

## Analysis of Mathematics Content Knowledge of Mathematics Teachers Based on Bloom's Taxonomy Revision

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**ABSTRACT**

This study aims to assess mathematics teachers' understanding of Mathematics Content Knowledge based on the Revised Bloom Taxonomy. The method used is quantitative descriptive research with a survey approach. The respondents of this study were mathematics teachers who taught at SMP/MTs in Losari District, Brebes Regency. Data was collected using non-test instruments in the form of questionnaires and question tests. Data analysis involves presenting data, testing differences, and concluding. The results showed that teachers' understanding of Mathematics Content Knowledge in teaching and mastery of the material was categorized as strong. Based on Bloom's revised taxonomy, teachers have good mastery, especially in knowledge dimensions such as factual, conceptual, procedural, and metacognitive knowledge, which are categorized as high. There was no significant difference in the average Mathematics Content Knowledge score of teachers, either with a working period of less than 10 years, 10-15 years, or more than 15 years.

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**1. INTRODUCTION**

Education is a process of transforming the attitudes and behavior of individuals or groups to facilitate human development through teaching and training methods. According to Law Number 20 of 2003 concerning the National Education System, Article 3 states that the purpose of education is to develop the potential of students through learning to become individuals who believe and fear God Almighty, have noble character, competent, independent, creative and become democratic and responsible citizens. The achievement of educational goals is closely related to the level of education quality, which affects the quality of human resources that have an impact on Indonesia's future civilization. However, issues related to the quality of education in Indonesia are still not resolved (Arifa & Prayitno, 2019a).

The quality of education in Indonesia is still low due to the lack of professional teachers (Hakim, 2015). To become a professional teacher, you must have four teacher competencies regulated in Law No. 20 of 2003, including pedagogical competence, social competence, professional competence, and personality competence.

Professional teachers, especially mathematics teachers, must also have good Pedagogical Content Knowledge, such as the ability to master teaching, understanding, and special abilities in combining material, curriculum, learning, teaching, and students. Mathematics teachers must also have a high understanding of mathematical content, one way of which is through Mathematical Content Knowledge (Hasanah et al., 2023; Dariah et al., 2022; Firly et al., 2022; Putri et al., 2022; Nuraena et al., 2022; Fitri et al., 2022).

Mathematical Content Knowledge or knowledge of mathematical content is an understanding that a mathematics teacher must possess. Mathematics is a very conceptual field of science. The teacher's teaching methods influence a student's achievement. A math educator must have a deep mathematical understanding. Understanding mathematics becomes the main goal in learning, showing that the material taught to students is not only to be memorized but, more than that, in the hope that students understand the concept of the subject matter (Hupudio, 1985).

Teachers play a role as the frontline in the school environment that has the potential to form young people with good integrity. The government takes various steps, such as the Teacher Competency Test (UKG), Teacher Performance Assessment (PKG), and Continuous Professional Development (PKB), to create a quality young generation. However, after the implementation of UKG, the results were not as expected. Secretary of the Directorate General of GTK (Teachers and Education Personnel) of the Ministry of Education and Culture Nurzaman admitted that there were criticisms related to the Teacher Professional Allowance (TPG), which was considered to have a less significant impact on improving teacher quality. Nurzaman explained that in 2017, based on evaluation, UKG was removed and replaced by PKB. The UKG that has been implemented becomes an analysis material to describe teacher profiles, which is then used as a basis for providing training. PKB no longer determines graduation but assesses the achievement of teachers' competencies (Oebaidillah, 2017). Based on the results of the Teacher Competency Test (UKG), mathematics teachers are in the sufficient category, especially high classification learning methods with a normal score of 66.29, and experts in the sufficient category with a normal score of 64.04.

Based on the results of the Trends in International Mathematics and Science Study (TIMSS) 2015, Indonesia ranks 44th out of 49 countries in mathematics ability (Arifa & Prayitno, 2019b). In addition, the results of the 2018 Programme for International Student Assessment (PISA) survey published by the OECD showed that Indonesian students' mathematics achieved an average score of 379 out of an OECD average score of 487 (Kemendikbud, 2019). The results of TIMSS and PISA show that students' mathematical skills in Indonesia are still very low. This indicates a problem in the learning process related to the teacher's understanding of mathematics. As Hill et al said (Krisnamurti et al., 2020), A teacher's understanding of mathematics is closely related to students' mathematics learning outcomes. Therefore, it is recommended that students improve learning outcomes by expanding mathematical knowledge.

Loewenberg Ball et al. (2008) describe the details of the categories of knowledge delivered by Shulman and classify the knowledge of mathematics teachers for teaching into six groups, namely Common Content Knowledge, Specialized Content Knowledge, Horizon Content Knowledge, Knowledge of Content and Student, Knowledge of Content and Teaching, Knowledge of Curriculum. Further, Shulman said (Yulianto & Nurjamil, 2016) that A teacher's teaching insight must also be supported by adequate content knowledge.

Knowing the teacher's MCK level about Mathematics Content Knowledge (MCK) will be very useful in the mathematics learning process, especially for educators who are still at the theoretical level. To see and find out the MCK of teachers can be used several taxonomies, one of which is the Revised Bloom taxonomy. Bloom's Revised Taxonomy is commonly used by teachers in schools to measure how capable students are of mastering all the material that has been taught by the teacher (Fitrawan, F., Ansharwati, S., & Arsyam, 2021). In Bloom's taxonomy, revisions are refined by (Anderson, L. W., & Krathwohl, 2001). Cognitive abilities are divided into two dimensions, namely, the dimension of knowledge and the dimension of cognitive processes. The Knowledge dimension includes Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Metacognitive Knowledge. Factual knowledge involves basic elements such as symbols associated with concrete references or "symbolic threads" that convey important information. Conceptual knowledge involves schemes, mental models, as well as explicit and implicit theories in various models of psychology. Procedural Knowledge usually appears as a series of steps to be followed, including knowledge of expertise, algorithms, techniques,

and methods collectively referred to as procedures. Metacognitive knowledge involves understanding consciousness in general, along with alertness and understanding of one's consciousness.

The above problems require more attention in order to be good for the future. Mathematics, as a basic subject in schools, should have the opportunity to overcome such difficulties. Teachers should have the option of dealing with science and figuring out how to be more active to help students' self-awareness. Mathematics learning needs to change and be more open to engaging with wider problems so that it can lead to more self-awareness, including student development. For this reason, it will be examined how the understanding of Mathematics Content Knowledge of mathematics teachers based on the revised bloom taxonomy in SMP/MTs, Losari District, Brebes Regency.

## 2. METHOD

The type of research used is quantitative descriptive research with survey methods. The survey method was used to determine the knowledge of the teacher's mathematical content based on the knowledge dimension in the revised Bloom's taxonomy. The study involved all mathematics teachers in three junior high schools in the Losari sub-district, Brebes regency: 2 teachers at MTsN 5 Brebes, 3 teachers at MTs Annur Karangjunti, and 5 teachers at SMPN 2 Losari.

Data were collected through non-test techniques (questionnaires) and tests. The questionnaire was given to find out the teacher's Mathematic Content Knowledge based on the Revised Bloom Taxonomy on the knowledge dimension of 25 statements. At the same time, the test instrument used consisted of 10 mathematical content description questions arranged based on the level of the revised Bloom taxonomic knowledge dimension. This test is intended to measure the teacher's knowledge of mathematical content—data analysis techniques with data presentation, difference testing, and concluding.

Prior to the study, the instrument was validated by 3 expert lecturers and 1 mathematics teacher. The results of the CVR questionnaire calculation showed that 23 items were declared valid, and 2 items were declared quite valid. In contrast, the CVR calculation results of the question test showed that all question items were valid. The study was preceded by describing the Mathematical Content Knowledge of mathematics teachers at MTsN 5 Brebes, MTs Annur Karangjunti, and SMPN 2 Losari by giving questionnaires. Then, describe the prospective teacher's Mathematical Content Knowledge based on Bloom's taxonomic knowledge revision by giving a set of written mathematical tests. Then, the results of questionnaires and Mathematical Content Knowledge tests are analyzed quantitatively, namely, the total score from teachers is calculated based on predetermined criteria.

## 3. RESULT AND DISCUSSION

This study aims to assess mathematics teachers' understanding of Mathematics Content Knowledge based on the Revised Bloom Taxonomy. After an assessment of the statement about Mathematics Content Knowledge based on the teaching process of 25 items, the results of the CVR calculation show that 23 items are declared valid and 2 items are declared quite valid as in the following table:

Table 1. Results of CVR Questionnaire Calculation

| Statement<br>Items | Expert Rating  |                |                |                | ne | N | n  | CVR | Description |
|--------------------|----------------|----------------|----------------|----------------|----|---|----|-----|-------------|
|                    | Validator<br>1 | Validator<br>2 | Validator<br>3 | Validator<br>4 |    |   |    |     |             |
| 1                  | 3              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 2                  | 4              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 3                  | 4              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 4                  | 4              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 5                  | 4              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 6                  | 4              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 7                  | 3              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |
| 8                  | 4              | 4              | 4              | 4              | 4  | 4 | 25 | 1   | Valid       |

| Statement<br>Items | Expert Rating |           |           |           | ne | N | n  | CVR   | Description |
|--------------------|---------------|-----------|-----------|-----------|----|---|----|-------|-------------|
|                    | Validator     | Validator | Validator | Validator |    |   |    |       |             |
|                    | 1             | 2         | 3         | 4         |    |   |    |       |             |
| 9                  | 4             | 4         | 4         | 2         | 3  | 4 | 25 | 0,5   | Quite Valid |
| 10                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 11                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 12                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 13                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 14                 | 3             | 4         | 4         | 3         | 4  | 4 | 25 | 1     | Valid       |
| 15                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 16                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 17                 | 3             | 3         | 4         | 2         | 3  | 4 | 25 | 0,5   | Quite Valid |
| 18                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 19                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 20                 | 3             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 21                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 22                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 23                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 24                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| 25                 | 4             | 4         | 4         | 4         | 4  | 4 | 25 | 1     | Valid       |
| $\Sigma$ CVR       |               |           |           |           |    |   |    | 24,00 |             |
| <b>Nilai CVI</b>   |               |           |           |           |    |   |    | 0,96  | Valid       |

Apart from the Results of the CVR Questionnaire Calculation, the following shows the results of the study are presented in tabular form and the percentage of each indicator.

Table 2. Analysis Common Content Knowledge (CCK)

| No Item        | $\Sigma$ Item               | Score | F  | $\Sigma$ Average Score | Percentage  |
|----------------|-----------------------------|-------|----|------------------------|-------------|
| 1, 2, 3, 4, 5, | 6                           | 4     | 23 | 92                     | 46%         |
| 6              |                             | 3     | 33 | 99                     | 50%         |
|                |                             | 2     | 4  | 8                      | 4%          |
|                |                             | 1     | 0  | 0                      | 0%          |
|                | Sum                         |       |    | 199                    | 100%        |
|                | Max Score                   |       |    | 240                    |             |
|                | Average Percentage Criteria |       |    | 83%                    | Very Strong |

As seen in Table 3, based on the results of the questionnaire, mathematics content knowledge teachers based on common content knowledge indicators get a percentage of 83% with very strong criteria. This shows that teachers have good knowledge of mathematical materials/topics related to the use of mathematical terms and notation appropriately, the ability to update mathematical knowledge from various sources, and solving mathematical problems by applying appropriate procedures.

A teacher needs to have a deep knowledge of mathematical material or topics, especially related to the proper use of mathematical terms and notation. This skill is key in conveying information clearly and providing good understanding to students. Teachers who have good mathematical knowledge can guide students effectively, explain concepts in more detail, and answer questions appropriately. In addition, the ability to update mathematical knowledge from various sources is also very important. With the development of science and technology, continuously implementing mathematical knowledge updates allows teachers to provide relevant and up-to-date material to students (Muthik et al., 2022).

Finally, teachers who can solve math problems by applying appropriate procedures provide concrete examples for students on how to deal with math challenges. This not only motivates students to learn but also helps them develop problem-solving skills that are essential in everyday life. Thus, good mathematical knowledge in the teacher not only benefits himself but also contributes positively to student learning and development.

Table 3. Analisis Specialized Content Knowledge (SCK)

| No Item                    | $\Sigma$ Item | Score | F  | $\Sigma$ Average Score | Percentage |
|----------------------------|---------------|-------|----|------------------------|------------|
| 7, 8, 9, 10,<br>11, 12, 13 | 7             | 4     | 37 | 148                    | 61%        |
|                            |               | 3     | 29 | 87                     | 36%        |
|                            |               | 2     | 4  | 8                      | 3%         |
|                            |               | 1     | 0  | 0                      | 0%         |
| Sum                        |               |       |    | 243                    | 100%       |
| Max Score                  |               |       |    | 280                    |            |
| Average Percentage         |               |       |    | 87%                    |            |
| Criteria                   |               |       |    | Very Strong            |            |

As seen in Table 3, in the special content knowledge indicator, the percentage is 87%, with very strong criteria. This shows that the average teacher has good knowledge related to mathematical abilities related to the school curriculum, understanding concepts and applying mathematical procedures in classroom learning, and the ability to solve various mathematical problems, including number theory, sets, systems of linear equations, comparisons, algebraic forms, social arithmetic, Pythagorean theorem, congruence, and congruence, as well as statistics and probability.

Teachers who have solid knowledge related to mathematical abilities play a very important role in improving the quality of learning in the classroom. A deep understanding of the school curriculum is the main foundation for teachers in compiling and implementing mathematics subject matter systematically. In addition, the teacher's ability to explain mathematical concepts clearly and provide applicable examples allows students to understand well and feel connected to the material. Teachers skilled in applying mathematical procedures appropriately provide a solid foundation for the development of students' analytical thinking and problem-solving skills. Moreover, teachers' ability to solve various mathematical problems, such as number theory, sets, systems of linear equations, comparisons, algebraic forms, social arithmetic, Pythagorean theorem, congruence, awakening, and statistics and opportunities, creates a challenging learning environment and motivates students to develop their mathematical skills better. Thus, good mathematical knowledge in a teacher not only forms a solid basis for mathematics education but also stimulates students' interest and involvement in learning mathematics (Sadiyah et al., 2022).

Table 4. Analisis Knowledge of Content and Student (KCS)

| No Item                    | $\Sigma$ Item | Score | F  | $\Sigma$ Average Score | Percentage |
|----------------------------|---------------|-------|----|------------------------|------------|
| 14, 15, 16, 17, 18, 19, 20 | 7             | 4     | 29 | 116                    | 50%        |
|                            |               | 3     | 32 | 96                     | 42%        |
|                            |               | 2     | 9  | 18                     | 8%         |
|                            |               | 1     | 0  | 0                      | 0%         |
| Sum                        |               |       |    | 230                    | 100%       |
| Max Score                  |               |       |    | 280                    |            |
| Average Percentage         |               |       |    | 82%                    |            |
| Criteria                   |               |       |    | Very Strong            |            |

As seen in Table 4, in the knowledge of content and student indicators, the percentage is 82% with very strong criteria. This shows that the average teacher has a good knowledge of students' understanding of the material learned (the ability to identify student characteristics and diagnose students' mathematical abilities), misconceptions, errors, or difficulties of students (the ability to

anticipate misconceptions that students may experience in understanding the material, and the ability to identify students who understand and lack understanding in mathematics learning); and Mathematics learning features (the ability to invite students to improve the ability to think logically, systematically, thoroughly and creatively, the ability to determine the right strategy for each material taught, and the ability to choose learning media to help students understand mathematics subject matter.

Table 5. Analysis Knowledge of Content and Teaching (KCT)

| No Item            | $\sum$ Item | Skor | F  | $\sum$ Skor Rata-rata | Persentase |
|--------------------|-------------|------|----|-----------------------|------------|
| 21, 22, 23, 24, 25 | 5           | 4    | 18 | 72                    | 45%        |
|                    |             | 3    | 26 | 78                    | 48%        |
|                    |             | 2    | 6  | 12                    | 7%         |
|                    |             | 1    | 0  | 0                     | 0%         |
| Sum                |             |      |    | 162                   | 100%       |
| Max Score          |             |      |    | 200                   |            |
| Average Percentage |             |      |    | 81%                   |            |
| Criteria           |             |      |    | Very Strong           |            |

As seen in Table 5, the knowledge of content and teaching indicator gets a percentage of 81% with very strong criteria. This shows that the average teacher has very strong knowledge about organizing subject matter (knowing the learning models and the right type of assessment used in mathematics learning) and choosing the presentation of the material (the ability to foster students' curiosity to learn mathematics and the ability to invite students to cultivate positive attitudes such as logical, critical, careful, conscientious attitudes and not easily given up in solving problems mathematics).

Teachers who have very strong knowledge of managing mathematics subject matter can create an effective and attractive learning environment. They not only master the learning models and the right type of assessment according to the curriculum but also have skills in choosing learning methods that can foster students' curiosity about mathematics learning. Use for the success of the learning process (Mualifah, Toheri, 2019). With this ability, teachers can invite students to have a positive attitude, such as being logical, critical, careful, thorough, and persevering in solving mathematical problems. Teachers who can create a dynamic classroom atmosphere and provide intellectual challenges can stimulate the interest of students to learn and participate in the learning process actively. In addition, the teacher's ability to motivate students to develop a positive attitude towards solving mathematical problems, such as accuracy and perseverance, forms a solid basis for the formation of the character of students who are ready to face various challenges in understanding mathematical concepts and overcoming complex problems. Thus, the teacher's in-depth knowledge not only affects students' understanding of mathematics but also helps shape attitudes and skills that are essential for success in learning mathematics.

Table 6. Descriptive Statistics MCK Math Teacher Based on Scores

|                       | N  | Range | Minimum | Maximum | Mean  | Std. Deviation | Variance |
|-----------------------|----|-------|---------|---------|-------|----------------|----------|
| Nilai MCK             | 10 | 14    | 16      | 30      | 24.90 | 4.887          | 243.50   |
| Valid N<br>(listwise) | 10 |       |         |         |       |                |          |

Based on Table 6 above, the average teacher's Mathematics Content Knowledge test score based on the score is 24.90, with a score of 83. This shows that the teacher's mathematics content knowledge is good. In general, this average has exceeded the KKM set by the researcher, which is 76, so the mastery of teacher mathematics content can be said to be good.

Mastery of mathematics content by a teacher has a crucial role in providing effective and meaningful teaching to students. The teacher's proficiency in understanding and mastering mathematical concepts becomes a fundamental basis for communicating the subject matter clearly to

students. A teacher who has a good mastery of mathematical content can answer students' questions appropriately, provide in-depth explanations, and guide students in solving math problems competently. A strong understanding of math content also allows a teacher to personalize the teaching approach according to the needs and level of understanding of students. Thus, good mastery of mathematics content by a teacher not only guarantees the quality of teaching but also provides a positive encouragement to students' interest and achievement in understanding and mastering mathematics subjects.

Table 7. Recapitulation of MCK Teachers Based on Knowledge Level

| Knowledge Level | Average Percentage | Category |
|-----------------|--------------------|----------|
| Factual         | 80%                | High     |
| Conceptual      | 80%                | High     |
| Prosedural      | 90%                | High     |
| Metacognition   | 78%                | High     |

Based on Table 7 above, it can be explained that Mathematics Content Knowledge teachers are in the high category based on their level of knowledge: factual, conceptual, procedural, and metacognitive. In general, it can be concluded that the teacher's Mathematics Content Knowledge based on their level of knowledge of Bloom's taxonomy revision is categorized as high.

Table 8. Output of MCK Descriptive Statistical Test of Teachers Based on Length of Service

|               | N  | Mean  | Std. Deviation | Std. Error | 95% Confidence Interval for Mean |             | Minimum | Maximum |
|---------------|----|-------|----------------|------------|----------------------------------|-------------|---------|---------|
|               |    |       |                |            | Lower Bound                      | Upper Bound |         |         |
| < 10 tahun    | 3  | 23.00 | 6.24500        | 3.60555    | 7.4866                           | 38.5134     | 16      | 28      |
| 10 – 15 tahun | 3  | 26.33 | 5.50757        | 3.17980    | 12.6518                          | 40.0149     | 20      | 30      |
| > 15 tahun    | 4  | 25.25 | 4.42531        | 2.21265    | 18.2084                          | 32.2916     | 21      | 30      |
| Total         | 10 | 24.90 | 4.88649        | 1.54524    | 21.4044                          | 28.3956     | 16      | 30      |

Based on table 8 above shows that the average Mathematics Content Knowledge test scores of teachers who have taught 10 – 15 years and > 15 years are greater than teachers who have taught < 10 years. It refers to understanding and experience that can contribute to proficiency in managing classes and understanding teaching materials. Adequate education, supported by extensive work experience, enables teachers to understand better various aspects of teaching tasks that are directly related to improving student achievement (Hasan, 2015).

Table 1. Output Uji One Way Anova

|                | Sum of Squares | df | Mean Square | F    | Sig. |
|----------------|----------------|----|-------------|------|------|
| Between Groups | 17.483         | 2  | 8.742       | .310 | .743 |
| Within Groups  | 197.417        | 7  | 28.202      |      |      |
| Total          | 214.900        | 9  |             |      |      |

As seen in table 8, the results of the One Way Anova test show that there is no difference in Mathematics Content Knowledge between teachers with a tenure of less than 10 years, 10 to 15 years, and more than 15 years. This is in contrast to the findings (Kurniawan et al., 2023), which show that there is a significant difference in the average exam results of teachers based on their length of service. This is different because teachers have mastered the mathematical content taught and have the understanding and ability to teach the content or material to their students so that Mathematics Content Knowledge teachers are not affected by their working period. The results of this study are supported by (Restiana, 2018) that the length of teaching the teacher does not influence the mastery of TPACK because the teacher's ability influences the mastery of knowledge.

#### 4. CONCLUSION

Based on the results of research that aims to describe the understanding of Mathematics Content Knowledge of mathematics teachers based on the revised Bloom taxonomy, it can be concluded that teachers have common content knowledge, specialized content knowledge, knowledge of content and teaching, and good knowledge of content and students, and test results show that Mathematical Content Knowledge of mathematics teachers is included in the high category based on the level of knowledge of Bloom's taxonomy Revision: factual, conceptual, procedural and metacognitive. Based on the one-way anova test, there is no difference between Mathematics Content Knowledge teachers who have taught for less than 10 years, 10 to 15 years, and more than 15 years. The results of this study can provide information to schools related to Mathematical Content Knowledge of mathematics teachers to further improve their efforts in training qualified teachers. As a teacher, you must be aware of your content knowledge so that you can continue to improve your knowledge of mathematical content in learning. Thus, efforts to improve the quality of education in Indonesia can be achieved through improving the quality of teachers. The limitation of this study is that the number of questions used is not balanced, so the chances of getting the right answer are also not uniform. It is recommended to conduct deeper and more comprehensive research on the teacher's Mathematical Content Knowledge based on the taxonomy of SOLO, Fink, Marzano, and others.

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