

# Pre-service Students' Responses to Being Tested on their Primary School Mathematical Knowledge

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The limited mathematical knowledge of pre-service primary teachers is an international concern. The areas of mathematical difficulties have been well documented, which has led to many universities instituting testing regimes to ensure that their pre-service teachers have appropriate knowledge of primary school mathematics. In this study, the pre-service teachers identify some benefits for being tested, but these were often related to having sufficient knowledge so that they did not lose face in front of a class. It is suggested that these students' emphasis on performance rather than competence could exacerbate a reliance on procedural rather than conceptual understanding.

This paper examines pre-service teachers' responses to being tested on their primary school mathematical knowledge. By placing these responses into the background of institutional responses to this concern, it is shown that without care, a testing regime can emphasise the importance of procedural rather than conceptual mathematical understanding to these students.

There has been international concern about pre-service primary teachers' mathematical knowledge. In reviewing research done in Australia, Tobias and Itter (2007) stated, "it is reasonable to conclude that many pre-service teachers may have peripheral beliefs, poor attitudes and feelings about learning mathematics" (p.4). As a consequence of this concern, several research projects have investigated the knowledge that many primary school pre-service teachers have as well as different ways to assess and improve this knowledge base (Goulding, Rowland & Barber, 2002).

The type of mathematical knowledge that pre-service teachers need is seen as being connected to their subsequent careers as primary school teachers. Ponte and Chapman (2008) stated that "[w]hile having strong knowledge of mathematics does not guarantee that one will be an effective mathematics teacher, teachers who do not have such knowledge are likely to be limited in their ability to help students develop relational and conceptual understanding" (p. 226). Skemp (1976) described 'relational understanding' of mathematics as "knowing what to do and why" (p. 21) and so is related to the conceptual underpinnings of the mathematics being studied. Goulding et al., (2002) suggested that:

Beliefs about the nature of mathematics may be tied up with SMK [subject matter knowledge] in the way in which teachers approach mathematical situations. If they believe that it is principally a subject of rules and routines which have to be remembered, then their own approach to unfamiliar problems will be constrained, and this may have an impact on their teaching. (p. 691)

Mathematical knowledge per se will not benefit pre-service teachers. Rather there is a need for them to have relational understandings, if this is the type of mathematics that is most beneficial for the primary students that they will ultimately teach (Ball, 1990). Pre-service teachers' views about the relevance of conceptual understandings may affect their attitudes to mathematics and how to teach it. At the same time, negative attitudes to mathematics may impede pre-service teachers' ability to engage in mathematical content and pedagogical subjects, which could improve their mathematical understandings (Ebby, 1999).



## Institutional Responses to a Perceived Lack of Knowledge of Mathematics

Like other government organisations (see Office for Standards in Education, 1994), the NSW Institute of Teachers (NSWIT) has accepted the need for teachers to have strong mathematical knowledge and recently changed the requirements for graduating primary school teachers. Teachers entering primary teacher education courses need:

Higher School Certificate minimum Band 4 Standard English, or minimum Band 4 English as a Second Language, or minimum Band 4 Advanced English AND Higher School Certificate General Mathematics minimum Band 4, or completion of Mathematics (2 unit). (NSWIT, 2006).

Consequently, NSW universities have adopted selection criteria that have included Band 4, two unit English and Mathematics (NSW Teachers Education Council, 2008). If students enrol in primary teacher education course without appropriate mathematics results from their high school studies then they must also complete a mathematics subject at university of an equivalent standard.

However, knowledge of Year 12 mathematics may not be the most appropriate mathematics for pre-service teachers of primary school students. Tobias and Itter (2007) in their investigation of pre-service teachers' mathematical knowledge found "[t]his study confirms that we cannot presume that pre-service teachers who have completed Year 12 studies in mathematics have sufficient mathematical content knowledge that will enable them to teach mathematics meaningfully" (p. 14).

At Charles Sturt University (CSU), there has also been concern over the mathematical knowledge of pre-service primary school teachers. A shared concern with other regional universities is that pre-service teachers may not have been taught by trained mathematics teachers because of the shortage of these teachers in rural and regional Australia (Tobias & Itter, 2007). Tobias and Itter (2007) hypothesised that this may well have had an impact on pre-service teachers' "mathematical understandings and attitudes" (p. 14).

Consequently, CSU not only requires pre-service teachers to have Higher School Certificate (HSC) Band 4 mathematics, but in 2008 they had to pass a Basic Skills Test (BST) of primary school mathematics topics, such as fractions, decimals, place value. This was done in the first mathematics subject of their Bachelor of Education degree. These requirements presumed that the HSC General Mathematics and the Basic Skills Test provide an appropriate basis to gain pedagogical content knowledge in mathematics.

In 2008, students had to gain 90 percent in a BST, although no marks were awarded to the final grade in their first mathematics pedagogy subject. Students could do the test four times, but if they did not pass then they had to redo the subject. The lecturer provided some support to students. However, at the beginning of the semester, it was presumed that most students would have sufficient knowledge to pass the test and so the limited teaching time (5 x one hour sessions) could be tailored to those students who really needed it. This turned out not to be the case and so these pre-service teachers were directed to numerous web sites and to the university's Learning Support Services who provided individual mathematics support.

## Method

The tests consisted of 30 short answer questions that were at Year 7 level. The mathematical topics covered were similar from test to test. Most topics were covered in one question, although some like fractions were covered in several questions. All of the tests were kept. After each test, students were informed whether they had passed. Students who had not passed were provided with information about the areas that they had not

completed appropriately, so that they would know what to study in order to pass the next test. It was hoped that this would help pre-service teachers focus on the conceptual understandings of the topics. However, the students who felt that knowing what answers they got wrong was what was important often resented this.

In the following semester, the pre-service teachers were asked about why they thought they had to do the BST and whether they thought this was a valid purpose. Then, they were asked about how they felt about the test and whether they could suggest alternatives to it. Nine students were interviewed across three focus interviews, in August and September 2008. Although two male students had originally volunteered to participate in the focus group interviews, neither showed up so all the interviewees were female. A research assistant who had had no previous contact with the students was the interviewer. It was felt that students would be more open with a stranger than with the lecturer who had been responsible for giving them the BST in the first semester. Some of the students had passed the BST in the first round whilst others passed on the second, third or fourth rounds.

### 2008 Pre-service Teachers' Results on the BST

As Table 1 shows the number of students who completed each test declined as the pre-service teachers gained the 90 percent in a test. Although all students had passed the test by the fourth round, the initial tests showed that many students entered their Bachelor of Education studies with very poor knowledge of primary school mathematics. As can be seen in Figure 1, many of their responses suggested that they suffered from similar misconceptions to those of primary school students. However, it is encouraging that by the end of the semester they had learnt sufficient to pass. This suggests that even if they forgot some of what they had learned before going out into classrooms they would be capable of relearning the material.

Table 1  
*Number of students*

Basic Skills Test 1	93
Basic Skills Test 2	62
Basic Skills Test 3	45
Basic Skills Test 4	23

Providing a short explanation in the following lecture easily rectified some topics that many students answered incorrectly in the first test. Other topics, such as place value, were still difficult for a large number of pre-service teachers even at the third test. Figure 1 provides examples of the sorts of difficulties that they had with place value.

State the total value of the underlined digit in 45.06 | tens

State the total value of the underlined digit in 65.03 | 3 tenths.

Figure 3: Two pre-service teachers' responses to place value questions.

## 2008 Pre-service Teachers' Views on Doing the BST

On the whole, the pre-service teachers recognised that it was important that they knew the mathematical knowledge that they would be teaching. They saw the BST as providing information about whether or not they had this knowledge. However, only one pre-service teacher made any reference that could be considered to illustrate that she needed conceptual understandings so that she could provide appropriate explanations to her future students.

And the kids might need a longer explanation than what you're giving them to start off with so you've got to know how to go into more depth but break it down even further so they can get it. (Interview 2, Student 1)

Although pre-service teachers knew it was important to have the mathematical knowledge for teaching, they felt that studying for the BST might not be a valid way to gain it. In some cases this was related to their views about the sort of mathematical knowledge they needed in the classroom.

Student 2: I personally am good at assignments and not tests because I don't remember anything so I can only do it if I know how to do it and for the basic skills test I had a lot of trouble revising and things and because my dad's mathematical he taught me different ways to do it and when you go out to teach the children you can't use those ways you've got to use the way it states.

Student 3: You actually had to study to the test, you had to actually just get through it. There was no learning how to teach it or anything it was just basically pass it or you don't move on. (Interview 3)

There were queries about how the BST connected to the NSWIT's requirement for HSC Band 4 mathematics.

Student 3: I want to know where this factors in to having a Band 4 in maths because I'm waiting to hear whether I need to do extra-

Student 1: so am I.

Student 3: And how does that figure then if I can pass a basic skills test why do I need to be Band 4 maths? If I have to do it like I don't know where that figures into the whole scheme of things either so it wasn't our question. I don't understand why I have to go to summer school. If I can get 90 percent in the basic skills test and I've done maths on my HSC why do I need to summer school again to get Band 4 maths? (Interview 3)

Other reasons for doing a BST had a performance rather than competence orientation for their learning. The BST was seen as ensuring that pre-service students could show that they had the appropriate knowledge for their university studies and for teaching in classrooms, either whilst on practicum or when they graduated. Pre-service teachers felt they needed to show what they knew (performance), and rarely linked this to being competent in supporting primary school students to learn (competence).

Student 1: I think it's to see that the students are of a particular standard for the course.

Student 2: I reckon it's just seeing what the students know like seeing where they are to sort of work on what they need to know for teaching and so that when they go out they have a background knowledge like if they're put on the spot of how to teach long division then they've actually done it in a funny kind of way. (Interview 3)

Sometimes, the need to do the mathematics was connected to being able to explain it to students, but more usually it was so that they, as teachers, did not lose face in front of the class and other school members.

Student 2: Yeah I think so as well because if you don't know the work and if you don't know how to do it yourself you're not going to be able to teach it.

Student 1: And they're going to ask a hard question and you're just going to be like I don't know how to do it and that doesn't reflect very good on you and then it reflects badly on the school and then the parents will find out and then they'll tell people and- (Interview 1)

Such comments were common and showed that performance in doing mathematics in front of others was a concern. One pre-service teacher saw the BST as contributing to her feeling comfortable about her mathematics knowledge. It is hard to know whether this student was also performance orientated or competency orientated.

To ensure that we have maths knowledge so you feel confident and help us in other subjects I guess.

On the other hand, another pre-service teacher who had had to sit the BST several times before she passed felt that the experience contributed to making her uncomfortable about her mathematics knowledge. Again the emphasis was on performance of the mathematics.

But that basic skills test pretty much demoralises people because it shows what you can't do so if you keep going repeatedly failing most of the time it just breaks you down because you think you can't do it. (Interview 3, Student 4)

These sorts of comments match the anxiety mentioned by students in other studies such as McNamara, Roberts, Basit and Brown (2002). However, some pre-service teachers felt that having four opportunities to pass the test was useful. This tended to be pre-service teachers who had passed on the first round.

Interviewer: The anxiety component to the basic skills test is mainly because of?

Student 1: Fear that they will fail the subject.

Student 2: Yeah that 90 percent rate if you fail that and you're out after 4, you get 4 opportunities, which I think is great I think that's great that you get the 4 opportunities because some people as I say have that fear. I think it's preparation; you've got to be prepared- (Interview 1)

Other pre-service teachers complained that they could not see how the BST fitted in with their other assignments in the subject.

But our assignments never linked to it I don't think anyone used the basic skills test to link anything for assignments, it was just like a one off thing you had to pass. (Interview 3, Student 3)

However, the pre-service teachers were unsure about how the BST could be replaced.

When I said it was really stressful and that I didn't like the fact that we had to do a test but thinking about it it's probably the only way that I could think of assessing and making sure that everyone knew about it. (Interview 2, Student 2)

Nevertheless, many of the students were unhappy about having to do a test. There was discussion whether studying for the test meant they just had to memorise it.

Student 3: Also with being four tests, by the time you got to the fourth one a lot of it you could do from memory, because the last three combined the fourth one, so you really didn't have to think you just had to regurgitate it.

Student 2: But they all had mainly the same structure so you knew what was going to happen it was going to be something on surface area or something on division and time you just knew that what was going to be there so you basically just had to revise everything from the first test.

Student 1: People were basically just learning enough to pass it and again I think it's important to break it all down into how you work it out, how you would go about teaching it. For me I just had to go and learn the basic concepts like all the place value of this and I had to learn all those terms again they were ...

Student 3: That was that thing where it's the net of something and ...

Student 1: Yeah I had to look that up.

Student 2: I remembered that.

Student 1: Just the mathematical terms that weren't quite as solid as maybe they should have been in your head to know what you were trying to get so again I think it's more important to break it down and teach it so you understand it and how you would go about teaching it to somebody else and then maybe see with a test then you see the knowledge that you've gained at the end of the course or something. (Interview 3)

The pre-service teachers blamed their high school mathematics experiences for why they could no longer do primary school mathematics. Many found it to be a real struggle to re-learn the mathematics by themselves. Cooney (1999) pointed out that “often pre-service teachers have a poor understanding of school mathematics [because they] last studied it as teenagers with all the immaturity that implies” (p.165). However, many pre-service teachers at CSU are only seventeen or eighteen when they took this test, implying that the issues faced at school may not be resolved when they reach university. Many wanted procedural rather conceptual understandings as their concern was about passing.

Student 2: Yeah, but I think that we should have probably gone over everything again in class like I personally didn't have too much problem with it but I know there were quite a lot of people that they just don't remember that far back to primary school and they couldn't do a lot of the stuff because as you said we used calculators through high school-

Student 3: So we just forgot everything that we knew basically and some things were hard to learn by yourself. Like you look at it in a book but it's not the same as if someone is showing you or if a teacher teaches you. You might be able to remember how they taught you which would be better to teach the children so I think they need to do more with teaching us how to do specific things, like she did a little bit but not much really. I got mine the second go, I think it was a bit stressing for some of us because some of our friends got it their 3<sup>rd</sup> or 4<sup>th</sup> go and I know I was stressed for the second go because I didn't want to fail it again because then it would be even more stressing

Student 1: I found it hard. I passed second time as well and I found it hard the second time to teach myself. I went online and I was going through it and stuff and some of the explanations were hard to understand to get the concept of how you got that and things like that because it just shows you the answer, it doesn't show you what you actually had to do so it was a bit confusing. (Interview 2)

As Tobias and Itter (2007) stated “[p]erhaps, these students have a performance view instilled in their prior learning experiences, where a ‘learn and forget’ attitude prevailed due to a lack of emphasis on understanding during the middle years of schooling” (p. 14). On the other hand, some students recognised that they should have known the material covered in the BST. Yet, they seemed excuse themselves by suggesting that ‘learn and forget’ attitude was the norm.

Student 1: You're so used to using calculators because as soon as you hit high school you just use calculators and you just forget how to do the simple things in your mind.

Student 3: Even times tables.

Student 2: Same but in saying that though a lot of those questions were the basis of maths that you do in high school, so in some ways we probably should still know them, but in another light what happens, in high school just recently like for the mature age students and stuff (Interview 2)

Nevertheless, some pre-service teachers found successful ways to study for the BST and passed on the first or second rounds. It came back to a question of whether the responsibility for the passing the test was that of the pre-service teacher or the lecturer providing the subject. Given that the pre-service teachers were only being tested on Year 7 mathematics, it does not seem unreasonable to expect them to relearn this material themselves so that the university subject can focus on new material.

Student 2: Yeah, I agree if you look at that test the amount of people who pass on the first round and had to keep going obviously there was a need for it, it showed that there were a lot of people either they weren't prepared or they just didn't have enough background. Before that test, I actually went on the website and I don't know if anyone else did and it had maths for teachers on the student learning and a lot of people weren't aware of that site, it had practice questions and everything there

Interviewer: that might be an option for people to prepare.

Student 2: It is if it was more advertised you know how they've got the interact site and there's part of the student notices or whatever put a link in there instead of having it in student life, put the link into [internet resources for the subject] so they can click on it and they can see and it was great and I did that quite a few times and maybe because I'm older I also brought a year 7 text book with basic skills.

Student 1: I bought a maths dictionary (Interview 1)

There was some discussion about the need to have a 90 percent pass mark. On one hand, this was seen as one way of ensuring that students were at an appropriate level.

Student 1: I think getting the 90 percent, I think that's got to stay to make sure that they know the work not guessing it I guess.

Student 2: Yeah, I think the level, the pass level needs to be that high. As far as the testing goes, I don't see it as a problem, actually the test. (Interview 1)

On the other hand, students also saw it as putting too much more stress on them.

Student 1: Too much pressure to be 90 percent pass.

Student 4: 90 percent is too high because for some people, me, when I was at school just last year I could barely get above 70 percent for all these things and then you come here and they're like you've got to get about 90 and it's just like it's pretty much impossible.

Student 3: I've never got 90 percent in anything.

Student 1: But then I think that comes back to the level they want people to have and that's their expectation that at that level of maths you need to be 90 percent. I can see where they come from to say you have to get 90 percent to pass like that's the level they want you to have but a different way of going about it. (Interview 3)

In many ways, the 90 percent pass rate focussed pre-service teachers on the performance of doing mathematics and away from knowing how to be an effective facilitator of primary students' learning. There was also some discussion about when during the semester the test should occur. This was tied into whether or not the students were taught the material or expected to relearn it themselves.

Student 2: I think they need a test like that what they've got but perhaps before they do it there's more instruction like you say. They have a booklet you either work through your own self-paced booklet and that's up to you, then you're responsible for your own learning but you have a self-created booklet with example questions maybe that might be in the test may not be and then put the test on.

Student 1: But then there's also going to be those people that already know a lot of stuff that's going to be in there like they already have a good background of maths that might-

Student 2: But if it's a self-paced module they can finish it quickly and then forget about it. Other people can work through for the first few weeks. (Interview 1)

Throughout the interviews, many pre-service teachers were focused on the performance of doing mathematics. This is perhaps unsurprising given that they had to pass at the level of 90 percent. These pre-service teachers were in their first semester of doing a Bachelor of Education and were not used to seeing themselves as primary school teachers, which may have supported them to see the relevance of having a competency

approach to learning mathematics. Many pre-service teachers may have found it difficult to imagine situations where they would need the mathematical knowledge to support students to understand the concepts behind the ideas. If pre-service teachers are to imagine a different rationale for learning primary school mathematics then the test and other structures around it such as its relationship to other assignments needs to change.

## Conclusion

It was clear that without some sort of incentive, pre-service teachers were unlikely to (re)learn the primary school mathematics topics. Even pre-service teachers who had recently completed HSC mathematics struggled with being able to pass the test on their first or second attempts. Consequently, many became stressed. Nevertheless, most recognised that there was a need to check their primary school mathematical knowledge.

However, the way the test was organised resulted in the pre-service teachers reinforcing their views that what was important in mathematics was knowing the rules rather than understanding the concepts behind the rules, so that they could facilitate students' mathematical understanding. Performance rather than competence was seen as why they needed to pass the test. It is unlikely that the requirement to have HSC Band 4 mathematics will disrupt this belief and this may have lasting implications for the pre-service teachers' teaching unless subsequent mathematics pedagogy subjects can alter these beliefs.

Often in teacher education, we instigate new initiatives with the best of intentions. If we had looked only at the pre-service teachers' results in the BST, we would have been able to prove to ourselves the necessity of providing such a test. However, interviewing pre-service teachers provided valuable insights into how these intentions were being thwarted by the circumstances in which the tests were being carried out. Therefore, the views of pre-service teachers have been crucial in our explorations of alternatives to the BST in 2009 and 2010.

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