Exploring the Knowledge of Content and Teaching (KCT) of prospective math teacher in planning mathematical literacy teaching.

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Abstract. This research aims to explore and describe the KCT of prospective math teacher in planning mathematical literacy integration in math class. One student with the highest achievement in mathematical literacy, mathematics, and pedagogic was chosen from 78 mathematics education students who were at least in the 5th semester. Data collection methods used were assignment and interviews. The subject was assigned to develop lesson plans to teach math literacy through math teaching in junior high schools. The lesson plans were analyzed by using KCT indicators and interviews were done as a data triangulation. In order to get the KCT profile of prospective math teachers, the data were analyzed descriptively. The results show that even though the subject had a good KCT in planning mathematical literacy teaching in math class but he was lack in utilizing mathematics tools and in connecting the math prior knowledge to support the mathematical literacy. The finding of this study suggests that in order to support students KCT in integrating mathematical literacy on math class, then higher education curriculum need to provide a program or courses to train the students to develop their mathematical literacy through math class.

1. Introduction
Mathematical literacy is defined as an individual’s ability to formulate, use and interpret mathematical knowledge in various contexts of real-world problems [1]. It involves the use of all mathematical content of concepts, facts, procedures and mathematical tools [2], mathematical reasoning to describe, to explain and to predict a phenomenon [2][3]. The skills used in mathematical literacy are skills in performing simple operations and making a simple conclusion [2]. The term mathematical literacy was mentioned by de Lange [4] which then used by PISA. Mathematical literacy also aligned with other terms such as numeracy [5], and quantitative literacy [6][7]. Nevertheless, these three terms agree that
mathematical literacy emphasizes the ability to recognize and use basic and simple mathematical knowledge in real life rather than the mastery of mathematics in schools, so that students with low math skills are able to do it.

This indicates that being a mathematically literate is a necessity for every individual to be able to face the challenges of the world in the future. Unfortunately, the result of mathematical literacy test in PISA survey in 2015 shows that many 15 year old students from countries participating in PISA survey, including Indonesia, have low performance. Whereas, this age is the final age of compulsory education, it means that there are likely many individuals who will be less capable of facing the challenges of the world in the future. Based on the results of this survey, many countries finally endeavour to make improvements to the curriculum with the mastery of mathematical literacy as the ultimate goal of education in different ways.

Unlike some countries, such as South Africa and Singapore, mathematical literacy is not a subject taught in Indonesia. However, mathematical literacy still can be taught to students by integrating it in the math class during the teaching and learning. Thus, the teacher should have a good Knowledge of Content and Teaching (KCT) about how to teach both mathematical literacy and mathematics through math class. As the students of mathematics education is the ones who will have the opportunity to teach mathematics in the future, their ability to make the integration is crucial. Therefore, the question in this research is to what extent does the prospective math teacher possess the KCT in teaching mathematical literacy integrated in the math class?

2. Mathematical literacy and mathematical content.
Inthis research, mathematical literacy content is defined as the mathematical processes that describe what individuals do to connect the context of a problem with the mathematics and thus solve the problem. It includes the ability to formulate situations or problems mathematically, the ability to use concepts, facts, procedures and mathematical reasoning, as well as the ability to interpret, apply and evaluate mathematical results [1]. To gain and use the ability, students should involve the fundamental mathematical capability. The capability includes: communication skills; mathematicalisation; representation; reasoning and argumentation; design strategy; use of symbols, formal language, techniques and operations; as well as the use of mathematical tools [1].

Mathematical content means the content of mathematics apropriote to math school curricula, i.e. algebra, change and relationship, quantity, and shape and space [1]. In this research, we only focus on content of algebra i.e relation and fuction. To integrate both mathematical literacy content and mathematics content then they should be supporting each other. Therefore, in a mathematics teaching with appropriate chosen basic competencies, one or more indicators of mathematical literacy skills involving some fundamental mathematical skills can be taught.

3. Knowledge of Content and Teaching (KCT) in teaching mathematical literacy.
Shulman classified the knowledge needed for teaching into three categories: Subject Matter Content Knowledge (SMCK), Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK) [8]. He argues that PCK is a special and interesting knowledge, because it is a collection of knowledge typical for teaching. In mathematics learning, PCK is an integration of pedagogical knowledge in general, mathematical teaching methodology and knowledge of mathematical disciplines. There are several opinions on aspects of PCK knowledge by some experts, some of whom are Ball, Thames and Phelps who categorize PCK into 3 aspects which include knowledge of content and student, knowledge of content and teaching, and knowledge of content and curriculum [9].

Knowledge of Content and Teaching (KCT) is a knowledge that combines knowledge of teaching and knowledge of mathematics. Shulman describes KCT implicitly as the most influential representation of ideas, analogies, illustrations, examples, explanations and demonstrations [8]. In other words, KCT is a way of representing and formulating learning materials so that they can be understood by others [8]. Furthermore, Shulman describes this knowledge as a teacher's ability to
transform his content knowledge in a form that is strongly pedagogical yet adaptive to the varied abilities and backgrounds of the students [10].

Many mathematics teaching tasks require interaction between the understanding of mathematical knowledge and pedagogical understanding which impact on student learning. Having KCT means that teachers should be able to utilize various resources [11]. Then teachers also should be able to evaluate the advantages and disadvantages of representation used to teach a particular content to fit the needs of students [9][12]. Therefore, teachers should be able to present content in a variety of ways such as; a matter of a concrete or contextual problem, image, situation or resource. In addition, teachers need to have the knowledge to organize content for learning [9][13], decide to use examples to start or examples to deepen understanding [9].

The success of teaching mathematical literacy depends on the teacher's skill to apply appropriate teaching approaches such as discussion and problem solving [14][15]. With KCT, teachers are able to choose appropriate strategies, approaches and learning materials for learning, and decide what tasks and assessment techniques will be used for teaching and learning [16]. The approach to teach mathematical literacy should be able to provide students with opportunities to engage with mathematical literacy in multiple contexts at a level so that students can understand it logically [17]. When conducting class discussions, teachers should know when to ask to clarify, when to use student notes to generate mathematical ideas, and when to ask new questions or to give new tasks to continue the learning [9]. A teacher should also know how to scaffold knowledge to help students develop their understanding [18]. KCT will help teachers to reflect on their learning [19] and improve effective communication between students and teacher [20]. Therefore, teachers need to know various ways to build students' mathematical thinking, or to correct student mistakes.

Based on the above description, what is meant by the KCT in teaching mathematical literacy through mathematics learning is a knowledge that combines knowledge about teaching and knowledge of mathematics and mathematical literacy. The KCT in this study is categorized into the knowledge of choosing and applying the learning strategy, the knowledge of organizing the material and the task of learning, the knowledge of choosing representation, and the knowledge of choosing the way of evaluation. Descriptions of each category are outlined in Table 1 below.

**Table 1. KCT indicators in planning the teaching of mathematical literacy.**

| Indicators | Descriptor of KCT Indicators |
|------------|------------------------------|
| Selection and implementation of learning strategies/approaches | Identify and select learning strategies and approaches to teach mathematical materials and mathematical literacy that match the content taught with regard to student needs. Know the shortcomings and advantages of selected strategies/approaches and know the alternative solutions. Plan the implementation of a strategy/approach that accommodates the diversity of students so that students can understand the learning materials. |
| Organizing materials and learning tasks | Choose the prerequisite materials that correspond to the topic/material to be taught. Organize/sort the content to facilitate student learning activities. Choose mathematical and mathematical literacy tasks appropriate to the topic/material taught, teaching aims and the strategies used. Choose an example appropriate for the purpose is to motivate, to clarify, or to deepen the material. Select contextual problem for students. |
| Selection of representation | Know and use representations, analogies, illustrations, explanations, examples and demonstrations that support the material to make it easier for students to understand. Understand the weaknesses and advantages of using certain representations to teach certain mathematical materials and mathematical literacy. |
| Selection and execution of evaluation | Choose an evaluation method that is appropriate to the learning strategy/approach and the material being taught. |

4. Research methods
This research was a qualitative research. Subject selection was conducted through mathematical literacy tests and document transcripts from 78 mathematics education students who were at least in 5\textsuperscript{th} semester at the University of Jember, Indonesia. The students voluntarily offered to take the test after the request to take the test was announced. While the transcript of student grade was obtained through the academic affairs of Universitas Jember, Indonesia. The students' test results were scored according to established coding guidelines and categorized into high, moderate or low mathematical literacy levels. An example of problem on occupational context and how to score the prospective teachers' performance were published in [21]. While, their transcripts are analyzed by calculating the GPA (Grade Point Average) for pure mathematics and educational courses by first separating the grade of pure subjects and the education (pedagogic) subjects. The GPA of pure subjects and educational courses is further categorized into three groups, namely high, moderate and low. Furthermore, One of them with high achievement in mathematical literacy, mathematics, and pedagogic was chosen as the subject. In addition, the reasoning communication ability[22] also be considered as the subject need to express his thinking.

Data collection methods used were assignment, observations and interviews. Subject was assigned to search information about mathematical literacy and to develop lesson plans and the learning material to teach math literacy through math teaching about functions and relationships in junior high schools. Subject was given flexibility in arranging the lesson plan, learning material and the number of sets of learning. The given time for the subject to complete the task is 3 weeks. As the lesson plans and learning material were submitted then researchers would analyzed it by some observation. The observation is based on the indicators and descriptors KCT on Table 1 to get the KCT profile of prospective math teachers. For deeper exploration and triangulation then the subject were interviewed based on the lesson plans.

5. Results and discussion.
Based on the data of mathematical literacy test scores and student grade transcripts then the researcher selected one highest achiever student in all three mathematical literacy, pure mathematics knowledge, and pedagogical knowledge. For the confidential purpose, for the next discussion the subject named as S1. S1 is a male mathematics education student currently sitting in semester 6 with a mathematical literacy, mathematical knowledge and pedagogical knowledge scores of 34 (maximum score 45); 3.685 (scale 4); 4 (scale 4). Thus S1 is categorized as high achiever student. At the very first discussion with S1, it was known that S1 did not have any knowledge before about the definition or characteristics of mathematical literacy. For completing the given task, S1 should sought information about mathematical literacy through several journals and books. S1 admitted that this was a bit difficult for him because most of the information he obtained was written in English, while information from an Indonesian-language source was not enough to help him to know more about mathematical literacy and how to teach it. At the end of the assignment, S1 handed over 2 sets of learning tools each consisting of a Lesson Plan with its scoring system and student worksheet. In the first meeting S1 taught math topics about the concept of relations and functions while at the second meeting about the formula of the function. The ability of mathematical literacy to be taught at both the first and the second meeting were identical, that was about the ability to formulate situations or problems mathematically, the ability to use concepts, facts, procedures and mathematical reasoning.

5.1. Selection and implementation of strategy/approach of learning subject.
Based on S1 lesson plan in teaching mathematics and mathematical literacy, S1 implements different strategies on every lesson plan. At the first lesson plan, S1 chose to use a scientific approach and discovery learning model. Then this finding was triangulated through the interview. According to S1, the combination of models and approaches was in line with the goals and materials to be taught. Because the purpose of learning was to find the concept of relations and functions then discovery learning would be appropriate while the phases in the scientific would help students to find the concept of function more systematically. S1 could also expose the constraints that may occur if
combines discovery learning and scientific approach is combined. S1 predicted that students would need a lot of mentoring so he would be overwhelmed. To overcome this, S1 planned to implement learning in small groups consisting of 4-5 heterogeneous students. S1 hoped with the heterogeneous group students with better skills would help a friend with ability below.

At the second lesson plan, S1 used a different strategy from the first one. In the second lesson plan, S1 choose to use the contextual teaching and learning (CTL) approach and the problem-based learning model. The problem-based learning model was chosen because according to S1 the use of problems for learning would be suitable for teaching both the formulation of functional and literacy skills which use concepts, facts, procedures and mathematical reasoning. While the CTL approach was chosen on the grounds that the use of contextual problems that were close and familiar to students would help the students to understand the problems and master the teaching materials. For S1, the use of this strategy would also have the same constraints as the use of the strategy at the first lesson plan so to cope with S1 would continue to use group learning with a heterogeneous small group of 4-5 students.

Based on these results it can be noticed that in choosing and applying the strategy/approach of learning S1 had been able to 1) identify and choose strategies and learning approaches to teach mathematical content and mathematical literacy that match the content taught by paying attention to the needs of students, 2) know the weakness/constraints and advantages of selected strategies/approaches and know alternative solutions, 3) Plan the implementation of strategies/approaches that accommodate the diversity of students so that students can understand the learning materials

5.2. Organizing materials and analysis of learning tasks.

To teach the concept of relation and function at first lesson plan, S1 organized learning materials in two learning task activities that were reflected in student worksheets. The first learning task was about finding the concepts of relations and functions in order to gain the mathematics teaching aims and the second task is about solving problems as application and problem to deepen the knowledge of mathematics from the first task. The first task is designed through a 5-steps of scientific approach. In observing activities assigned S1 presented contextual problems to pairing various kitchen spices and the flavor this problem was as an illustration function and then followed up with the presentation of various examples and non-examples of function (or relation). In the questioning activities, students were encouraged to ask questions related to observations. On hypothesis activities students were asked to make a conjecture about the function characteristic. Furthermore, on the activities of experimenting students were invited to test the truth of students' hypothesis. In communicating activities, students were asked to communicate in writing about the sense of function by using their own words. Thus the design of the task of learning in this first activity involves covering the teaching of mathematical material on the concept of function and relations, but also includes teaching the fundamental mathematical abilities of reasoning, modeling, devising strategies for solving problems, and communication. While, on the second task, S1 presented two problems of mathematical literacy with occupational context about chicken farming (see figure 1) for first problem and personal context about shopping at stationery stores (see figure 2) for the second problem. S1 argued that the contexts was familiar to students since certainly every student had the experience of buying stationery and that they often heard or read about farming chicken on their social environment. On this task, S1 planned to teach the ability to formulating situations mathematically; employing mathematical concepts, facts, procedures and reasoning; and interpreting, applying and evaluating mathematical outcomes as the mathematical literacy content on both problems. To solve the problem, S1 planned to trigger the students to use the fundamental mathematical capability such as communication, mathematization, representation, reasoning and argumentation, and devising strategies for solving problems.
Andi will buy school equipment in a store. At the store the price of notebooks is Rp2000, Pencil worth Rp1500, Ballpoint with price Rp2000, Ruler worth Rp1000 and eraser with price Rp500. If Andi brings money Rp10,000, mention 3 possible school equipment options that can be purchased if Andi must buy at least 2 types of school equipment! Show a relation in the store! Explain!

Mr. Heri has a chicken and duck farm. The ratio of the number of chickens and ducks is 3:4. The number of Pak Hadi's cattle are 840 animals. Each chickens lay 8 eggs each and each ducks lay 5 eggs. If all the eggs will be placed in an egg container like the picture on the side. If each container can hold 30 eggs how many egg containers are needed? Is laying eggs into their containers a function? Give your reason!

To teach the function formula on the second lesson plan, S1 uses only one learning task that was developed into three mathematical literacy problems. Unlike the first lesson plan, this time S1 would teach mathematical content and mathematical literacy content through one problem. S1 used mathematical literacy problems to deliver the construction of mathematical knowledge. In each case, students were asked to solve the problem as a means to teach mathematical literacy. Furthermore, students were given further questions to teach mathematical knowledge.

In relation to prerequisite materials, both at the first and second lesson plan S1 was lack in exploring the prerequisite knowledge needed to teach mathematical topics and mathematical literacy skills. S1 just wrote that the prerequisite knowledge for first lesson plan was just about the set whereas at the second lesson plan was the concept of the set, and the relations and functions. He argued that the students' knowledge to understand the set and register their members is important to introduce domain, codomain and range terms in both lesson plan. Then, it was not necessary to write out or to inform the students about the prerequisite knowledge of second task (mathematical literacy task) because mathematical literacy was not the main aims of the math teaching. Yet the activities contained in the student worksheets required more prerequisite knowledge. For example, in the second problem of the first lesson plan (see figure 2), prerequisite materials on ratio, and linear equation of one variable are needed to solve the problem. In addition, S1 never plan or think of using mathematical tools such as calculator to help student in carrying out the strategy to solve the problem during the math class. S1 assumed that the use of calculator was not necessary so that students could practice their ability in counting.
Based on the description above it can be noticed that S1 was able to organize the material and analyze the learning tasks quite well. This was because S1 had been able to: 1) select the prerequisite materials that match the topic/material to be taught despite lack of detail, 2) organize/sort the content to facilitate student learning activities well, 3) choose mathematical tasks and mathematical literacy topics/materials taught, teaching aims and strategies used, 4) choose a contextual problem for student.

5.3. Selection of representation.

In the first meeting S1 used contextual problems to represent the intended concepts such as pairing various kitchen spice with the flavor to introduce the concept of function. S1 also used the representation of the arrow diagram to assist students to understand the rules of installation of a relation or function. S1 describes a variety of arrow diagrams that illustrate examples and non-examples to help students construct function concepts (see figure 3). As in the first meeting, at the second meeting S1 used contextual problems by using the arrow diagram to represent the material formula of the function. For example S1 used problems related to the payment of the taxi cost analogous to the formula of multiples. S1 also realized that modeling of this function formula may be difficult for students because according to S1 students are not used to be involved in the process of reasoning. Therefore, S1 planned to use three problems with different contexts but have the same assignment questions so that students can analogize the second problem solve through the first problem, the third problem through the first and second, and so on. However, the solution offered by S1 has a weakness. Problems which are presented repeatedly will soon become a routine. Hence, students will memorize the solution with minimal reasoning. This may not support the achievement of mathematical literacy

![Figure 3](image3.png)

**Figure 3.** Design of examples and nonexamples in constructing the function concept.

5.4. Selection and execution of evaluation.

At the first and second meeting, S1 chose the same evaluation method. S1 used a scoring rubric to assess student performance during the learning process through activities in the student worksheets. Rubric assessment process prepared by S1 aimed to assess the mathematical knowledge and mathematical literacy students. The mathematical knowledge was assessed through indicators of correctness of answers while mathematical literacy was judged on the ability to choose appropriate problem-solving strategies and use appropriate mathematical knowledge. S1 also planned to use attitude assessment through teacher assessment, self-assessment and peer-assessment.

6. Conclusion.

Based on the results of the study, it can be concluded that subject S1, high achiever prospective math teacher, has a good KCT. S1 was able to choose and apply the strategy/approach to learning well; organize the material and analyze the learning tasks fairly well; choose the representation quite well; and choose and implement the evaluation of learning well. However, S1 was lack in utilizing
mathematics tools such as calculators and in connecting the math prior knowledge to support the mathematical literacy. S1 did not give any attention on the possessing of the prerequisite of mathematics knowledge needed to solve the mathematical literacy problem. This may cause some difficulties for students. They may lack of the ability to reason and to use the concepts, or procedures in order to solve the problem. The finding of this study suggests that in order to support students KCT in integrating mathematical literacy in math class, then higher education curriculum need to provide a program or courses specializing on how to teach mathematical literacy through math class.

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