Relationship of Teacher’s Content Knowledge on Fraction Topic Toward Student Performance

A H W Kutub*, P Wijayanti and Manuharawati

Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Indonesia

Email: akh.17070785042@mhs.unesa.ac.id

Abstract. The aim of this study was to describe the relationship between teacher content knowledge and student performance in Fraction. This study used the mixed method that provided Content Knowledge test for fifteen teachers who taught the seventh class. The test consists of multiple choices to measure facts and procedures, knowledge of concepts and relationships, and knowledge of generalization. The study was divided into two phase, Quantitative phase and Qualitative phase. The Quantitative phase, teachers were mapped in two different levels, low and high based on score of Content Knowledge test. Two samples were classified into low level and high level. Furthermore, two groups/classes of the teacher samples were analyzed using Chi-Square test to investigate the relationship between teachers and student performance. The Qualitative phase of the study were included into three stages: (1) teacher interview, and (2) Student Problem solving, (3) description of the relationship of teacher’s content knowledge and student learning performance. The results of the study showed that the Teachers content knowledge in Fraction were affected to student performance, in addition, there were also similarities in the pattern of student performance tests on fraction and the teacher's answers based on the results of the CK test.

1. Introduction

Fractions are one of the richest and most complex topics in mathematics teaching programs [1], and are considered to be one of the most difficult to teach, most cognitive and most important mathematical topics for advanced mathematics [2,3], especially for elementary school students [4]. This is also confirmed by research by numerous studies regarding the low performance of students in algebraic problems involving fractions [5,6].

Teacher knowledge affects to the student performance and achievement [7,8], even becoming one of the most influential factors in student learning [9]. Thus, teachers are expected to be able to teach effectively. The teacher does not only to be a master on the material but also be able to explain using various methods including Get hand On, Use Visuals, Get the Games Out, etc.

Yeo [10] reported that a teacher cannot be expected to be able to explain mathematical concepts if he does not have a complete understanding of the mathematical concepts. A success learning depends on the teacher’s content knowledge [11], teachers with a limited content knowledge, have a fewer opportunities to influence student performance than those who conceptually understand. In other words, teacher’s mastery of subject matter is very important in the learning system.

However, knowledge of matter alone is not enough, "Saving knowledge of a subject matter is not enough to teach it" [12]. Teachers need knowledge that can be used to transform the knowledge of content (content knowledge) into effective learning, teachers able to present material effectively will help to develop student’s knowledge [12].
A number of experts have developed several works focusing on the teacher knowledge in different domains, such as the definition of numbers [13], Algebra [14], Geometry and Measurement [15], Statistics [16], Ratios and Comparisons [17] and Fractions [18]. However, none of these studies analyzed the relationship between teacher knowledge and student performance.

Other research pathways, such as those carried out by Tchoshanov, [11,19]; Campbell et al., [20] Hill, Rowan & Ball, [21], Ofos R et al., [18] Trobst S et al. [22], provided an alternative that specifically addressed to the relationship between various types of teacher knowledge and student achievement. In general, research on the relationship of teacher and student knowledge is divided into two categories: quantitative research [11,23] and qualitative research [18, 20-22] with indicators of teacher knowledge are CK and or PCK.

These studies indicated that teacher’s knowledge has an impact on student achievement or performance, but which teacher's knowledge? Therefore, this study departs from the assumption that teacher’s content knowledge, has an impact on the student performance. Therefore, the question of this study is, (1) is there a relationship between teacher’s knowledge of certain content on the student performance? And, (2) what is the relationship?

2. Theoretical Background

2.1 Teacher Knowledge

Shulman [12] defines teacher knowledge as a framework of understanding and skills, tools and values, character and performance that shape teaching abilities, which later in 1987, Shulman shared teacher knowledge in seven categories of basic knowledge that must be possessed by a teacher: (1) Content Knowledge, (2) General Pedagogical Knowledge, (3) Curricular Knowledge, (4) Pedagogical Content Knowledge, (5) Knowledge of learners and their Characteristics, (6) Knowledge of Educational Contexts, and (7) Knowledge of purpose, educational purposes and educational values [24].

These seven basic abilities are the basis of research development in the following years. However, from the seven categories of teacher knowledge, the category of content knowledge (CK) and pedagogical content knowledge (PCK) received much attention from a number of experts on the development of teacher knowledge research after 1987, because CK and PCK were the main parts of learning, this also Shulman emphasized that, PCK is a differentiator of teacher professionalism in learning [19,25].

In general, teacher knowledge research is mapped in 3 categories: (1) Teacher knowledge in certain categories (PCK, CK, MCK, etc.), this research was initiated by Shulman and consistently developed by Hill and Ball (Tchoshanov, 2011). In addition, Rowland, Huckstep and Thwaites [26], and Blomeke S et al., [27]. In their research, they emphasized the importance of various aspects of teacher knowledge in certain categories, such as knowledge about teaching, teacher knowledge about learning content, knowledge of pedagogical content and others. (2) Teacher's knowledge is related to certain material, such as: Understanding Numbers [13], Algebra [14]; Geometry and Measurement [15], Statistics [16], Ratios and Comparisons [17] and Fractions [18,19]. (3) Teacher's knowledge and relation to student performance. There are at least three names that consistently conduct research and this category, Tchoshanov [11,19] and Campbell [20] and Depaepe, F [22,25].

2.2 Teacher Content Knowledge

Success in learning depends on teacher’s content knowledge [11]. Teachers who have limited content knowledge have fewer opportunities to influence student achievement than teachers who conceptually understand material/content. Content Knowledge is defined as "the amount and organization of knowledge per se in the mind of the teacher" or the amount of knowledge contained in a teacher [12]. Such knowledge includes, (1) Subject Matter Knowledge (SMCK) or knowledge of content in the subject matter, (2) Knowledge of pedagogical content, and (3) Knowledge of the curriculum. This involves conceptual knowledge (knowledge of concepts, principles and definitions) and procedural
knowledge (knowledge of procedures and problem solving), why this statement is true or false and how knowledge is constructed [11].

Campbell et al., [20] defined Content Knowledge as knowledge related to mastery of material, content or mathematical content; whereas Pedagogical Content Knowledge is knowledge integrated teacher knowledge of certain material and how to integrate it into learning, thus the material is easy to understand and can improve student knowledge. This statement is slightly different from what was stated by Shulman [12] which PCK is part of CK. In contrast to Campbell et al., Olfos et al., [18] provide different research alternatives, to analyze more deeply the specific knowledge of mathematics of teachers and teacher teaching knowledge, Olfos et al., Refers to Vergnaud's conceptual theory which divides CK teachers in two categories, (1) Conceptual content Knowledge (Cck) and (2) Representational Knowledge (RK).

Ball, Hill, and colleagues [21,28] analyzed teacher mathematics knowledge for teaching (Mathematical Knowledge of teaching (MKT)) and its effect on teaching quality and student achievement. In his research, CK was mapped in three categories of knowledge, namely (1) knowledge of general content, (2) knowledge of specific content, and (3) knowledge of content horizon. While for PCK, mapped in 3 categories, knowledge, namely content and student knowledge, content and teaching, and content and curriculum [28].

Tchoshanov [11] used the word cognitive demand as a function of teacher content knowledge (p.145) related to the many opportunities for learning and teaching in the classroom. In the aspect of learning, how much thought is needed in the classroom, or how far the subject matter knowledge of the teacher in the teaching material in the class. While in the teaching aspect, which type of teacher knowledge is needed to support students' thinking in the classroom.

Therefore, Tchoshanov [11,19] used cognitive type as an instrument to measure teacher knowledge content. Cognitive classification used in this study builds the existing research and consists of knowledge of facts and procedures (for example, procedural knowledge), knowledge of concepts and connections (for example, conceptual knowledge), and knowledge of models and generalizations (for example, generalized knowledge).

3. Research Method

3.1 Research Design

This study consisted two phases, quantitative and qualitative. The Quantitative phase is related to the connection performance of each group from the class taught by the selected teachers. The qualitative phase included two stage, (1) collect data from teachers, analyze it and then determine the important point for the interviewed teacher, and (2) Student Problem solving.

3.2 Participants

The participants in this study were all seventh-grade students and all teachers who taught in seventh grade, at the Al-Amien Prenduan Foundation. The details of the participants are as follows, 490 male and 599 females, so that the total number of students is 1089. Meanwhile, the Teachers consist of 6 male and 9 females, the total number of teachers is 15 teachers.

Given to these 15 teachers, the CK-Test, and 1089 students, were given questions about fractions. CK-test scores and student performance scores are the main data for statistical analysis in the quantitative phase. then, based on the CK-test score, teachers are mapped into two groups, low TCK and high TCK. for each group, one was chosen to represent low TCK and high TCK. The low TCK is taken from the teacher with the lowest CK-test score (Ahmad selected), and the high TCK is chosen from the teacher who has the highest score (Muhammad).

The CK-test instrument was designed and developed to measure teacher Content Knowledge based on different cognitive types, according to the Tchoshanov framework [19]. There are three types of Cognitive Teacher Content Knowledge:
1. Type 1: Knowledge of Fact and Procedure.
   This type is called Procedural Knowledge, the knowledge that emphasizes memorizing facts, definitions, formulas, properties, and rules, performing procedures and calculations; make observations, take measurements, and routine problems solving.

2. Type 2: Knowledge of Concept and Connection.
   Called Conceptual Knowledge, which is emphasizing to the concepts understanding, making relationships, choosing or giving many representations, and resolving non-routine problems.

3. Type 3: Knowledge of Models and Generalization.
   The knowledge that integrates two types of prior knowledge, generalizes mathematical statements, designs and makes mathematical models, tests expectations and proves a theorem.

   Type 1 focuses on recall capabilities, and applies basic mathematical facts, rules and algorithms to routine procedures. For example, students are asked to solve the following fraction questions, \( \frac{2}{3} \div \frac{1}{2} = \), if students are able to solve the problem, then they are declared to have procedural knowledge of fraction distribution. If students are able to solve the above questions in more than one way (such as completing in the form of diagrams etc.), then they have type 2. However, type 3 requires integration of the two previous types of knowledge, and is more theoretical [11]. For an example, when is the statement \( \frac{a}{b} : \frac{c}{d} = \frac{ac}{bd} \) (for a, b, c and d integers), it is always true? unlike questions in the two previous types, students are asked to have a reason, model and generalize knowledge of the concept of fraction sharing. There are indicated that the difficulties faced by students when performing fraction operations are due to the weak knowledge of the model and the generalization of students to the concept of fractional operations [19].

4. Results and Discussion

4.1 Teacher response to Content Knowledge Question

Two selected teachers are given three questions, focused on the type of teacher’s cognitive knowledge based on the results of a test of teacher content knowledge and interviews.

4.1.1 Teacher Response to Content Knowledge Question-1

| Ahmad | Muhammad |
|-------|----------|
| Statements A, C, and D, false and true are B. (The teacher does not give specific reasons, but mentions that in the book it is mentioned \( \frac{p}{q} - \frac{r}{s} = \frac{qs - pr}{qs} \)) | The answer is B, that \( \frac{p}{q} - \frac{r}{s} = \frac{qs - pr}{qs} \). Because in addition operations and subtractions of ordinary fractions, the denominator must be equated with the same number. So that in an ordinary Fraction (here \( \frac{p}{q} \)) the denominator is multiplied by "s" so that it gets \( \frac{ps}{qs} \) (the numerator is also multiplied by s so it doesn't change the value of the Fraction). In the same way \( \frac{ps}{qs} \) is obtained. So, the correct statement is \( \frac{p}{q} - \frac{r}{s} = \frac{sp - qr}{qs} \). |

It seems that the two teachers have different approaches in answering questions 1. The response from Ahmad provided a bit of procedural understanding, Ahmad used procedural knowledge in the absence of the development of the concept of procedural knowledge. In contrast, Muhammad gave a better explanation of procedural knowledge than Ahmad. However, in interview session, both of them were able to explain the nature of the reduction of a Fraction, namely by equating the denominator first of a Fraction.
4.1.2 Teacher response to Content Knowledge Question-2

In this second question, the teacher was asked to complete $\frac{1}{4} : \frac{1}{2}$ with two approaches to completion, and then gave an example of a real problem that represents the problem.

| Table 2. Teacher response to Content Knowledge Question-2 |
|----------------------------------------------------------|
| **Alternative 1:** |
| Ahmad: $\frac{1}{4} : \frac{1}{2} = \frac{5}{4} \times \frac{2}{1} = \frac{10}{4} = \frac{5}{2}$ |
| Muhammad: $\frac{1}{4} : \frac{1}{2} = \frac{5}{4} \times \frac{2}{1} = \frac{10}{4} = \frac{5}{2}$ |
| **Alternative 2:** |
| Ahmad: $1.25 : 0.5 = 125 \times 50 = 2.5$ (Ahmad wrote on his paper as above, without giving any information) |
| Muhammad: $\frac{1}{4} \times \frac{2}{1} = \frac{2}{4} \times \frac{1}{2}$ |

The response from the two teachers to the second question is correct, but if observed, Ahmad's response shows more on procedural knowledge, using the formula that when a Fraction is divided by another Fraction, the Dividing Fraction is reversed and the "divide" changes into multiplication. Note also on the answer to the second alternative, Ahmad converts Fractions into decimal forms, which means Ahmad means more that Fractions are a value, this is reinforced during the interview session.

Researcher: Why can the division of Fractions turn into multiplication?

Ahmad: The multiplication rule states that when a fraction is divided by another fraction, then the sign "divide" changes to times and the divider is folded, the denominator becomes the numerator and vice versa.

Researcher: In the second alternative, you change Fractions to decimal, Why?

Ahmad: To make it easier for me to work, isn't the answer correct?

Researcher: How do you understand students and illustrate that the statement is true?

Ahmad: yeah ... returned to the original formula.

Muhammad's response, gave a different analysis and approach. Muhammad seemed to be trying to answer like Ahmad did, but was not in a hurry to immediately use "flip". Muhammad, like giving a reason for the "flip" trait, can be used in the division operation in Fractions. Even with the second alternative, Muhammad tried to illustrate Fractions in the form of cubes, $\frac{5}{4}$ illustrated with 5 cubes, with each cube being a quarter. Then construct a half-sized cube by grouping two cubes a quarter into one half cube. So that there are two half cubes, and $\frac{1}{2}$ of the half cube. Muhammad's response indicated procedural knowledge supported by adequate conceptual knowledge. This is also reinforced by each teacher's answer to a factual problem that represents $\frac{1}{4} : \frac{1}{2} = \frac{5}{4} \times \frac{2}{1} = \frac{10}{4} = \frac{5}{2}$.
Table 3. Teacher response to Content Knowledge Question-2

| Ahmad | Muhammad |
|-------|----------|
| Suppose Ani has 1 ¼ kg of flour and wants to divide the flour by ½ kg. How many people get the flour? | Pak Umar has a garden planted with coconut trees. One day Pak Umar will give the coconut tree fertilizer. Pak Umar carries 1 ¼ kg of fertilizer. Each coconut tree is given ½ kg of fertilizer. Determine how many coconut trees if the fertilizer that Mr. Umar brings is used up? |

Ahmad's conceptual understanding is not as good as Muhammad's, note the illustration of the problem Ahmad gave, Ani has 1 ¼ kg of flour and wants to divide the flour by ½ kg. then the question immediately appeared, how many people got the flour? The problems given are correct but not right, and will be ambiguous to students, especially the answers given, are 2½, how will students illustrate two and a half people, While Muhammad gave problems properly thus easy to understand. This reveals Muhammad's conceptual understanding is better than Ahmad.

4.1.3 Teacher response to Content Knowledge Question-3

The aim of this question is to find out the knowledge of teacher generalization. What is the statement $\frac{p}{q} : \frac{r}{s} = \frac{pr}{qs}$, ever true for All p, q, r, and s are integers, with q and s not zero.

Table 4. Teacher response to Content Knowledge Question-3

| Ahmad | Muhammad |
|-------|----------|
| The statement is wrong. Look again at the formula for the division of two Fractions. The answer must be: $\frac{p}{q} : \frac{r}{s} = \frac{p}{q} \times \frac{s}{r} = \frac{ps}{qr}$ | If an ordinary fraction (in this case $\frac{p}{q}$) in the multiplication or division operation will be equal if multiplied by the identity of a multiplication and division. So, in the $\frac{p}{q}$ Problem: $\frac{p}{q} : \frac{r}{s} = \frac{pr}{qs}$ is a true statement if $r = s$, because if $r = s$ in the $\frac{r}{s}$ problem will be the multiplication and division identity, namely 1. |

Ahmad gave the wrong response to the third question. Ahmad was too focused on procedural knowledge, so he ignored the conceptual analysis of the question. In contrast, Muhammad's answer was correct even though the explanation was not provided a suitable evidence. Muhammad assumed that the statement was true if $r = s$.

4.2 Student response to Fraction Question

4.2.1 Student response to Fraction Question -1

The first Student questions are identical to the first teacher questions: results for 1 ¾ and ½ are. Almost all students in both groups correctly resolved the fraction distribution problem given: 28 of the 29 students in Ahmad's group, and 25 of 26 students in Muhammad's group. We conducted a linguistic analysis of the terms used by students in both groups while explaining their solutions to the Fraction distribution problem. The most frequently used terms emerge from students' written responses are "flip", "cross multiplication", "divider", "first fraction", and "second fraction". The table below (Table 5) captures the frequency of terms used by students in both groups along with the chi-square value.
Table 5. Frequency of terms used by students while solving the fraction

| Term Used by Student | Ahmad Group (n=29) | Muhammad Group (n=28) |
|----------------------|--------------------|-----------------------|
| Flip                 | 20                 | 18                    |
| Cross Multiplication | 15                 | 11                    |
| Dividend             | 0                  | 8                     |
| Divisor              | 2                  | 8                     |
| First Fraction       | 11                 | 2                     |
| Second Fraction      | 12                 | 4                     |

Table 5 shows that the two groups are not a much difference in using the word "flip" which are 65% for Ahmad and 61.53% for Muhammad. In contrast, the two groups relatively use the same word of multiplication. Although in quantity there are more Ahmad groups, but proportionally, the two are not much different, but if there is a tendency for the Ahmad group to use the words "first Fraction" and "second Fraction" more than Muhammad's group, many use the word "divisor" and "dividend", which were mathematically accurate.

4.2.2 Student response to Fraction Question -2

Almost all students in both groups answered correctly on the issue of Fraction distribution, 26 of the 29 members of the Ahmad Group answered correctly, and 25 of 26 members of Muhammad's group answered correctly. However, 8 of the 29 members of Ahmad's group were able to present the factual example of the division question correctly, indicating that students had sufficient procedural knowledge, but did not have sufficient cognitive abilities. In contrast to Ahmad's group, 19 of the 26 members of Muhammad's group were able to correctly present the factual example of the issue of Fractions. Some of them use the approach, Fractions as "measurements", and Fractions as part of the whole.

The following are examples, interpretations given by students. “Mother buys 1 3/4 kg of sugar to make a cake. How many cakes can he make if one cake requires 1/2 kg of sugar?”; Students provide fraction interpretations as measurements. While other students gave the example of Fractions as part whole as follows, Fatimah took 1 3/4 bottle of oil. This was only half of what Aishah had. How many bottles of oil were taken by Aishah?

4.2.3 Student response to Fraction Question -3

Based on student work analysis, some responses were obtained, including wrong responses such as "never right" and "impossible", some correct responses such as "true if a = b and c = d" (or "true if a = b = c = d = 1 "), and the response is correct -" true if c = d ". Only one student in Ahmad's group could find a solution that was partly incorrect while in Muhammad's group 8 students offered the correct solution and two students - a partially correct solution. The frequency of student responses along with chi-square values is illustrated in Table 6 below.

| Student response | Ahmad Group (n=29) | Muhammad Group (n=28) |
|------------------|--------------------|-----------------------|
| Never true       | 24                 | 8                     |
| Impossible       | 4                  | 4                     |
| True if ps = qr  | 0                  | 5                     |
| True if r=s      | 1                  | 11                    |
| Always true      | 0                  | 0                     |

According to the results as shown in table 6, there is a statistically significant difference in the response of students in choosing "Never True" in favor of Ahmad's group, and the response of students who choose "right if r = s" in favor of Muhammad's group. But, both groups have the same choice of answers, "impossible" and "always right" answers.
4.3 Connection between Teacher and Student According to Cognitive Knowledge

4.3.1 Connections between teacher and student procedural knowledge

When responding to Question 1, both teachers emphasized the importance of student skills in applying the rules for the division of Fractions. Based on the above analysis, Ahmad spoke only of the "standard situation", while Muhammad spoke further to "non-routine problem-solving situations" that are very important in developing student reasoning.

Subsequent observations related to mathematical terminology and teacher vocabulary usage. Although Ahmad and Muhammad had the same average score on items that measured teacher knowledge of facts and procedures, the use of mathematical vocabulary and terminology was more accurate in Muhammad's case. He used the terms "dividend" and "divisor" which are mathematically accurate in answering question 2, while Ahmad used inaccurate terms "first fraction" and "second fraction" which are then reflected in student responses: there are statistically significant differences in use the terms "dividend" vs. "first fraction" and "divisor" vs. "second fraction" between groups. More specifically, students in Muhammad's group preferred to use the terms "dividends" and "divisor" which were mathematically accurate compared to the terms "Fractions first" and "Second fractions" which frequently used by students in Ahmad's group. In addition, Muhammad's articulation of the idea of the inverse nature of the operation (see the response to question 2), and reciprocal ideas (see the response to question 3), contributed to his deep understanding of the division of Fractions.

4.3.2 Connections between Teacher and Student Conceptual knowledge

In this second question, it is divided into two approaches, completing the Fraction distribution problem and describing the problem into a factual problem. When completing the Fraction distribution problem, both teachers were able to answer correctly, and almost all students answered correctly. However, the performance shown by Ahmad places more emphasis on procedural knowledge, using the existing formula and nature of the distribution of quotations, without being reinforced by good rationalization. And when giving an example of a factual problem from the question of the operation given, Ahmad was able to answer correctly but not exactly.

Along with Ahmad, the response given by Ahmad's group was not much different. 26 of the 29 Ahmad students were able to answer correctly the Fraction distribution problem, but 3 of 29 were able to provide a correct description of the factual problems involving the Fraction operation.

Muhammad gave a better response from Ahmad, although explicitly Muhammad's answer was not much different from Ahmad's, but Muhammad was able to provide better rationality. This shows that Muhammad's conceptual knowledge is better, and in depth this will also have an impact on students' understanding and performance. It was proved by the response of Muhammad's group on the second question, 25 of 26 were able to answer and 17 of 26 were able to provide a good illustration of factual problems involving fractional operations.

4.3.3 Connections between teacher and student Generalization Knowledge

As discussed in the previous section, Ahmad gave the wrong answer, and Muhammad gave the correct answer but it was not followed by the depth of proof and explanation. Interesting to see is the answer from Ahmad's group, 1 of 29 answered correctly, 24 of 29 students always answered wrongly, and 4 students answered it was impossible. This is also the same as Ahmad's explanation and answers. Meanwhile, 10 out of 26 students from Muhammad's group answered correctly, while the rest were divided into always wrong (7 students), Not possible (4 students), and $ps = rq$ (5 students). And based on the results of student performance, it seems that Muhammad emphasizes good understanding of content in learning, it was seen from the depth of rationality in students' answers.

Overall, we observe differences in the approach used by the teacher to non-routine questions: while Muhammad recognized and accepted the challenge, Ahmad ignored and avoided it. Our observation also shows Ahmad's weak conceptual understanding with questions that explore his conceptual understanding of the division of Fractions. This observation resonates with the difference between the
average scores of Ahmad and Muhammad in the Content Knowledge test which measures their conceptual and general knowledge (see the Results section). The most convincing difference in teacher knowledge was related to their students’ performance in solving question 3: there was a statistically significant difference between groups at the p-value level <0.01 in choosing ”never True” (supporting Ahmad’s group) and ”True if c = d” (supports Muhammad’s group) responses. Lastly, but not least, in-depth observations about statistically significant differences between groups in the number of blank answers (no solution) for question 3: four students in Muhammad's group decided not without any solution (maybe, because of doubts) instead of anything. The solution compared to Ahmad's group: all students in Ahmad's group except one were ”sure” to give the wrong solution.

5. Conclusion

The main result of this study is to provide answers and analysis of research questions stated in the introduction. To answer these questions, as we explained in the Methodology section, we deliberately selected two opposite cases based on the average score on the teacher content knowledge test in the Fraction Material to examine carefully the relationship between teacher content knowledge and student performance. While solving a set of three questions related to the division of Fractions. As we expected based on teacher scores on type 1 cognitive items (measuring knowledge of facts and procedures) from Test Teacher Content Knowledge Score (Ahmad score - 80% and Mohammad score - 90%), there were no observed differences between student performance in the two groups at procedural questions 1. With regard to teacher scores on cognitive type 2 items (Ahmad scores - 46% and Mohammad scores - 69%), we observed a statistically significant difference ($\chi^2 = 3.933, p<0.05$) in knowledge measurement students about concepts and connections. The clearest difference between student performance in the two groups observed in question 3 (measuring model knowledge and generalization) which was also statistically significant ($\chi^2 = 8.43, p<0.01$) and revealed a close relationship with teacher scores on type 3 items cognitive from TCKS (Ahmad score - 30% while Mohammad score - 70%). Student performance is related to their teacher’s knowledge: students in Mohammad's group performed better than the students in Ahmad's group, especially in solving questions 2 and 3. Thus, this study contributes to a body of research that claims that teacher content knowledge is very important for student learning with a narrow focus on Fraction topic.

Research on teacher knowledge is very relevant because of its significant relationship with student knowledge. This is consistent with the claims of several experts (Baumert et al., Hill, Shilling, & Ball), that the teacher's content knowledge is very influential on student learning [8,21]. Teachers cannot teach what they do not know [18,19], therefore this research makes a special contribution to the field that shows the relationship between teachers and students' knowledge in certain material, namely Fractions. Teachers need to continue to improve their competence and participate in professional development activities, especially in content knowledge. The findings of this study can add research-based literature and recommendations on developing teacher awareness about a particular knowledge topic and its relationship to students' knowledge and understanding.

References

[1] Aksoy N C and Yazlik D O 2017 J. of Educ. and Training Stud. 5 219
[2] Norton A and Boyce S 2013 The J. Math. Behav. 32 266
[3] Siegler R S, Thompson C A and Schneider M 2011 Cogn. Psychol. 62 273
[4] Trivena V, Ningsih A R and Jupri A 2017 J. of Phys. Conf. Ser. 895 012139
[5] Gabriel F 2016 Aust. Prim. Math. Classr. 21 36
[6] Booth J L, Newton K J and Twiss-Garrity L K 2014 J. of Exp. Child Psychol. 118 110
[7] Goldhaber D and Brewer D J 2000 Educ. Eval. and Policy Analysis 22 129
[8] Baumert J et al 2010 American Educ. Res. J. 47 133
[9] Ma’rufi, Budayasa I K and Juniati D 2017 J. Phys. Conf. Ser. 954 012002
[10] Yeo J 2008 Proceedings of the 31st Annual Conference of the Mathematics Education Research Group of Australasia 621

[11] Tchoshanov M 201 Educ. Stud. in Math. 76 141

[12] Shulman L S 1986 Educ. Res. 15 4

[13] Izsaak A, Jacobson E, Araujo Z D and Orrill C H 2012 J. for Res. in Math. Educ. 43 391

[14] McCrory R, Floden R, Ferrini-Mundy J, Reckase M and Senk S 2012 J. for Res. in Math. Educ. 43 584

[15] Murphy C 2012 J. of Math. Teach. Educ. 15 187

[16] Groth R E and Bergner J A 2006 J. Math. Think. and Learn. 8 37

[17] Ekawaty R, Lin F L and Yang K L 2015 Eurasia J. of Math. Sci. and Tech. Educ. 11 513

[18] Olfos R, Goldrine T and Estrella S 2014 Revista Brasileira de Educacao 19 913

[19] Tchoshanov M et al 2017 J. of Math. Behav. 47 54

[20] Campbell P F et al 2014 J. for Res. in Math. Educ. 45 419

[21] Hill H C, Rowan B and Ball D L 2005 Am. Educ. Res. J. 42 371

[22] Tröbst S et al 2019 Unterrichtswissenschaft 47 79

[23] Odumosu M O and Olisama O V 2018 Int. J. of Educ. and Res. 6 83

[24] Shulman L S 1987 Harvard Educ. Rev. 57 1

[25] Depaepe, F., et al (2015), Teachers' content and pedagogical content knowledge on rational numbers: A comparison of prospective elementary and lower secondary school teachers. Teaching and teacher education. 47. 82-92

[26] Rowland et al 2005 The knowledge quartet: a tool for developing mathematics teaching. Paper presented at the European Conference on Educational Research, University College Dublin, 7-10 September 2005

[27] Blomeke S et al 2016 Teach. and Teach. Educ. 56 35

[28] Ball D L, Thames M H and Phelps G 2008 J. of Teach. Educ. 59 389