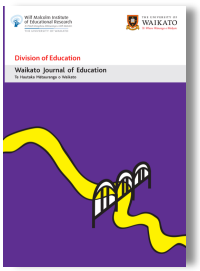

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Revisiting the Mathematical Content Knowledge and Attitude of Pre-Service Primary Teachers a Decade On

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Abstract

This research investigated the mathematical content knowledge and attitudes of a cohort of primary education student teachers and is a comparative study to that of Young-Loveridge et al. (2012a, 2012b), which was undertaken 10 years prior. In both studies the student teachers were about to commence their first compulsory mathematics education paper. The focus was on student teacher understanding of the mathematics concepts involved in solving word problems that included two-digit whole numbers, decimals, and fractions. As with the initial study the findings indicate that there was minimal difference in the number of tasks correct between those with UE and those without. Overall, there was little difference in student teacher beliefs and attitudes towards maths. There was very little difference in their mathematical understanding—when solving the tasks most of the students used algorithmic procedures and a range of misconceptions were identified. This raises questions about the nature of mathematics education during the school years and the position of mathematics content knowledge development during initial teacher education (ITE). In this study student teachers were asked to evaluate their confidence in the accuracy of their answers. Their responses indicated a concerning inaccuracy in judging the reasonableness of their answers. Combined, these findings have significant implications for the proposed entry requirements to ITE programmes.

Keywords

conceptual understanding; strategy; algorithm; attitude; beliefs; mathematics; student teachers

Introduction

In New Zealand reforms have seen ongoing change in curriculum and student learning since the introduction of the original Education Act in 1877. The *New Zealand Curriculum* ([NZC], Ministry of Education [MoE], 2007) saw a change in emphasis from a coverage of topics to a system of expected learning outcomes for each curriculum level for all students nationwide. This resulted in an approach to mathematics education where prominence was placed on teaching students *how* to solve problems, alongside teaching them *about* problem-solving, and the skills required *for* problem-solving. Recent research has indicated that challenging mathematical tasks are important for all students in the primary mathematics classroom because they promote conceptual understanding, learner autonomy, and

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mathematical reasoning (Bobis et al., 2021; Tran & Bobis, 2023). However, many primary teachers are reluctant to implement challenging mathematical tasks because of their own experiences and beliefs surrounding such tasks. Therefore, as Tran and Bobis (2023) indicated, understanding the past experiences of initial teacher education (ITE) primary teacher students (from here on referred to as student teachers) and what beliefs they hold is essential because it is these beliefs that may influence their instructional practices in their future classrooms.

Building on this idea, a New Zealand study was carried out in 2012 to understand the mathematical content knowledge and attitudes of first-year ITE student teachers in the Number strand (Young-Loveridge et al., 2012a, 2012b). Ten years later, the study reported in this paper paralleled that study, aiming to find out whether there had been any change in student content knowledge and attitudes towards mathematics over the past decade. The follow-up study was timely, given evidence that some primary teachers felt underprepared and lacked confidence in teaching mathematics. For example, the National Monitoring Study of Student Achievement (NMSSA) study (NMSSA, 2023) found that while most teachers enjoy teaching maths and agree it is important, 15% of Year 8 teachers (n = 186) indicated that they were not confident about responding to difficult questions from their students. However, overall, the Year 8 teachers were more likely than the Year 4 teachers to state that they were "very confident" teaching each of the sub-strands of the Mathematics and Statistics learning area of the NZC. More recently, New Zealand beginning primary teachers were surveyed by the Education Review Office (ERO) in 2023 (MoE, 2024a). They found "that nearly a quarter (24 percent) felt 'unprepared' in their mathematics content when they first started" (p. 4). The limited confidence of teachers in mathematics, combined with poor student achievement in PISA and TIMSS reports, indicates that teachers are not as well set up as they could be. This is particularly important with the focus on teacher knowledge, with current policy moves and a new refreshed curriculum for mathematics being introduced (MoE, 2024b). This refreshed curriculum is a knowledge-based curriculum, with a highly structured sequencing of content and concepts. It is essential that the content knowledge, and attitudes, of students in ITE programmes are well understood so that teacher education programmes are well-informed of the learning journey the student teachers need to embark on. This paper goes some way to addressing this need through a report on findings from a survey of student teachers' mathematics content knowledge and attitudes just prior to their first mathematics education paper.

Literature Review

Mathematics Content Knowledge

When addressing the complexity of the knowledge required for teaching, Shulman (1986) recognised that a balance needed to be achieved between the three categories of *general pedagogical knowledge*, *knowledge of curriculum*, and *knowledge of subject matter*. This interaction provides teachers with specialised teaching knowledge, to which he gave the phrase pedagogical content knowledge (PCK). Subsequently, Shulman (2015) acknowledged the significance of affective factors and incorporated *attitudes and beliefs* into the realm of PCK.

Within mathematics education, the significance of subject matter knowledge (SMK) and the mathematics knowledge required for teaching (MKT) within PCK, has been extensively researched (Ball et al., 2008, 2009; Downton, 2008; Gigaliūnienė et al., 2025; Ma, 2010; Mills, 2019). Ma (2010) used the data from her research to introduce the idea of "a profound understanding of fundamental mathematics" (p. 120). Ma suggested that a teacher's SMK of mathematics generally differs from that of a non-teaching person since teachers' need for knowledge derives from their responsibility to promote student learning. Ma emphasised how important teachers' mathematical knowledge is to effective teaching and student improvement and stressed that the knowledge for teaching relies on understanding that is deep, broad, and thorough. It was fundamental mathematics understanding that was investigated in this study, specifically number sense.

Number sense can be defined as the "well-interconnected knowledge about numbers and how they operate or interact" (Baroody, 2006, p. 22). It utilises an ability to improvise and use creativity with numbers while finding sensible ways to make computation easier (Briand-Newman et al., 2012).

Number sense is recognised as foundational to teachers' and students' understanding and linking quantities to numerical constructs and mathematical strategies. A person with well-developed number sense has developed a meaning for numbers and their relationships (Briand-Newman et al., 2012) and can often find an answer more quickly using basic computational techniques than using a calculator.

Preservice Teachers' Mathematical Content Knowledge

Internationally there has been a move to assess student teacher mathematical content knowledge on entry or as a prerequisite to graduation. ITE in New Zealand requires student teachers on entry to provide evidence of having achieved a specified level of numeracy knowledge. At the time of data collection, this required students to pass a numeracy competency assessment as set by their teacher education provider. The assessment had to be no lower than the equivalent to University Entrance (UE) in numeracy.

The limited mathematical content knowledge (MCK) of student teachers when solving the tasks in Young-Loveridge et al.'s (2012a, 2012b) research can be identified in the findings of other researchers who have investigated the solving of number problems. Understanding of basic facts is crucial in problem solving if students are to be able to check their answers for reasonableness (Perso, 2007, 2011). Reasonableness means someone is able to estimate the solution of a problem using mental computation based on their knowledge of numbers and how they work, perform the calculation (using a method of their choice, including a calculator), and judge the solution obtained makes sense based on their estimation and the context or situation. In the New Zealand context, Mills (2019) explored understanding of the fundamentals of multiplication in relation to teaching the concept. She found understanding the meaning of the times symbol within the written equation was a key limitation and need. Word stories were emphasised as significant in her work as they provided students something meaningful to relate the written equation to.

Beliefs and Attitudes

Expert teachers are proficient in creating an optimal classroom climate for learning through their passion for teaching and reflect their attitude to teaching and learning with emotion and expression (Hattie, 2009; Shulman, 2015). Instructional practices affecting students' mathematics achievement may be influenced by a combination of the teacher knowledge, professional background, and beliefs (Askew, 2008). Beliefs have been described as "embodied conscious and unconscious ideas and thoughts about oneself, the world, and one's position in it developed through the membership in various social groups, which are considered by the individual to be true" (Francis, 2015, p. 175). Connections have been made between PCK and beliefs about teaching (Campbell et al., 2014; Loughran et al., 2012; Walshaw, 2014). A teacher's emotional relationship with mathematics cannot be separated from their intellectual knowledge of the subject (Askew, 2008). Hence, efforts to help teachers make substantial changes in their teaching needs to support them to develop both new knowledge and a change in beliefs and attitudes. Changes in practice require knowledge of what is taught and how it can be taught. They also require knowledge of how students think and what they understand before they learn the subject matter as well as how they think while they are learning.

Student teachers have often approached mathematics timidly, with memories of unhappy school experiences, and struggle with several of the basic concepts found in mathematics at the primary level (Grootenboer, 2001, 2008). When discussing experiences of mathematics at school with 40 pre-service primary school teachers, Grootenboer found that many described the impressions given to them by their teachers as having had a substantial effect on their own beliefs and attitudes towards mathematics. About two-thirds of Grootenboer's students described a teacher (secondary school) who belittled them, gave sarcastic comments, and made them scared to contribute to class. This ultimately resulted in an avoidance of mathematics and a dislike of it as a subject. This mathematics anxiety has been described as a negative reaction to situations in which mathematics reasoning or problem solving must be performed. Peers and teachers can be critical of mistakes made, and judgement from others causes anxiety and stress, as the pressure to get the "right" answer becomes the desired outcome (Grootenboer, 2008).

Method

The participants in this study were student teachers about to commence their first compulsory mathematics education paper as part of their studies towards the Bachelor of Teaching degree in 2022. Due to a change in the programme structure of the university with the first compulsory mathematics paper being moved to the second year of studies (note: when the original study of Young-Loveridge et al. [2012a, 2012b], took place the first compulsory paper was in the first year), a small cohort of the student teachers had enrolled in a Mathematics option paper (MTHED) during the first semester of their studies, prior to this study taking place. The MTHED paper was focused on conceptual understanding in mathematics and covered some of the knowledge and understanding involved in solving the tasks given within this study. Hence, while the MTHED students are included in the overall results of the findings, they have also been identified as a separate group in most of the analysis. While it was made clear at the outset that the inclusion was voluntary, all student teachers present during the first week of the compulsory mathematics education paper agreed to participate (n=65).

The majority of the 65 student teachers in the study had gained a UE qualification (94%) prior to their university studies, only four (6%) did not have UE due to age eligibility entrance (see Table 1). Fourteen of the student teachers with UE (representing 22% of the overall number for this study) took the MTHED paper, while three of the four without UE also enrolled in MTHED (see Table 2).

Table 1. ***Number and Percentage of Participants According to Pre-Research Status***

Category of Entry to University	No. of students *(n=65)*	%
University Entrance (UE)	61	94
No UE	4	*6*

Table 2. ***Number and Percentage of Overall Participants Who Also Enrolled in the MTHED Paper***

Category of Entry to University	No. of students *(n=17)*	%
MTHED Paper & UE	14	22
MTHED Paper & No UE	3	5

In Young-Loveridge et al.'s (2012a, 2012b) study, the student teacher assessment consisted of nine tasks that were aligned with expected achievement of upper-primary students for the curriculum of the time (MoE, 2007), and this is still content that is present in the primary school curriculum being newly implemented (MoE, 2024b). Tasks were suitable for expected achievement by upper-primary school pupils (the end of Year 8). Due to the restricted time available for collection of the data, the task focus was limited to the number domain. The tasks were based on some fundamental mathematics concepts required for teaching Number at the primary school level (Young-Loveridge et al., 2012a, 2012b): computation of two-digit and three-digit problems involving whole numbers and proportional reasoning. The participants were asked to show the thinking they used to solve each of the problems and, where possible, sketch a diagram to support this. As with the original study, while the answers were marked as correct or incorrect, any information recorded on the student teachers' answer sheets showing their thinking used was also coded by strategy used.

For comparative purposes, the tasks were aligned to those in the original study: task scenarios were updated, while allowing for a similar range of strategies to be used in solving the problems. For example, the scenario for the triple-digit subtraction problem (Task 2) used in Young-Loveridge et al. (2012a, 2102b) was: "John needs $403 to buy a stereo. He has saved $297. How much money does he still need?" The current study used the following context: "Blake needs $903 to buy a new phone. He

has saved $697. How much money does he still need?" The numbers in both tasks allowed for a similar range of strategies to be used, such as the standard algorithm and equal adjustment. Similarly, for the double-digit division problem (Task 6) Young-Loveridge et al. used the scenario: "If 56 plums are shared among 14 people, how many plums will each person get?" In this study the problem was: "If 60 apples are shared evenly among 15 people, how many apples will each person get?" Again, the numbers lead to the use of similar strategies for solving the problem. Students may see the original Task 6 in a quotative manner and solve it with the use of doubles: Double 14 is 28; and double 28 is 56 giving the answer of 4. Similarly, double 15 is 30; and double 30 is 60, giving an answer of 4.

Alongside the tasks that were mathematics problems, a short survey of four questions sought student teachers' attitudes towards mathematics at primary school, secondary school, and currently. Unlike Young-Loveridge et al. (2012a, 21012b), who used a four-point Likert-type rating scale, in this study a five-point scale was used to allow the student teachers a neutral option. This option is sometimes avoided on Likert scales but was deemed important to acknowledge that participants may not feel strongly one way or the other (Cohen et al., 2017).

The student teachers in this study were also asked to say how confident they were in believing that they got all questions correct or incorrect. Schoenfeld (2011) emphasised that if you want to know why people's attempts to solve challenging mathematical tasks are successful (or not) alongside their knowledge base, self-regulation, and problem-solving strategies, you must also analyse their beliefs. Schoenfeld described beliefs as "an individual's sense of mathematics, of themselves and of the contexts which shape what they perceive and what they choose to do" (p. 4). While beliefs were not included in the original research of Young-Loveridge et al. (2012a, 2012b), researchers in the current study wanted to know whether the student teachers thought that the answers they had given to the problems were correct. Again, a five-point Likert-type rating was used ranging from very confident to very apprehensive. Participants were invited to say which two questions they were most confident they had correct and which two they were the least confident about being correct and to explain why they felt that way.

The study had ethics approval from the Division Ethics Committee. Responses were anonymous to allow the students the freedom to share their ideas without worrying about critique, which meant papers were unable to be returned to the students. However, we took account of student responses as we prepared to teach them in the following and final year paper.

Research Findings

Student Teachers' Mathematical Content Knowledge

The student teachers' responses to the tasks were analysed across the whole cohort to identify the percentage who were successful on each task. The strategies used by those who were correct, and the misconceptions embedded in incorrect responses were analysed. This paper does not allow room to present all the strategies used for every task. Attention is drawn to some of the correct and incorrect strategies used, based on the number of participants using them and the appropriateness of the strategy in relation to the question asked. The number of student teachers who were correct on each task was also analysed according to their entry status, including those with and without UE. Readers are reminded that there are only four participants who did not have UE, and therefore the need to view these results with caution. A further category was included for those who had participated in the optional MTHED paper. In most instances percentages between categories were similar, with the only differences arising in the non-UE category due to the small sample size. See Table 3.

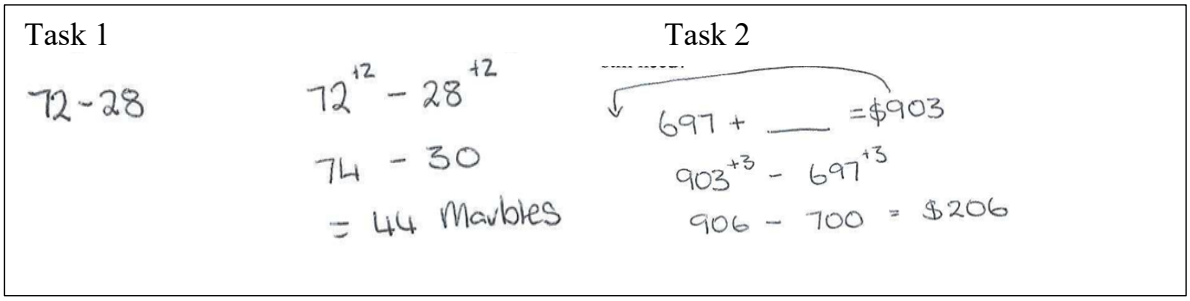
Table 3. Percentage of Students Who Answered Each Task Correctly

#	Question	Overall *n=65*	No UE		
			UE *n=61*	*n=4*	MTHED *n=17*
1	Trudy has 72 marbles. She loses 28 when they roll away. How many does she have left?	72	70	100	76
2	Blake needs $903 to buy a new phone. He has saved $697. How much money does he still need?	83	82	100	82
3	Jill used 9.4 metres of blue material and 2.56 metres of yellow material to make netball skirts. How much material did she use altogether?	85	85	75	76
4	Hone bought 6.5 metres of rope to put around a tree in the playground but ended up using 4.89 metres. How much rope was left over?	54	51	100	59
5	If 24 teams are in the rugby tournament and each team has 18 players, how many players are there altogether?	42	39	75	41
6	If 60 apples are shared evenly among 15 people, how many apples will each person get?	77	75	100	76
7	Leah and Ian buy two pizzas. Leah eats 2/3 of one pizza while Ian eats 5/6 of the other one. How much pizza do they eat altogether?	55	56	75	47
8	If Ryan got 64 out of a possible total of 80 marks, what percentage was that?	17	16	25	18
9	Tama spent $90 on school shoes. He got one-third off the original price, because there was a sale on. What was the original price?	33	30	75	29

The two subtraction tasks were at NZC Level Three, an expected level of achievement for students at the end of Year 6. The tasks were formulated with a different mathematical concept emphasised: The first asked for "how many were left?" (Task 1 in Table 3), while the second asked for "how much more was needed?" (Task 2). The wording of these problems was shown to have an impact on the strategy used for solving it. For example, in Task 1 the strategy used most by those who solved the problem correctly was the standard vertical algorithm (36%). One participant used reversibility (turning the subtraction notion into an addition problem), a strategy more commonly used for finding "how many more" is needed. In Task 2, where the emphasis was on increasing the subtrahend (the number taken away), 26% used the vertical algorithm correctly, while 35% chose to use reversibility. It would appear asking "how much more does he need", suggests reversing the subtraction problem into an addition one starting with the $697 and building it up to reach the $903 required. A common error noted was related to place value misunderstanding, where rather than looking at the number in its entirety, student teachers partitioned the place value of the numbers and then separately subtracted the small number from the larger in both instances. For example, some participants did 900 - 600 and then subtracted 3 from the larger numbers of 97 (97 - 3), adding the two resulting numbers of 300 + 94 to get an incorrect answer of 394.

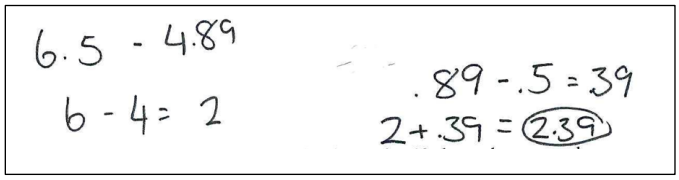
A key strategy frequently used when the ones digit in the subtrahend is larger than the ones digit in the minuend, is *equal adjustment*. Equal adjustment has a focus on recognising that the concept of subtraction can be interpreted as the difference between the two numbers, as opposed to taking one number away from the other: an ideal way to solve Task 2. In using equal adjustment, the same amount is added to both the minuend and the subtrahend (usually by rounding the latter to a tidy number). Adding the same amount does not affect the difference between the two amounts. One student teacher utilised this strategy for both Task 1 and Task 2 (see Figure 1), while two (including the aforementioned) used it for Task 2.

Figure 1. ***One Student's Use of The Equal Adjustment Strategy***



The remaining tasks (Tasks 3 to 9) are all suitable for NZC Level Four, or for students to achieve by the end of their primary schooling in Year 8. Task 3 and Task 4 were decimal number problems, with more student teachers correct in Task 3, the addition decimal problem (85%), than in Task 4, the subtraction decimal problem (54%). In both instances the most favoured strategy used by those correct was the vertical algorithm. Both problems relied on place value understanding of decimal numbers, where one number involved had one digit after the decimal point and one number had two digits. In the subtraction problem, of those who were incorrect, two common errors occurred in place value understanding. The first error was similar to the triple-digit subtraction in Task 2. The participants began by subtracting the smaller whole number from the larger whole number (6 - 4), repeating the same idea with the decimal numbers (0.98 - 0.5). However, this meant swapping the decimal-place digits from the two numbers around, then adding the two resulting numbers together (Figure 2). The second common error occurred when attempting the steps of the algorithm.

Figure 2. ***Subtracting the Smaller Number from the Larger Number for Each Step in Decimal Subtraction***



Questions 5 and 6 involved double-digit multiplication and doubled-digit division respectively. Fewer than half of the student teachers overall (42%) were able to solve the multiplication task correctly (Task 5), with 39% of the students with UE able to solve this correctly. Of those who were correct, 59% used a vertical algorithm to solve the problem, with many others (37%) deriving from known facts. The most common error was to multiply the tens together (20 ×10) and multiply the ones (4 × 8) and then add the partial products together (200 + 32) to get an incorrect answer of 232. However, the cross-product part of the procedure was missed, which was multiplying each of the tens with each of the ones (10 × 4 = 40; 20 × 8 = 160). When you add these two numbers together you get 200 and that needed to be added to the 232, which results in a total product of 432.

Task 6, the division task, was based on the equation 60 ÷ 15. Although 77% of the student teachers correctly answered this partitive division problem, many of them did not answer the question asked of

them in the word problem. The question asked for 60 apples to be shared out evenly among 15 people. Primary school children often solve this by going one for you, one for you until all objects are shared out, giving one at a time to each of the 15 children until they are all gone (Figure 3). However, many students solved Task 6 in a quotative manner, dividing the 60 into groups of 15 (Figure 4). While this gives the correct number for the answer, it disregards the context of the problem being solved. Quotative division relies on students making groups of objects as indicated by the divisor, in this case the number 15. The problem presented in Task 6, was to share the 60 apples out between 15 people and did not ask for the 60 apples to be put into groups of 15.

Figure 3. ***60 ÷ 15 Using Partitive Division***

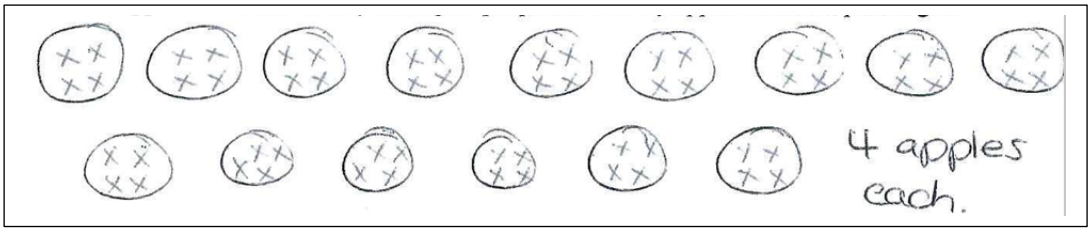
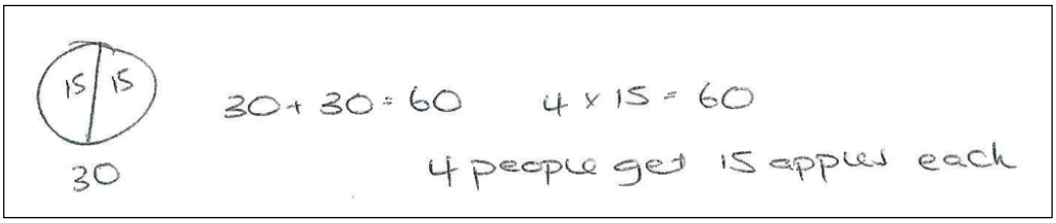


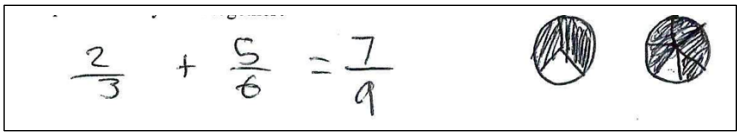
Figure 4. ***60 ÷ 15 Using Quotative Division***



Some student teachers implemented early quotative thinking and used groups of 15 by going 60 – 15 – 15 – 15 – 15. Others used doubles and known multiplication facts, such as 2 × 15 = 30; 2 × 30 = 60; which resulted in 4 × 15, or 4 groups of 15.

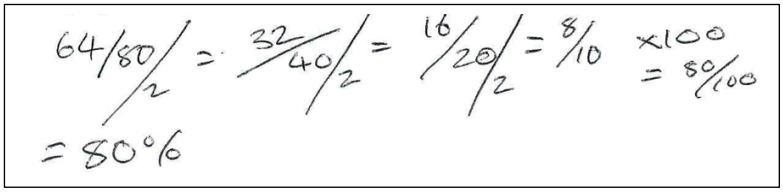
The final three tasks (7 to 9) were all based on proportional reasoning and proved to be three of the most difficult. Addition of relatable fractions (Task 7) was found to be the easier of the three, with 55% of the students solving the problem correctly. The most common mistake was to add the numerators together and the denominators together. Some student teachers added across the given fractions of $\frac{2}{3}+\frac{5}{6}$ to get an answer of $\frac{7}{9}$, while others found the equivalent form by converting the $\frac{2}{3}$ to $\frac{4}{6}$ and then added across. Many student teachers drew diagrams to support their thinking: in some instances, this gave them the correct answer, while in other instances it either added to their confusion or was ignored during the addition process. For example, when looking at the diagram in Figure 5, it shows a lack of conceptual understanding and understanding of reasonableness on the part of the student. The diagram shows that when combining the two pizzas (fractions) it would result in more than one whole pizza, and yet a fraction less than one was given for the answer.

Figure 5. ***Task 7: Using The Add Across Error for Adding Fractions***



Task 8, which involved proportional thinking, proved to be the most difficult with only 17% getting this correct. Nearly half of the student teachers (43%) responded "I don't know" or gave no response at all. Only a few of the student teachers were able to see that the numbers 64 and 80 were both multiples of 8 and were to use that to find the correct percentage. Of those who were correct, some used ratio thinking by simplifying the fraction until they reached a fraction in tenths and then multiplying by 10 to get the percentage (Figure 6).

Figure 6. ***Task 8: Simplifying the Fraction Into Tenths***



The second most difficult was Task 9, with approximately one-third (33%) of the student teachers solving it correctly. Of those incorrect, the most common error was to find one-third of the 90 (= 30), then add the 30 onto the 90 to get an answer of 120. What they failed to realise was that the $90 represented two-thirds of the original price, therefore it needed to be divided into two parts, not three. If they had that understanding, they would have then been able to work out what the original amount was.

Attitudes Towards Mathematics

As with the Young-Loveridge et al. (2012a, 2101b) study, attitudes towards mathematics were included in this study. The student teachers in both studies were asked to rate how much they had liked mathematics at primary school, at secondary school, and now. The highest proportion of students who really liked or liked mathematics was for primary school (Table 4). There was a noticeable decline for secondary school, with an increase again to the present time.

Table 4. Percentages of Students Who Liked, or Really Liked, Mathematics

	Overall n=65	UE n=61	No UE n=4	MTHED n=17
At primary school	45	44	75	65
At secondary school	29	31	0	29
Currently	40	36	100	71

The MTHED paper students had the biggest increase from liking mathematics at secondary school until the time of the research. (Note: three of the four participants with no UE had taken the MTHED paper and are included in that percentage.) Similarly, the greatest decline in the number of students who disliked mathematics at secondary school until the time of the research was seen among the MTHED group (Table 5). One-fifth of the students overall (20%) had disliked, or really disliked, mathematics at primary school (Table 5). This number increased at secondary school, with the fewest number of participants disliking it now.

Table 5. Percentages of Students Who Disliked, or Really Disliked, Mathematics

	Overall n=65	UE n=61	No UE n=4	MTHED n=17
At primary school	20	21	0	6
At secondary school	38	38	50	35
Currently	15	16	0	6

The student teachers were invited to comment on why they liked, or conversely did not like, mathematics at school, and why they had changed their ranking for the current time. The range of positive responses is summed up by the following: "I had great teachers who were really passionate, and I worked hard at school and at home." "Maths has always come easier to me than other subjects." "Honestly, it is thanks to the MTHED elective. It gave me a better understanding and deeper appreciation of mathematics." This last comment, along with the data presented in Tables 4 and 5, shows that having engaged in a paper prior to their compulsory mathematics education paper whose purpose was to develop student teachers' conceptual understanding of mathematics seemed to have had a positive impact on their attitude towards mathematics.

There was a range of negative responses: "I struggled during my early years and became less engaged over the [later] years." "I never understood I/this impacted my own belief in my ability." "I had teachers at secondary school who were unhelpful and didn't help me to understand the concepts." "I had a hard time grasping concepts at secondary school."

There were many students who chose the neutral category: 22 for primary school, 20 for secondary school, and 29 for "now". Most of the reasons were along the lines of: "It wasn't that I liked or dislike maths, I wasn't very good at it—it didn't make sense." The increase in students in the neutral category at the current time came from those in the "did not like" category at secondary school. They did not like maths at secondary school, where they faced the examination system, but were now more open to learning, although not prepared to say they now like maths. Neutral responses included: "Was okay at it—it wasn't my favourite [subject], but I understood it most of the time." "I have started to enjoy maths in my later years as I started understanding it." "Neither liked it nor disliked it—I had an okay understanding of numbers." "I was always competent at it but never loved it."

Confidence in the correctness of answers

An addition to this study involved recognising the implications of student teachers' beliefs about their capability to solve problems correctly. Therefore, after they had completed the tasks, student teachers were asked, "How confident are you that you got the answers to all nine of the questions above correct?" As noted in the Methods section, a five-point Likert-type rating scale was used, ranging from very confident to very apprehensive. A cross-tab analysis of confidence versus total tasks correct was conducted. Twenty-three student teachers (35%) stated they were either "very confident" or "confident" they got all nine tasks correct (Table 6) compared to the four student teachers (6%) who did.

Table 6
Percentages of Student Teacher's Ratings of Confidence All Their Answers Were Correct

	Overall n=65	UE n=61	No UE n=4	MTHED n=17
Very confident/confident	35	34	0	44
Apprehensive/Very apprehensive	48	48	100	38
No Response	6	3	25	6
Percentage with all correct	6	7	0	0

At the opposite end of the scale, nearly half of the student teachers (48%) gave "apprehensive", or "very apprehensive" responses combined. This proportion is closely related to student teachers' actual answers, as 45% of these participants got fewer than five of the nine tasks correct.

Student teachers were then asked, "For which two questions are you most confident about getting the answer correct?" The two tasks noted by the student teachers that they were most confident in getting correct corresponded with the tasks with the higher percentages correct: 46% of the student teachers had Task 1 as one of their responses, although nearly a quarter (23%) of those participants provided an answer that was not correct; 40% of the student teachers had Task 2 as one of their preferences, with only 8% of this group giving an incorrect answer.

Task 8 was one of the tasks most student teachers were least confident about their answer, with 48% of the student teachers identifying this task; 17% of these student teachers gave the correct answer. Task 7 and Task 9 were each listed by 22% of the student teachers as a task they were least confident about. Interestingly, over half of these student teachers (55%) were correct on Task 7 and a third (33%) were correct on Task 9. Task 5, which resulted in the third lowest number of correct answers (42%), was only listed by 9% of student teachers as a question of concern.

Discussion

Overall, this research found that the mathematical content knowledge of the cohort of students who responded to the survey had not changed from the results of the prior study. This points to systemic issues with the level of knowledge they are leaving school with and also identifies clear priority for teacher education. The nine assessment tasks were based on the mathematics taught to children in the upper primary school (Years 6 to 8), and all those who participated in the research were enrolled in a primary-school teacher education degree programme, and 94% had achieved a UE qualification. Only four of the 65 student teachers (6%) solved all the tasks correctly; 29 (45%) got fewer than half correct. The data suggests some disparity between the current knowledge of the students and what programme entry requirements at the time of the study would suggest. Student teacher responses are of concern given Ma (2010) found that to be a proficient teacher of mathematics teachers require a "profound understanding of fundamental mathematics" (p. 120). As Ma suggested, if teachers are to understand students' responses and set goals for lessons, then they must have breadth, depth, and a thorough understanding of mathematics and be able to draw on their personal SMK. Given tasks in our research focused on number, in our view they constitute mathematics knowledge which is fundamental for teachers who are aiming to be primary school teachers in the New Zealand context. Our results suggest that student teachers enter the university programme with considerable new learning required in a limited time for them to reach the necessary level of SMK to teach competently.

When the percentage of correct answers was analysed task-by-task, many concerns are evident (Table 7). The first is that for all tasks, with the exception of Task 7, which involved the addition of compatible fractions, the percentage correct was fewer than for a similar assessment task a decade earlier (Young-Loveridge et al., 2012a, 2012b). While it is acknowledged that the sample size varied (n = 65 here; n = 248 in 2012), the decline in correct answers is of concern given the increased emphasis on numeracy.

Table 7. ***Comparative Data of Task Results One Decade Apart***

	1	2	3	4	5	6	7	8	9
This data, 2023 (n = 65)	72	83	85	54	42	77	55	17	33
Data, 2012 (n = 248)	95	86	88	62	64	92	32	28	62

Of the misconceptions that arose for each task, many were similar across both studies. In both studies a large number of the student teachers incorrectly utilised a traditional vertical algorithm to solve tasks, indicating that they did not understand the concepts behind the procedure. The algorithm appeared to have been learned as a rote procedure despite several years of education reform with greater emphasis placed on conceptual understanding and number sense. Student teachers' inability to accurately solve double-digit multiplication was an example of this in both studies. A disregard of the cross-product of the tens and ones part of the procedure was made, and this step was omitted.

Research indicates students are more likely to remember mathematics strategies when they can relate them to other mathematical ideas and real-life examples (Ma, 2010; Young-Loveridge & Mills, 2010; Mills, 2019). Therefore, all the tasks presented in both studies were presented as word problems based on everyday contexts to assist the students in making sense of the numbers within the tasks. However, it appeared that in some instances (for example Task 6, division; and Task 7, addition of fractions) the participants misunderstood the word problem as presented. Perso (2011) emphasised being able to read, comprehend, and transform mathematics problems are part of the capabilities needed to use mathematics effectively at home and in the community.

Many of the student teachers failed to use number sense to check the reasonableness of their answers. This was evident in most tasks. For example, in Task 5 many participants gave the answer 232. If they had considered 24 groups of 10 (24 × 10) is 240 they would have recognised that 232 was not a reasonable answer for 24 x 18. Similarly, when adding fractions many gave an answer less than one. One of the fractions was $\frac{5}{6}$ which is very close to one, so if you add $\frac{2}{3}$ to it, how could you get less than one whole? The ability to be able to estimate mentally and judge the reasonableness of solutions was strongly advocated by Ma (2010). Perso (2007, 2011) argued that these were the "21st century basics" and as such teachers require both the mathematical content, and the skills and processes needed, to use and apply them.

The significance of affective factors was originally omitted from Shulman's (1986) formulation of PCK. However, Shulman (2015) later acknowledged the influence of beliefs, attitudes, and values towards subject areas in terms of quality teaching practice. Compared with Young-Loveridge et al. (2012a, 2012b), the participants in the present study were currently a little less positive towards mathematics (40% vs. 48%); however, fewer were currently negative (15% vs. 36%). While it is (somewhat) positive to see the number of students who dislike mathematics is fewer than in 2012, given the participants are preparing to be teachers, it is of concern that fewer than half currently liked mathematics. In both studies, teachers were mentioned as positive and negative reasons for liking and disliking mathematics. Given this there is a need for ITE to support students to reflect on their attitudes towards the subjects they teach and the influence this might have on the students in their classrooms.

Confidence of correctness as student capacity to self-assess

Student teachers' evaluation of their confidence in the accuracy of their answers indicates they begin studying maths education with diverse capabilities in judging reasonableness. This capacity would seem to be a critical aspect of a teacher who is interacting with students about ideas and answers. It is an issue if they don't know they don't understand and if they do understand and don't realise that they do.

Conclusions and Implications

Over the past decade there appears to have been little change in the mathematical content knowledge of student teachers entering a three-year primary education degree programme. It is concerning that students who have completed their schooling are not able to demonstrate a conceptual understanding of mathematics concepts related to the class levels they will teach. This finding reinforces the need for schools (both primary and secondary) to promote the conceptual understanding of mathematics alongside procedural application in relation to number. It has significant implications for proposed mathematical entry requirements for ITE programmes and the implementation of the refreshed mathematics curriculum with its stronger focus on knowledge. More positively, the study found a slight decline in the number of students who dislike mathematics. Hopefully, this shift in attitude will allow for an improvement in students' learning over the duration of their university studies. An extension of this research might be to include more problem-solving tasks across the strands of the curriculum.

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