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Exploring Pre-service Teacher's Knowledge of Content and Teaching (KCT) and Computational Thinking: The Case of Addition and Subtraction

Abstract: This research discusses the knowledge of content and teaching (KCT) and computational thinking (CT) of pre-service elementary school teachers on student work results. How much do pre-service teachers deepen students' thinking about the concepts of addition and subtraction? This research aims to get an overview of pre-service teachers' thinking about KCT and CT so that the results can be used to determine educational policies for developing human resource capabilities in elementary schools. The subjects of this research were three pre-service teachers at elementary school that selected by purposive sampling. The criteria for pre-service teachers are those who have taken basic concepts of mathematics, mathematics education, and mathematics development. The subjects in the low, medium, and high categories from state universities with A accreditation in Yogyakarta, Indonesia. The type of research is a case study. The research instruments namely the results of elementary school students ' work about addition and subtraction, then interview instruments to give an idea of how deeply they think about the material. The KCT's findings are that pre-service teachers do not understand the Van De Walle concept of addition and subtraction, do not understand the prerequisites for addition and subtraction material, and pre-service teachers find unique ways of learning from students. In the CT component, there are two components that appear in them, namely pattern recognition and decomposition. An interesting finding was that pre-service teachers only learned about the Van de Walle technique after seeing the results of the work carried out by students. This means that previously they did not use those techniques at all. This picture shows that pre-service teachers' KCT and CT is still not optimal, so further, and in-depth research is needed to explore their understanding.

Keywords: knowledge of content and teaching (KCT), computational thinking, pre-service teacher, mathematics, addition and subtraction

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Introduction

Learning math is an interesting thing. Various thoughts both formally and informally can develop in math learning activities. Every student, especially elementary school students, has a level of thinking

according to their cognitive abilities. On the other hand, learning mathematics is a learning object that has a level of difficulty that is considered high (Arlinwibowo et al., 2020; Hafiz et al., 2017; Kooken et al., 2013). One proof is the PISA results in the field of mathematics of students in Indonesia which are still low (Chirkina et al., 2020). The PISA results show that students still lack reasoning and understanding skills.

Each student has diverse thoughts. This emphasizes the need for a teacher to convey a topic to students. This teacher's ability requires a mathematical situation, in creating a learning bridge for students (Muntazhimah & Ulfah, 2020). The focal point is the teacher's ability to design an appropriate contextual framework to build this knowledge (Niss, 2013; Rakhmawati & Mustadi, 2022). Mathematical didactics place students in appropriate learning situations. This theory was developed by Brousseau who built on the constructivist foundation of how humans can interact with the environment, and influence each other (Balacheff, 2016).

The acquisition of mathematical knowledge requires typical natural situations, and there is no natural scientific method for teaching mathematics (Balacheff, 2016; Oktay et al., 2021). This statement means that mathematics teaching has a social dimension, meaning that it can be influenced and has an influence on the social environment. The main study in mathematical didactics is how teachers examine the material in-depth and transform it into contextualized learning situations (Ariyanto et al., 2017; Gök, 2019; Suryadi, 2010).

The KCT domain has a fundamental urgency for prospective elementary school teachers. Ability in the KCT domain involves understanding various techniques and methods of effective numeracy thinking to be conveyed to students (Metz, 2018). In this domain, pre-service elementary school teachers can design problem-solving, reasoning, and application of numeracy concepts in everyday life. KCT is a combination of knowledge about teaching and knowledge about mathematics (Hill et al., 2008). Mastery of numeracy knowledge combined with strategies and techniques for teaching numeracy to students. At this stage, the role of KCT is closely related to CCK. Research (Chikiwa et al., 2019) proves that KCT is the focus of MKT development, and CCK is one of the domains that has a mutually influencing relationship with KCT. The KCT domain is strongly influenced by the teacher's abilities and knowledge. The KCT domain requires the teacher's ability to connect mathematical concepts and ideas with pedagogical approaches to produce meaningful and effective learning (Raiula & Vijaya Kumari, 2018).

KCT also includes the teacher's ability to identify common mistakes that students often make, relate numeracy concepts to real-world situations, design activities that encourage problem-solving, and provide constructive feedback to students. Ways to explore teachers' KCT in teaching are in various ways, for example, questionnaires containing questions that require teachers to organize the listed numeracy concepts or skills (rational counting, matching number symbols with dotted cards, and rote counting) and indicate the sequence of how they should be taught and then support their answers (Chikiwa et al., 2019; Koponen et al., 2019). How to measure KCT in numeracy for prospective teachers' students can use numeracy questions that contain problem-solving. Apart from that, it can be connected to questions related to numeracy teaching techniques for elementary school students.

Computational thinking (CT) is interpreted as a series of thinking patterns that provide representation, reasoning in various abstractions, and solving problems effectively (Gadanidis et al., 2017). CT can develop as a science related to programming languages on computers that work quickly. The essence of CT is the process of thinking quickly in solving a problem. Computational thinking is also seen as an approach to problem-solving that uses concepts and techniques from computer science to analysed and solve complex problems (Tedre & Denning, 2016). CT as a thinking process helps individuals deal with problems systematically and logically, by utilizing concepts such as abstraction, decomposition, pattern recognition, and algorithmic thinking (Wing, 2020).

CT in the context of the numeracy process refers to the application of principles and concepts from computing in solving mathematical problems. This involves structured, algorithmic, and logical thinking to analyze, solve, and model numeracy problems (Romero et al., 2017). It is believed that the role of computational thinking in numeracy learning activities can provide opportunities for individuals to improve their PISA scores (Niswar, 2021). The relationship between these two variables is that they have the same intersection in supporting and using higher-level thinking processes. In the process of implementing activities with Computational thinking, there are two ways, namely (1) presenting a classroom that has activities that specifically discuss the thinking skills being taught or (2) integrating thinking skills into existing lessons (Ye et al., 2023).

Learning related to addition and subtraction in elementary school students is very diverse. Students can learn according to the experience they have, or learning obtained at the previous stage (Castro et al., 2021). Students also have various problems, one of which is difficulty in understanding basic number operations (Baroody, 2006). Addition and subtraction 1-20 are basic materials. Students have an urgency to be able to understand this material so that in the future there will be no non-contextual terms in student learning activities. Terms that are often found in learning math are borrowing, and saving, even in Indonesian terms there is the word "owe". The term is deemed inappropriate for student learning in elementary school.

In this study, the addition and subtraction concepts used strategies developed by (Walle et al., 2018). Addition and subtraction can be framed into 3 activity structures. Based on the above series of addition and subtraction learning activities, four strategies can be used for students. These strategies include joining, separating, part-part-whole, and comparing. Joining can be interpreted as describing the initial process, modifiers, and results of combining. Separating is interpreted as the initial process, the change in the form of separating, and the result of the change. Part-part whole as a process from a combination then becomes a branch, or from a branch form to a whole form. In the comparison part, it is from a whole form and then compared in a smaller form.

The urgency of this research is the diverse abilities of students who have the potential to make new findings or ways in the mathematization process. This diverse student thinking needs to be explored in depth and become a potential for the development of the mathematics learning process in elementary schools (Suri & Herman, 2020). In addition, computational thinking is one of the competencies that must be possessed today. Computational thinking supports students' thinking patterns with various components (Wing, 2020). The purpose of computational thinking is to help students think mathematically, this mathematical process that allows students to learn.

The difference between this research and the previous research is that this research begins with the findings of a grade 2 student who has alternative thinking in working on subtraction problems. The student thought that, 12 - 4 can be produced by adding 2 as a unit with a pair of 4. The pair of 4 to become 10 is 6, so that the result can be obtained 2 + 6 = 8. Thus, 12 - 4 is 8. The student explained that he tried to find a pair of 10 to help him solve addition and subtraction problems. This student no longer uses fingers or borrowing and saving techniques. This data is used to measure KCT and CT from pre-service teachers for elementary schools.

Research Methods

This research used qualitative method with case study. The purpose of this research was to explore the central phenomenon on addition and subtraction material 1-20. The research instruments used were student grade 2 activity and interviews for pre-service teachers. The data collected in the form of learner work results and interview transcripts were analysed by retrospective analysis to find learning design conclusions based on the design obtained.

Research subjects were selected using purposive sampling with categories of low, medium, and high mathematical ability. Location at a state university with A accreditation in Yogyakarta, Indonesia. Pre-service teachers have taken courses in basic mathematical concepts, mathematics education, and mathematics development. This course is a prerequisite course before they dive into the practice of teaching elementary school mathematics. There are 3 students regardless of gender. Pre-service teachers try to explore the thinking of second grade students using answer sheets and student activities.

The research refers to mathematics learning using addition and subtraction materials 1-20 in elementary school students. The theory used refers to the concept of Van den Walle (Walle et al., 2018). Further calculations depend not only on the knowledge of composing numbers carefully and basic skills in flexible calculations, but also on insight into developing strategies, attitudes towards mathematics, and other pleasures in calculating (Heuvel-panhuizen, 2003).

The instrument for KCT uses 4 indicators from (Koponen et al., 2019) including 1) Know different teaching methods and styles; 2) familiar with educational trends; 3) Favor varied teaching methods; 4) Base teaching on students' ideas. The instruments for CT use from (Wing, 2020) instruments from which include decomposition, pattern finding, abstraction, and algorithms. Data analysis was carried out by analysing the pre-service teacher's answers by finding coding in the answers.

Result and Discussion

Result

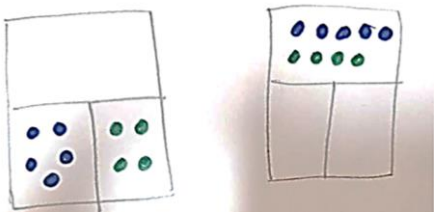
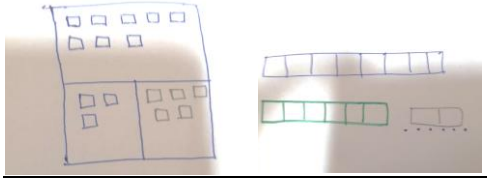
The results of this research are interviews with class 2 students' answers. There are 3 pre-service teachers with PST code 1 for the first pre-service teacher. PST 2 for the second Pre-service teacher. PST 3 for the third Pre-service teacher. From the class 2 students' worksheets, the abilities of pre-service teachers in KCT were explored. The research used 4 indicators from (KCT) by (Koponen et al., 2019) with the following results.

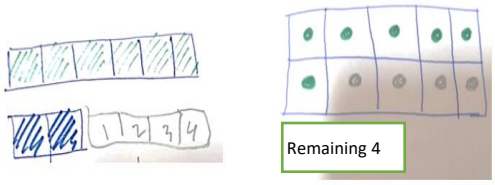
Table 1. Results from KCT interviews

No	Indicators	Questions	PST 1	PST 2	PST 3
1	Know different teaching methods and styles.	If asked to teach addition and subtraction 1-20, how would you do it?	"I will use concrete media available in the school environment. Apart from that, I will count backwards on my fingers."	"In the past, I was taught by counting backwards or on my fingers. Apart from that, I was taught by saving and borrowing techniques"	"I use concrete media and ask my students to draw pictures. If the numbers are large, I use the save and borrow technique."
2	familiar with the educational trends	Do you know any variations of mathematical thinking for teaching addition and subtraction 1-20?	"As far as I know, I counted on my fingers and my teacher used to memorize 1-10"	"I don't know many techniques about it, I also forgot how to learn that material when I was in elementary school"	"I don't know many ways, because in the past I only counted together with my classmates"
3	Favor varied teaching methods	Do you know the concept of Van de Wahle addition and subtraction which consists of 3 points?	"We've never learned about that"	"Sorry, we never knew. But I've seen the boxes in a 2nd grader's book."	"Never before, and just found out."
4	Base teaching on students' ideas	What are the prerequisite materials for teaching addition and subtraction?	"The prerequisite material for this case is that students must be able to count numbers, understand the concept of units and tens"	"Students of course already understand the concept of numbers, and know larger numbers are smaller. Or you can also learn about jumping numbers ".	"The right prerequisite material is writing numbers and counting. Apart from this answer, it is very important to have knowledge about pairs of 10.

These results illustrate pre-service teachers' thinking about KCT components. The results above are also supported by the results of a pre-service teacher study on the performance results of grade 2 elementary school students. These results are as follows in Table 2.

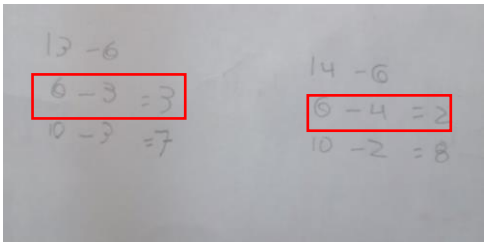
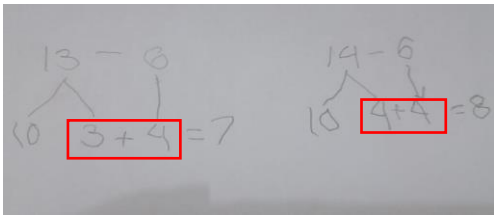
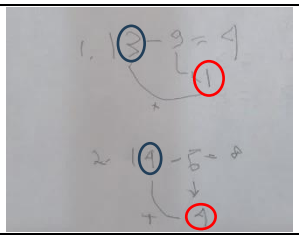
Table 2. Pre-service teachers' thinking on the basic concepts of addition and subtraction

The results of the work of grade 2 students	Results of pre-service teacher comments for elementary schools
	PST 1: "This student tries subtraction and addition techniques with columns of boxes accompanied by different colors." PST 2: "This student uses techniques like in the class 2 book." PST 3: "This student uses subtraction and addition thinking simultaneously. A dancing technique"
	PST 1: "The way it is presented is more unique with 2 different concepts." PST 2: "The first method is the same as student 1. The second method is for him to calculate the difference." PST 3: "This student's thinking is more varied, in 2 different

	ways"
	PST 1: "This student uses the technique of calculating the number of differences from the whole." PST 2: "This student's method is easier to read because of the symbols." PST 3: "This student counts differences, in 2 different ways. One with boxes and one with different colors."

These results illustrate the teacher's thinking in exploring students' answers. Apart from that, it shows the teacher's ability regarding the 3 methods of addition and subtraction presented by van de whale. In the answers above it can be seen that no one understands this concept. The next study is the technique for calculating students using their own methods and thoughts, namely in Table 3.

Table 3. Pre-service teachers' thinking on student counting techniques

	PST 1: "Wow, this student found a unique way by counting the units first. A different way, because so far I only counted on my fingers." PST 2: "So far I have been counting backwards. My teacher used to ask us to use our fingers or borrow a friend's fingers. This technique is new for me." PST 3: "After I observed him using the concept of ones and tens. This technique can replace the countdown technique that is taught a lot in schools."
	PST 1: "This student is more structured for students in the lower category." PST 2: "I prefer this technique, because it is more coherent. This child is more creative, and the method is easy to accept." PST 3: "It turns out that I have found many ways to count. If you look at it, it looks like the last number uses a pair of 10s."
	PST 1: "This student uses the same technique as before, but faster. I have never been taught that way." PST 2: "When we were at school, we never had this method. It turns out this technique is easier." PST 3: "This student thinks faster, from this it further proves the importance of knowledge of pairs of 10 for addition and subtraction material."

Discussion

Knowledge of Content and Teaching (KCT)

Pre-service teachers' content knowledge about the concepts of addition and subtraction is limited to the way they learned it when they were in school. The three research subjects understood how to add and subtract using the backward counting technique. Apart from that, the technique that is mastered is the storing and borrowing technique. Storing on addition and borrow on subtraction. The backward counting technique has a high error rate if a student does not master the sequence of forward and backward numbers. Sometimes students also make mistakes because they miss numbers (Desli, 2016; Wahyudi et al., 2018). Not only that, the concept of storing and borrowing is widely used by teachers in Indonesia and is difficult to eliminate. This concept uses a set of 10. Students in Indonesia are very familiar with this method, almost all schools only learn using this technique. These results are in accordance with research results which illustrate that students use a lot of storing and borrowing techniques (Sujarwo et al., 2020).

According to the three respondents, this was the first time they had seen the technique of working

with bond 10. It was very surprising that after learning basic concepts of mathematics, mathematics education and mathematics development, they did not know about this technique. There is something missing that this concept does not reach pre-service teachers. Looking at this fact, it can be found that pre-service teachers also do not know about this technique.

Not only that, for them Van de Walle's concepts, namely joining and separating, parts whole, and comparing, are not yet fully recognized. There were respondents who had seen the part-whole technique in books but did not know the name of the concept. The concept of joining and separating was not discussed much in these three responses. The concept of parts-whole is the concept most familiar to respondents. The concept of comparing has been recognized by showing the difference in numbers in the results of the third student's work.

Interestingly, these results are in accordance with research (Singh, 1998) that the van de whale concept for grade 2 elementary school students has not been explored well and students still do not use this technique much. However, this research was 15 years ago, when various technical developments should have occurred. It is impossible for past and present results to remain the same considering the highly developed student backgrounds, varied learning media, more qualified teachers, and the rapid development of the times. If so, the pre-service teacher's thinking is still the same as before. Because looking at the results, students have used various ways of thinking, but pre-service teachers don't know these techniques.

On the other hand, this research and research of (Robiansyah et al., 2018) found that elementary school students have unique mathematical thinking. Especially for the three respondents who had never encountered this method before. This adds to the significance of this research and is proof that pre-service teachers can learn directly from students' various thoughts and problem solving. This finding is important in that students directly bring adults into their thinking world. Not only do they receive a touch of learning from adult concepts, but students can now think according to the reasoning they have.

In analyzing stage 2 answers from the three elementary school students, many pre-service teachers were amazed by their way of thinking. These various mathematical process skills are important for elementary school students (Stigberg et al., 2022). This mathematical process forms mental mathematical thinking in students, which continues to grow with age and the amount of practice. These three students showed numeracy thinking that was different from that which had been studied by pre-service teachers.

The pre-service teachers try to recognize each student's technique. In the first student analysis, respondents had started to guess about the concepts used by the students. Student 1 uses the concept of subtraction in units. For example, in question 13-6, what is subtracted is 6-3 = 3, then 10 -3 = 7. The concept presented by the students was recognized by respondents with the answer that this technique requires reinforcement of the prerequisite learning about tens and ones. The relationship between ones and tens is very useful for learning addition and subtraction (Wilkie, 2014).

The second student analysis, the respondents looked more at the systematic structure of students' answers. In problem 13-6, 13 is first decomposed into 10 and 3. This student sees the pattern of the pair 10 of 6 being 4. The student adds these 2 patterns by taking a number that is not 10, namely 3 and 4 for a total of 7. This technique is recognized by students. Respondents as the technique most likely to be applied by grade 2 elementary school students. The response admitted that this method has a combination of a prerequisite understanding of counting 10 bills and the application of the concept of ones and tens. The third student's analysis was not much different from the second student's answer. These students were quicker to use the concepts of 10 bonds and place value. Thus, the third student calculates more quickly according to his abilities. The results of this research are in line with the results of research of (Khanby, 2018) which has proven the effect of bond 10 on the learning process of addition and subtraction.

KCT consists of knowledge about content and how to teach mathematics to students. If we look at the various results of pre-service teacher answers, it is found that coding includes never, don't know, and amazed. Haven't referred from the answer to van de walle's concept. Don't know refers to answers about mathematical thinking process techniques, especially on addition and subtraction material. Amazed, that is, the respondents were very amazed at the thinking skills presented by the students. This coding finding illustrates that the KCT of pre-service teachers is still not well described. It is a big reflection that this basic concept has not been mastered by pre-service teachers. The respondents have started training or

teaching practice at school. However, with these findings, it allows them to teach in the way they learned in the past. There is no development of mathematical thinking presented by teachers to students.

In discussing prerequisite material, pre-service teachers do not yet fully understand the material that students must master to master addition and subtraction operations. They only say that students must understand numbers in sequence. Prerequisite material includes the concept of forward and backward continuous numbers, the concept of ones and tens, filling in gaps, understanding the concept of skip numbers, and the concept of 10 bonds. If students master this prerequisite material, it will be easier for students to master addition and subtraction material (Afridayanti et al., 2022).

The fact is quite surprising that teachers' KCT for understanding prerequisite material is still not optimal. This can cause students in grades 1 and 2 to experience difficulties, especially in subtraction. Another surprising fact is that this method is a common technique abroad but is still something new for pre-service teachers here.

Computational Thinking

The patterns that pre-service teachers find are part of one of the thoughts of computational thinking. The various activities that pre-service teachers have done are one of the applications of computational thinking that is indirectly carried out by students. CT components are abstraction, llgorithmic, decomposition, and pattern recognition (Mota et al., 2016; Yongheng et al., 2020). In this study found in the research part of decomposition in pre-service teachers. Pre-service teachers can divide the problem into smaller solutions so that to get a solution. The method of decomposition found is that they understand the core of a big problem, then try to divide it into branches of solution. They found this when exploring students' thinking.

Pre-service teachers can also find patterns that are used when trying to explore how students work. This activity is an activity that refers to the CT component (Cansu, 2016; Kafai & Proctor, 2021). In these two components, pre-service teacher can rigidly explain the reasons underlying their thinking. When using the bond 10 technique with joining, pre-service teacher found a number pattern from student's thinking. The findings of this study prove that elementary school students can also process learning activities that refer to higher-order thinking. In line with that, the results of research (Romero et al., 2017; Varol & Farran, 2007) that elementary school students can also do learning activities with computing. Existing computations refer to math learning activities. The pattern of work carried out by grade 2 students has begun to be discovered by pre-service teachers which means that they fulfill one of the CT components.

The thinking of grade 2 elementary school students is in fact diverse even with the provision of the same milieu. In this research, the learning design uses vertical matematizazion. The mouth of this activity is that students can make generalizations in learning activities. The generalization obtained by students is that students find that pairs of 10 can be found in various ways. Diverse ways of learning students can produce one-way discoveries. Both students' thoughts and results are based on students' ability to illustrate the results of their thinking.

This is an interesting and new finding for pre-service teachers. They had never encountered this CT way of thinking before, and only discovered it after seeing these students work on questions about addition and subtraction with bond 10. The abstraction and algorithm components do not appear because these pre-service teachers do not work on the questions directly. Thus, these two CT components cannot be read properly. This component can be measured directly with a CT test for pre-service teachers.

Conclusion

This research produced findings about Knowledge of Content and Teaching (KCT) which includes understanding Van De Walle addition and subtraction, prerequisite material for addition and subtraction, and unique ways of thinking of students that can be used by pre-service teachers. The findings show that Van De Walle addition and subtraction are still new things for pre-service teachers, they have never known and used these concepts. The same results in mastering prerequisite material that they have not been able to explore. This shows that the condition of KCT pre-service teachers is still not encouraging.

Apart from that, the CT capability has not yet appeared. The CT that emerged from pre-service teachers was that they had found two components, namely pattern recognition and decomposition. An interesting result was that the pre-service teachers learned the thinking process from students' answers. They were amazed by the method presented by the students, even though this method was already widely used. This indicates that the KCT and CT of pre-service teachers is still not encouraging. However, by analysing students' answers, they can gain greater insight into teaching addition and subtraction.

These findings open new research with a wider range of respondents, resulting in more varied findings. KCT and CT has an important role in equipping pre-service teachers before serving and teaching. In this way, further research can be formed to develop human resources for pre-service elementary school teachers.

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