

Confidence, Knowledge and Teaching Strategies: A Study of Pre-service Science Teachers in a New Zealand University

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Introduction

The dilemma of little time to educate primary and secondary pre-service teachers to teach science in ways that enhance science learning led us to take stock of what we do well and what we can do better in initial teacher education (ITE). This paper presents initial results of a three-year longitudinal study from pre-service through two years of in-service teacher development. Loughran (2007) posits that science teaching and learning is problematic and cannot be fixed by just applying the correct approach, and theorises that it can be managed through dilemmas such as “learning about practice rather than solving a problem with practice” (p. 1043).

The research is focused on pre-service primary and secondary teachers’ perceptions at the end of ITE. Specifically:

- confidence in their ability to teach science
- ability to access and update subject knowledge together with factors that influence the development of that knowledge
- application of science teaching strategies and approaches.

The perspective taken in this study is that teacher confidence and knowledge influence classroom practice. Teacher confidence can determine whether and how science education occurs in the classroom (Appleton, 2006; Jarret, 1999). Lewthwaite (1999) reported New Zealand primary teachers lack confidence in using an investigative approach. Amongst the sets of knowledge that teachers bring to teaching are subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (Abell, 2007; Shulman, 1987). SMK for primary teachers has been an ongoing issue in science education in New Zealand and internationally (Appleton, 2006; Education Review Office, 2002, 2004; Lewthwaite, 2000; Osborne & Simon,

1996). It is also seen as an issue by New Zealand primary teachers themselves (McGee et al., 2003). Loughran, Mulhall & Berry (2008) indicate that SMK can also be an issue for secondary teachers. They found that secondary teachers, when faced with a topic they have not taught before, turn to a more transmissive approach to delivering the content. Teachers are dissatisfied with this approach but use it because they do not possess the depth of content knowledge they have for topics they have taught before and for which they have adequate SMK. The nature and breadth of SMK for science can be challenging and ways of building this knowledge need to be addressed along with the beginnings of PCK development in teacher education programmes. PCK is about how to teach particular content to enhance student understanding, and its development includes learning about science specific strategies and instructional approaches (Abell, 2007; Loughran, Berry, & Mulhall, 2006; Shulman, 1987).

Theoretical underpinning of the courses and *Science in the New Zealand Curriculum*

SMK includes both syntactic and substantive elements (Shulman, 1987). In terms of syntactic knowledge, the perspective of the nature of science promoted in the ITE courses here is one in which theories about how the world works are developed by people and that these ideas change over time as new evidence is presented, discussed and critiqued by the scientific community. This view of science is developed in lectures and reinforced in tutorials as pre-service teachers explore different aspects of science. A social-constructivist approach to science learning is encouraged which is in congruence with the approach promoted by *Science in the New Zealand Curriculum (SiNZC)* (Ministry of Education, 1993). The characteristics of this curriculum are openness to enable teachers to select topics relevant to their students, the integration of content with the development of scientific skills and attitudes, and the nature of science and its relationship with technology. *SiNZC* promotes education in meaningful contexts. The curriculum itself does not prescribe details of content to be covered, but rather provides broad objectives covering a range of overarching science concepts. This said, the senior enacted curriculum is constrained by the requirements of assessment for qualifications that occurs in the final three years of schooling.

Methodology

Participants

The research was conducted among volunteers from pre-service primary, and secondary school teacher education courses. Participants were primary (n = 33 of 50) and secondary (n = 12 of 16) teachers at the end of their ITE. The entry requirement for teaching at primary level (teaching Years 1-8, ages 5-12) is any tertiary degree. In this cohort only two primary

pre-service teachers had science degrees. Secondary school science teachers in New Zealand are expected to teach general science to junior high-school (Years 9-11, age 13-15) and a senior subject – physics, chemistry or biology – to senior secondary students. The entry requirement for teaching at this level is therefore a tertiary degree in a science discipline. The pre-service teachers were males and females between the ages of 21 and 50 and were a mixture of ethnicities including New Zealand Europeans, Māori, Pacific Nations, and Asian. The predominant ethnicity was New Zealand European.

Description of the science courses undertaken by participants

a) Primary

In the primary graduate diploma, the science education course consisted of 12 hours of lectures and 12 two-hour practical tutorials. Lectures and tutorials have a pedagogical focus set in contexts that assist with SMK and PCK development. As well as supporting pre-service teachers in learning ways to address conceptual development, the course models the teaching of science in ways that assist students to investigate their own questions and to develop and discuss explanatory theories using evidence. Pre-service teachers are scaffolded in tutorials and through written feedback to complete an assignment that requires them to: build their content knowledge of a science topic of their choice; identify students' common alternative conceptions about their topic; design and carry out an appropriate diagnostic activity with a group of students; and then plan a short lesson sequence to address an aspect of science learning identified as appropriate for the students based on their findings from the diagnostic activity. Because of the timing of the course with the practicum there is no requirement to teach the planned sequence.

Pre-service primary teachers are introduced to, and encouraged to use, resources commonly available in New Zealand classrooms. The *Building Science Concepts* (BSC) series¹ of 64 primary science teacher books published for the New Zealand Ministry of Education in the early 2000s contain both subject matter and pedagogical content and cover a range of contexts (http://www.tki.org.nz/r/science/curriculum/bsc/index_e.php). Subject matter presented in these books includes the related key science ideas and a summary of the science background to a particular topic that is written in easily accessible language for primary teachers. Pedagogical content presented includes: alternative conceptions commonly held by students; diagnostic activities designed to help teachers identify students' underlying science ideas about the topic; activities that will help students consider the relevant science ideas; and key aspects to watch

¹ Building Science Concepts series: A government provided resource for elementary science teachers designed to support teacher knowledge and pedagogies in a variety of science contexts.

for as students engage with the activities. These books have been issued free to New Zealand primary schools.

Thus pre-service primary teachers are supported to develop ways of building both their SMK and their PCK, although the latter would be described as “untried” PCK (Appleton, 2006, p. 48) as not all pre-service primary teachers have the opportunity to teach science on their practicum. Two thirds of the participating primary teachers indicated, however, that they had taught science on practicum.

b) Secondary

In contrast, the secondary diploma science education course involved 30 two-hour workshops and time allocation of 20 hours to complete an online course in their senior specialist science subjects. There were no lectures in this course. The secondary course focuses on teaching science (SMK), teaching about science (Nature of Science) and doing science (investigations) (Hodson, 1998; Monk, 2006). Workshops provide students with the opportunity to explore science concepts, become familiar with teaching and assessment strategies, participate in practical activities and investigations, and to address the reasons for teaching in particular ways. Each workshop finishes in a structured reflective way by unpacking the session both in terms of learning and management. The courses are supported by comprehensive and up-to-date books of readings. The senior online courses require students to become familiar with *SiNZC* as well as the senior subject curriculum documents for biology, physics and chemistry. The senior online courses also help the students to become familiar with the examination requirements and processes followed for assessment for qualifications.

Data collection

A questionnaire that comprised a mixture of Likert-scale, selected and ranked responses, and open-ended questions provided the data. The same questionnaire was used for both groups. The questionnaires were piloted to ensure common understandings of the questions. All researchers collaborated in coding and processing the responses to reduce bias. Grbich's (2007) frame of block and file method was used for analysis of open-ended questions. Responses for qualitative data were sorted as themes emerged.

Results

Both groups saw science as an important curriculum area to be taught, commenting that: *students need to understand the world; science promotes curiosity; [science] equips students' investigative skills; and [science] encourages critical thinking and questioning.* Both groups expressed a positive shift in their attitude toward science teaching during ITE. Primary pre-service teachers reported improvements in personal attributes such as level of interest, understanding, and confidence. For secondary teachers the changes related more to their

pedagogical approach than to their SMK. Several teachers from both groups commented on the importance of science in understanding environmental issues.

Confidence in the classroom

All secondary and nearly all primary teachers (29/33) felt well prepared by their pre-service science course. Both groups (24/33 and 9/12 respectively) indicated that they were confident or very confident about their ability to teach science. A large majority (30/33 primary and 12/12 secondary) credited their pre-service science education course as a reason for this. A smaller number credited their experiences in the classroom or their associate teachers. Primary pre-service teachers' reservations focused on their own effectiveness and knowledge, whereas secondary pre-service teachers commented less on personal deficits and more on restricted opportunities for science teaching.

Subject matter knowledge

Both groups indicated that their ability to access SMK had developed as a result of their ITE courses (30/33 primary and 11/12 secondary). Although both groups indicated that their ability to access SMK had increased, more primary pre-service teachers said they lacked confidence in doing so. Participants were asked which aspects of the ITE course supported their ability to access new SMK. Primary teachers (33) gained confidence in accessing SMK from BSC (11), tutorials (9), web-based resources (6), experiments/class activities (5), and sample teaching resources provided (5), and secondary from teaching resources distributed by lecturers (5), experiments/class activities (5), ideas presented in tutorials, websites and sharing ideas with peers (2 each). Secondary teachers were not asked to include SMK derived from previous academic study.

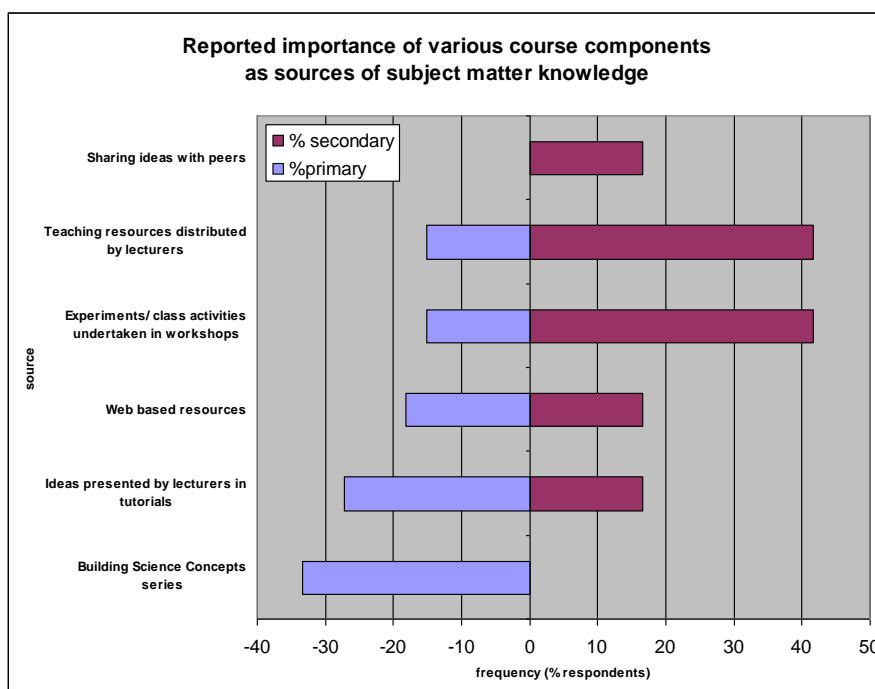


Figure 1: Reported sources of subject matter knowledge by primary and secondary teachers

Teaching strategies and approaches

As part of the questionnaire, participants were provided with a list of teaching strategies derived from those covered in the courses and those commonly used in science classrooms. They were asked to indicate on the list those they had used and the degree of success which they experienced in using them.

The most common strategies used by the primary teachers were experiments, cooperative group work, analogies and PEOE (Predict; Explain; Observe; Explain). This is a strategy where students predict what they think will happen in an experiment, explain their prediction, observe what happens and then explain their observations (Palmer, 1996). Secondary teachers used demonstrations, teacher-led discussion, formative assessment, and worksheets (see figure 2).

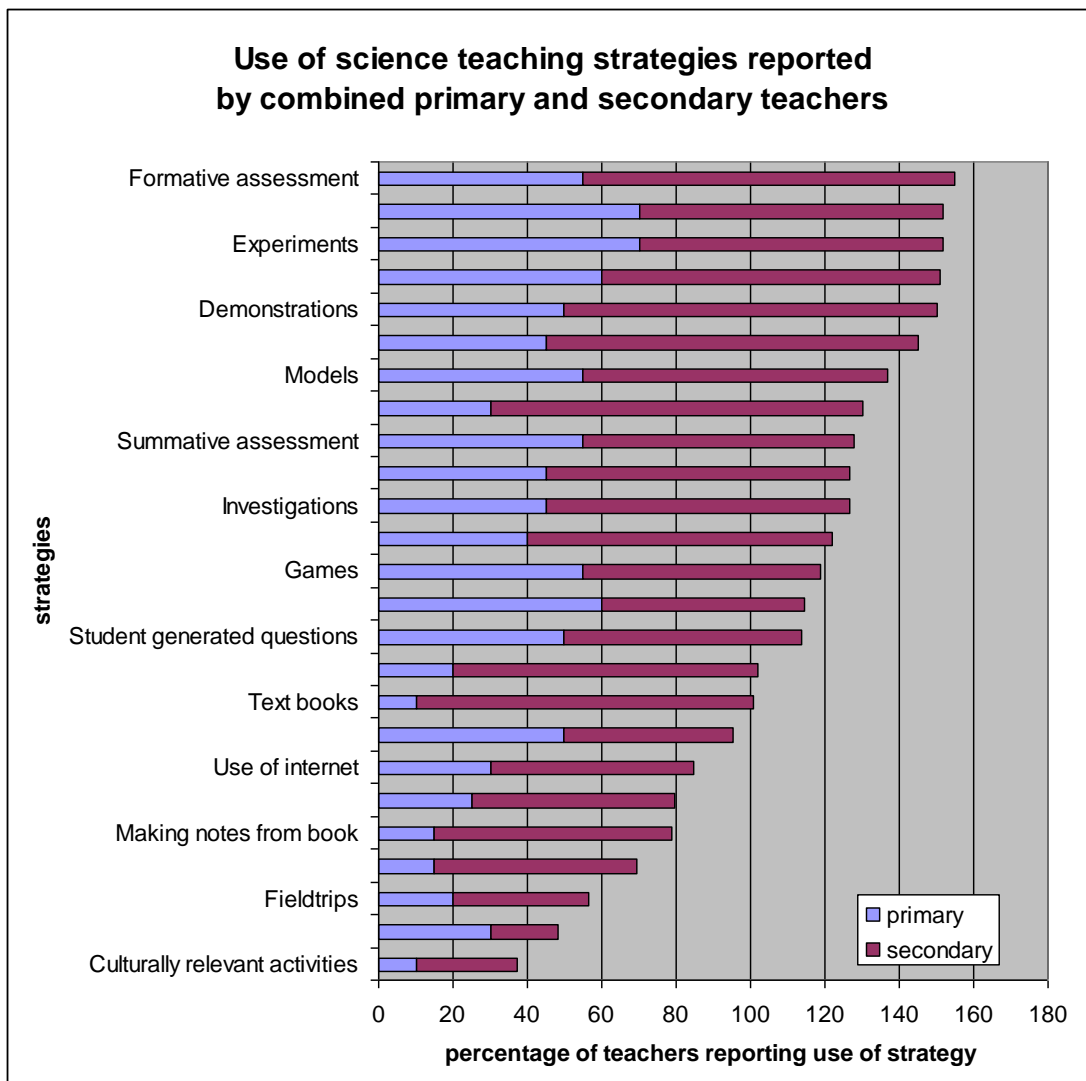


Figure 2: Comparative use of teaching strategies by primary and secondary teachers
 (The percentage of primary and secondary teachers' responses were calculated separately then combined. This approach gives equal weighting to both the primary and secondary teachers.)

There were pedagogically significant differences in choice of strategies reported by primary and secondary teachers (see figure 3). The largest differences between primary and secondary teachers were the frequent use by secondary teachers of demonstrations, teacher-led discussion, worksheets, textbooks and analogies. To a lesser extent primary teachers used an integrated approach; PEOEs and stories more. It is acknowledged that both groups reported using a wide range of additional strategies.

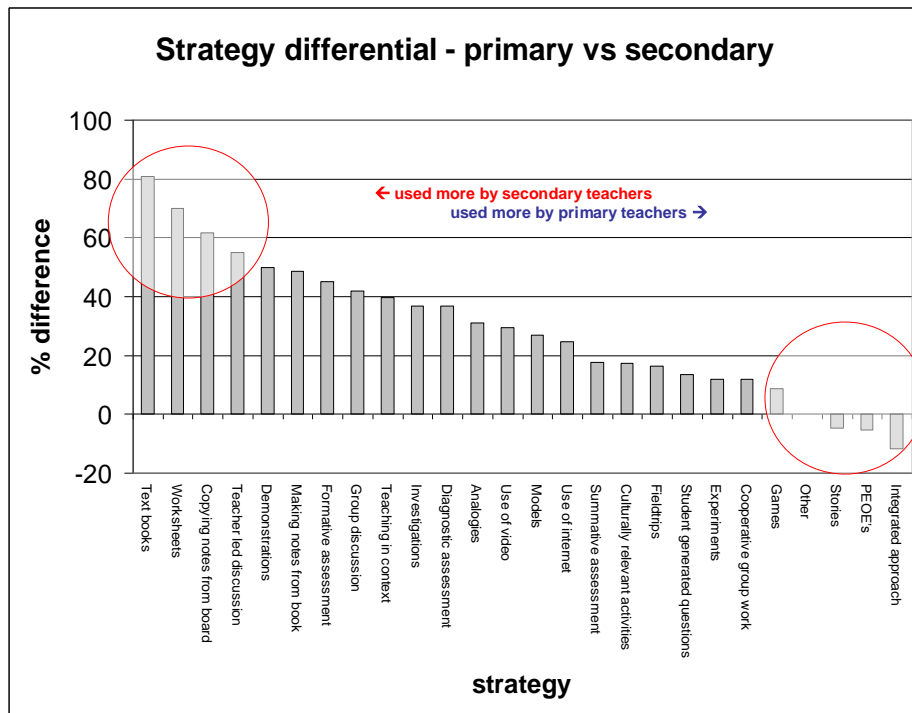


Figure 3: Difference in the use of strategies as reported by primary and secondary teachers

Percentage differences were calculated by subtracting the percentage of primary teachers who reported using any given strategy, from the percentage of secondary teachers reporting use of the same strategy.

Conclusions and discussion

Both groups expressed confidence in their ability to teach science and access appropriate SMK. As might be expected, primary teachers were less confident in their SMK compared to their secondary counterparts. Primary teachers identified the BSC books as particularly helpful in developing SMK and providing concept-based practical activities. This supports Appleton's (2006) view of "activities that work" (p. 38) as being a starting point for the development of primary teachers' knowledge useful for teaching science. It also validates the New Zealand Government's initiative in supporting primary teachers with this resource and shows the usefulness of modelling its use in ITE.

Secondary pre-service teachers identified experiments they had tried out and resources given to them as most useful aspects of their ITE. This may reflect a greater confidence with their existing SMK that means they can focus more on beginning to develop PCK. Both sources of SMK reported are presented in the context of PCK. Inclusion of the sharing of ideas with peers, use (and sharing) of websites, and working with ideas presented by lecturers have also contributed to their SMK. These ideas represent collaborative approaches which have been modelled and encouraged in their ITE course.

Magnusson, Krajcik and Borko (1999) outline a range of orientations to teaching science (the teacher's knowledge and beliefs about the purposes and goals for teaching science) and the teaching approaches associated with them. A more didactic orientation is associated with the goal of transmitting the facts of science where the characteristics of the teaching approach include that the teacher conveys information, and questions to students are to hold them accountable for knowing the facts produced by science. These authors provide research evidence showing how such orientations may influence the development of PCK accordingly. Henze, van Driel and Verloop (2008) also hypothesise from their work with secondary teachers teaching new SMK that development of PCK is related to teachers' general pedagogical knowledge and their beliefs about the nature and purpose of science education. We need to move the secondary teachers towards an increased use of interactive teaching strategies. A greater influence on teaching strategies used by the secondary teachers may be associated with the focus on assessment, especially in the senior school, and the need to 'cover' the content. Perhaps greater attention needs to be paid to their beliefs about the nature of science and the purpose and goals of science education. These aspects will be explored with participants in the next phases of this research.

We found a clear link between useful aspects of the course and confidence of secondary teachers. Secondary teachers say they find the practical aspect of their course useful in gaining the confidence to try teaching activities on their teaching experience. This is reflected in the strategies they say they have used successfully during the practicum, for example cooperative group work, experiments, models and analogies. Secondary teachers' use of teacher-led discussion, worksheets and written work is in congruence with Loughran et al.'s (2008) findings that when student teachers are faced with topics they have not taught before and for which they do not have depth of content knowledge, they turn to a more transmissive approach to delivering the content even though they are dissatisfied with doing so.

Primary teachers need more practice in using the BSC books as we have observed in our courses, so that as they engage with this resource they become increasingly confident in using it. This could be built into the in-service professional development. Both groups place importance on practical work in developing science concepts; however, as Magnusson, et al. (1999) point out, it is not so much the inclusion of practical work, but the nature of the teaching that surrounds it that is indicative of teachers' approaches and orientations to science teaching. While at this early stage of their teacher development the use of practical work to develop science concepts appears to be a valuable insight to have gained, we need to pay more attention to their beliefs about its purpose and how they use it in their teaching.

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Master of Science in Teaching at Fordham University. The online Master of Science in Teaching program prepares aspiring teachers (grades 1-6) for initial teaching certification or dual certification in teaching and special education. Master of Science in Education (MSE) in Educational Leadership at University of Dayton. As the primary teaching strategy under the teacher-centered approach, direct instruction utilizes passive learning, or the idea that students can learn what they need to through listening and watching very precise instruction. Teachers can differentiate in a number of ways: how students access content, the types of activities students do to master a concept, what the end product of learning looks like, and how the classroom is set up. Teachers and students are increasingly using mobile technologies in teaching and learning. Therefore, it is purposeful to responsibly integrate technologies into the educational process. In order to increase service quality in education, studies on many different subjects are run by the researchers. In addition to this, teachers are expected to reshape their educational lives as a reflection to these studies. Attitudes of more. In order to increase service quality in education, studies on many different subjects are run by the researchers. In teacher training programs primary aim is to train teachers that have more qualitative and more scientific view of life. Research was made according to general screening model and quantitative data obtaining tools were used. When a teacher implements a combination of effective teaching strategies, their students have more opportunities to perform better in class. There are many different approaches you can use in your classroom. 1. Model as you teach. When presenting a new subject to your class, it helps to include a demonstration. While some students will be able to grasp a new concept by hearing the information alone, others – particularly visual learners – will need to see it. In certain classes, this is practically required. Studying the different types of fish in a local pond is an excellent example of learning from experience. You would start in class, going over the different species and how each animal contributes to the environment around it. Once you’ve completed the lesson, take the class to the local pond.