Fundamental Mathematical Capability of Seventh Grade Student’s Mathematical Literacy in the One Variable Linear Equation and Inequality

S Z Nurohmah¹*, Mardiyana¹ and H Pratiwi²

¹Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Jl. Ir. Sutami No.36 A, Kentingan, 57126, Jebres, Surakarta, Indonesia
²Department of Mathematics, Faculty of Mathematics and Science, Universitas Sebelas Maret, Jl. Ir. Sutami No.36 A, Kentingan, 57126, Jebres, Surakarta, Indonesia

*Email: zuhriena@gmail.com

Abstract. Equation and inequality are aspect of the traditional mathematical content that are primary in describing, modelling and interpreting change phenomena. The study aims to describe fundamental mathematical capability of student’s mathematical literacy in the one variable linear equation and inequality. They are communication; mathematizing; representation; using symbolic, formal and technical language and operation; devising strategies for problem solving; reasoning and argument; and using mathematical tools. This study used qualitative descriptive method. The data was collected through tests and interviews. 102 subjects seventh grade students of MTs Negeri 1, MTs Negeri 2 and MTs Negeri 4 Kebumen did the written test. 9 students with high, moderate and low categories are selected with purposive sampling for interviewed. The result shows that students are lack in all fundamental mathematical capability, especially in representation; using symbolic, formal and technical language and operation; devising strategies for problem solving; reasoning and argument; and using mathematical tools capabilities.

1. Introduction
Mathematics is needed as a critical instrument to deal with real-world issues and challenges in societal, scientific, occupational and personal context [1]. Capacity to formulate problems mathematically (F), employ mathematical concepts, facts, procedures and reason (E), and interpret and evaluate mathematical outcome (IE) to predict phenomena, solve the problems and make decisions namely mathematical literacy [1]. Certain focus of mathematics curricula balance between skills and concepts development [2]. However, students struggle in mathematics was caused by lacking in basic mathematics skill or algebra [3]. Algebra, including algebraic expression, equation and inequality is an aspect of traditional mathematics content as a central in describing, modelling and interpreting change phenomena [1]. One variable Equation and inequality is a compulsory basic competency for modelling and solving problem. Student’s competency in one variable equation and inequality is low in UN year 2017 and 2018. It is assumed that mathematical literacy development through school mathematics need to be underpinned by fundamental mathematical capability.

Communication and representation are crucial processes [4] and essential ingredient [2] in mathematical literacy development. PISA (Programme of International for Student’s Assessment)
formulate the seven abilities that underlie students' mathematical literacy. These abilities are communication (C); mathematizing (M); representation (R); using simbolik, formal and technical language and operation (SLO); devising strategies for solving problem (DS); reasoning and argument (RA); dan using mathematical tools (MT) [1]. The interpretation of each ability is different in each process of mathematical literacy.

Communication (C) means the ability to read, encode, interprete statements, questions, tasks, objects, summarize and present sequel of mathematical results, present, explain and provide justification for the solutions found [1], and demonstrate mathematical ideas and symbols verbally or orally, and in writing, pictures and diagrams [5]. Mathematical communication indicators include: (1) describing situations of mathematical problems and ideas; (2) describe the situation and state the problem-solving design using algebraic forms or images; (3) using mathematical symbols, ideas, structures and sentences; (4) use integrated representation to express mathematical concepts and solutions; (5) building a particular problem or case from a certain model [6]; (6) reading with an understanding of mathematical equations; (7) develop conjectures, arguments and generalization of definitions; (8) convey mathematical sentences in their own language [7]; and (9) accuracy of symbols and notations, explanation of concepts, use of mathematical terms and mathematical calculations [8].

Mathematizing (M) is the ability to change problems defined in the real world into precise mathematical forms (structuring, conceptualizing, making assumptions and or formulating models), or interpreting or evaluating mathematical results or models in relation to actual problems, and describing mathematical activities base is involved [1]. Mathematics is divided into two types, namely horizontal mathematics and vertical mathematics[9–11]. The process of mathematics in algebra consists of: (1) understanding the problem to identify mathematical concepts relevant to the problem; (2) formulating the problem into a mathematical model; (3) solving mathematical problems and reflecting on the solving process; and (4) interpretation [9].

Representation (R) is the ability to select, interpret, translate, and use multiple representation to capture situations, interact with problems, referring to graphs, tables, diagrams, pictures, equations, formulas and concrete materials [1]. The mode of representation according to NCTM (2014) adapted from Lesh et al (1987) is visual representation, verbal representation, contextual representation, physical representation and symbolic representation [12]. According to [12], visual representations makes use of diagrams, pictures, sequence of numbers and other mathematical images to describe mathematical ideas. Words and phrases are used in verbal representation to interpret, discuss, define or describe mathematical ideas, bridging informal and formal mathematical language. Contextual representation is putting mathematical ideas into everyday, real-world, or imaginary situations using various discrete and continuous measurements. Physical representation is using concrete objects to show, research, act on or manipulate the mathematical ideas. Symbolic representation is using numbers, variables, tables and other symbols.

Reasoning and argument (RA) is a process of logically deep thinking that investigates and connects problem factors to make conclusions, examine the justifications given, or provide justifications or solutions to problems [1]. Indicators of mathematical reasoning are: (1) the ability to draw logical conclusions based on existing data; (2) the ability to check the validity of the argument; (3) ability to explain figures and tables; and (4) ability to prove the relationship between mathematical concepts [13]; (4) making assumptions, (5) performing mathematical manipulation, (6) providing reasons or facts for the validity of the solution [14].

Devising strategies for solving problems (DS) is how to recognize, formulate and solve problems effectively [1]. According to [15], problem solving strategies consist of cognitive strategies, metacognitive strategies and combined cognitive and metacognitive strategies. Cognitive strategies include the stages of rehearsal, elaboration and organization. Metacognitive strategies include stages of critical thinking and self-regulation. The combined cognitive and metacognitive strategy includes the stages of prediction / orientation, planning, monitoring and evaluating. Polya in [16] formulates a problem-solving strategy with stages (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, (4) looking back. Furthermore, still in [16], Schoenfeld states that in the end the problem solving process is a dialogue between problem solvers and previous knowledge, efforts and long thinking.

Using symbolic, formal and technical language and operation (SLO) is understanding, interpreting, manipulating and utilizing symbolic expressions in a mathematical context including arithmetic
expressions and operations determined by mathematical covenants and rules [1]. The types of symbols in mathematics are (1) symbols for numbers, quantities, variables or objects, including symbols of trigonometric functions, powers, roots, logarithms; (2) operating symbols that describe operations on numbers such as addition, subtraction, division, multiplication and set symbols, integral factorial and differential; (3) the symbol of the relationship that describes the definition of something such as equations (=) and inequalities (< and >), ratios [17].

Using mathematical tools (MT) is important role in communicating the results. It includes physical tools such as calculating tools, such as calculators and computer-based tools, knowing a variety and limitation of the tools, and being able to use a variety of tools that allow assisting mathematical activities [1]. Using mathematical tools includes performing addition, subtraction, multiplication and division operations correctly in solving problems [18].

2. Method
This study used descriptive qualitative method. The purpose of this study was to describe the fundamental mathematical capabilities that underlie students’ mathematical literacy in the linear equations and inequalities of one variable. The research subjects were 102 grade VII students of MTs Negeri 1, MTs Negeri 2 and MTs Negeri 4 Kebumen for the 2019/2020 school year. The subject are selected through purposive sampling.

The instrument of data collections used written test and interview. The fundamental mathematical capabilities data that are consist of communication; mathematizing; representation, using symbolic, formal and technical language and operation; devising strategies for problem solving; reasoning and argument, and using mathematical tools were collected by essay test. 9 students in the high, medium and low categories were selected for the interview. Interviews were conducted to obtain additional data about students’ perceptions in working on the questions.

The data source triangulation was used by comparing the fundamental mathematical capabilities written test and interview result to confirm the validity of the data. The steps of data analysis techniques are reducing the data, displaying the data, and concluding.

The indicators in this study are based on the relationship between mathematical processes and fundamental mathematical capabilities that underlie PISA mathematical literacy which is applied to the linear equations and inequalities of one variable. The indicators are shown in Table 1.

|   | C | Present problems into mathematical ideas |
|---|---|------------------------------------------|
|   | Reading problems with understanding the linear equations and inequalities of one variable |
| M | Identify variables and formulate problems into a mathematical model |
|   | Identify relevant mathematical concepts |
|   | Understand the extent and limits of mathematical solutions that are a consequence of the mathematical models used |
| R | Describe the problem situation visually and express in terms of linear equations and inequalities one variable |
|   | Symbolically describe problem situations based on relevant mathematical concepts |
|   | Interpret mathematical results in various formats in relation to the situations used |
| RA | Make predictions of problem solving, present mathematical manipulation and problem |
|   | Presents mathematical manipulations to determine solutions |
|   | Test solutions to confirm the correctness of the representations and manipulations used |
solving of the representations used

|   | F                                                                 | E                                                                 | IE                                                                 |
|---|------------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------|
| DS | Using cognitive, metacognitive strategies, a combination of the two, or Polya's steps to solve linear equations and inequalities of one variable | Using cognitive, metacognitive strategies, a combination of the two, Polya's steps or prior knowledge to solve single variable linear equations and inequalities | Using cognitive, metacognitive strategies, a combination of the two, Polya's steps or prior knowledge to evaluate and validate mathematical solutions to the problem context |
| SLO | Use symbols for objects or variables, operation symbols and signs of equations and inequalities | Using object or variable symbols, operation symbols and signs of equations and inequalities according to relevant mathematical concepts | Understand the relationship and fit between the problem and solution |
| MT | Uses operation symbols to solve linear equations and inequalities of one variable | Use operation symbols and relationships to define solutions | Use operation symbols and equation and inequality symbols to emphasize the correctness of mathematical results |

3. Result and Discussion
Students work on paper 5 items problems that are involving processes in mathematical literacy. The processes are formulating (F), employing (E), and interpreting and evaluating (IE).

3.1 Test Item
The first item is involving process F and E:
The freezing temperature for the best fish quality ranges from up to. The frozen fish will be shipped to the United States, which measures the temperature in Fahrenheit (F). Let:

$$ C = \frac{5}{9} (F - 32) $$

The temperature range for freezing fish in America in Fahrenheit (F) expressed by the sign of inequality is ....

**Figure 1.** Student’s high category answer

**Figure 2.** Student’s middle category answer

Students should describe situation into one linear inequality, and substitute the known variable value into formulae to solve the problem. In the fact, students who have good prior knowledge represent with change formulae:
However, they make a mistake in operating and get uncorrect answer. Most students cannot solve the problem because they unable to change the formulae either substitute the variable.

The second item involves the process F:
The stunting rate in Central Java in 2016 was 28%. By 2022 it is targeted to decrease to 19%. The target to reduce stunting rates every 2 years is ....

\[
C = \frac{5}{9} (F - 32) \quad \text{to} \quad F = \frac{9}{5} C + 32
\]

Figure 3. Student’s high category answer

Figure 4. Student’s low category answer

Students should describe problems in the equation to find out the solution. Students with high and several in the middle category are able to solve the problem, even without using an equation. Students with low categories make a mistake in the process.

The third item involves the process F:
A car box from a Mineral Water company came to Budi’s shop carrying 8 boxes of mineral water in bottles. However, the mineral water in one of the boxes has decreased by 5 bottles. The box car came three times with the contents always the same. Budi still has 6 bottles of mineral water from his previous sales to be sold again.
The box car then came to Wati’s shop carrying 11 boxes of mineral water in the same package and 8 bottles of mineral water. The car came twice with the same contents in the box. Before being sold, Wati took a bottle of mineral water for herself.
Many bottles of mineral water that Budi and Wati sell are the same. If the profit is about one carton each plus three bottles, then the many bottles of each benefit would be ....
Students in high and middle category are able to identify the variable, the task, and using symbolic operation. They understand the step to reach the solution, that the bottle quantity must be found. The students in high category encode the equation relation (=), but the students in middle category do not. The both of the student's categories are unable to solve the problem completely. The constraint is how to represent in an equation. Student in low category only rewrite the question without giving the argumentation or describing in the mathematical idea.

The fourth item involve the process F and E: A rectangular garden intersected by 10 palms on the long side and 7 palms on the wide side with equal spacing between trees. However, as observed, the distance between the 9th and 10th trees on the long side is 9 meters. While on the broad side, the distance of the 6th and 7th trees is 2 meters narrower. If the circumference of the park is not more than 210 meters, then the length of the park is ...
Students should describe the problem in an inequality. Students in high categories are able to solve the problem completely, make sense of the solution and the problem. Students in the middle category are able to solve the problem and unfortunately they make a mistake in interpreting the solution into the problem. Students in the low category identify the problem and the task, but they make mistakes in using mathematical symbol operation and mathematical tools.

3.2 Student’s Fundamental Mathematical Capability Result

The result of a student’s fundamental mathematical capability based on scale 0-4 is shown in Table 2.

| Capability                                      | Score | Category |
|------------------------------------------------|-------|----------|
| Communication                                  | 0.89  | Low      |
| Mathematizing                                  | 0.92  | Low      |
| Representation                                 | 0.47  | Low      |
| Devising strategies for problem solving        | 0.62  | Low      |
| Reasoning and argument                         | 0.52  | Low      |
| Using symbolic, formal, and technical language and operations | 0.43  | Low      |
| Using mathematical tools                       | 0.51  | Low      |

*Score range: 2.67 ≤ Score ≤ 4.00 ≡ High
1.34 ≤ Score ≤ 2.66 ≡ Middle
0.00 ≤ Score ≤ 1.33 ≡ Low

3.3 Communication

Most students lack in revealing mathematical ideas. Students with a high score category are able to understand the problem situation, present the steps to reach the solution even though they are unable to represent the equation and inequality. They can demonstrate the justification for the result which is
compatible with mathematical ideas and problem contextualized, utilizing their prior knowledge. Students in the middle category understand the problem, but lack a present intermediate solution and construct the argumentation to the context of the problem. Students in the low category most of them rewrite the problem than describe a mathematical problem, constrained revealing the steps to reach the solution.

3.4 Mathematizing
Students also lack in identifying the variables, transforming into mathematical model, connecting to the relevant concept and understanding extent and limits mathematical solution. Students in high category are able to identify the variable, transform in mathematical sentence, employ the prior knowledge to assist represent the situations and understand extent the solution. Students in the middle category are able to identify the variables and transform into mathematical models. Most students in the low category rewrite the question to identify the variable.

3.5 Representation
Students are unable to represent an equation and inequality, because they have not learned the subject yet. Students in the high and middle category use visual representation, or connect to relevant concepts and facts to describe the problems. All of the student constraints in symbolic representation such as equation and inequality relationship symbol, and variable. They are able to express themselves in operational symbols.

3.6 Devising strategies for problem solving
Students still use cognitive strategy only to assist solving problems that involve the process of employing mathematical concepts, facts and procedures. Utilizing prior knowledge is important for helping students plan and implement strategies to solve the problem.

3.7 Reasoning and argument
Students in high categories are able to reason, make conjectures of problem solving, present mathematical manipulation and problem solving logically in formulating situations mathematically without symbolic representation. Students in middle and low category struggle to reason and argue mathematically.

3.8 Using symbolic, formal, and technical language and operations
Students are unable to transform variable into simbolik language, to use simbol of the relationship such as an equation (\(=\)) and inequality (\(<, >, \leq, \geq\)). Students recognize simbolik operation, and make mistake because of inaccuracy using.

3.9 Using mathematical tools
Actually, students can use mathematical operations correctly. However, they use incorrect operation, or they constraint in prior processes such as mathematizing, representation, devising strategies, reasoning and argument and using symbolic language and operation.

4. Conclusion
Fundamental mathematical capability is important to underpin mathematical literacy [1]. Algebra, including one variable linear equation and inequality is an aspect of traditional mathematical content as a primary to describe, model and interpret phenomena of the change. Based on the result of the student’s fundamental mathematical capability, students are lacking in all capabilities. Especially in representation; using simbolik, formal and technical language and operation; devising strategies for solving problems; reasoning and argument; and using mathematical tools. Actually, the students have their prior knowledge that must be utilized to encourage their fundamental mathematical capability. Fundamental mathematical capability needs to be enhanced in mathematical school.

References
[1] OECD 2017 PISA for Development Assessment and Analytical Framework (Paris: OECD Publ) pp 53-61
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