with numeracy literacy questions using analogical reasoning. Students are guided to find as many concepts and knowledge as possible related to the source problem before being transferred to the target problem.

In addition, by providing varied and tiered questions starting from the easy level to the high level, it can also be done to train students' analogical reasoning in building numeracy literacy. If students are not assisted by analogous reasoning, it will be difficult for them to understand, find, and analyze information such as those contained in numeracy literacy indicators. The stages possessed by analogical reasoning help students in building numeracy literacy, which consists of structuring, mapping, applying, and verifying. Furthermore, the development of numeracy literacy-based learning designs with analogical reasoning can also be used as a way to build students' numeracy literacy. Teaching materials and questions based on numeracy need to be well prepared.

CONCLUSION

Analogous reasoning is one way that can be used in learning to build numeracy literacy because, with analogical reasoning, students will try to find problems that are similar to the questions given and then learn them by reading

and understanding the information provides. However, analogous reasoning in research can only be done by students with high abilities, while students with low abilities have not been able to use this reasoning. One of the reasons for this could be the lack of habituation to solve high-level questions in numeracy literacy and the unfamiliarity with using analogical reasoning. Analogous reasoning is not the only reasoning used to build numeracy literacy; other types of reasoning can also be used in building this numeracy literacy. Nowadays, reasoning is very mandatory to use in literacy-based learning because literacy requires reasoning, without reasoning, it will be difficult for students and prospective teachers to be able to solve numeracy literacy questions. Therefore, for prospective teachers to be able to solve numeracy literacy questions and be able to convey them to students, numeracy literacy needs to be built from now on.

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