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Gillian Ward
University of Auckland

Helen Dixon
University of Auckland

Helen Withy
University of Auckland

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Primary Science Teachers' Self-Efficacy And Outcome Expectancy: A Case Study

Gillian Ward
Helen Dixon
Helen Withy
The University of Auckland, New Zealand

Abstract: Self-efficacious teachers are critical in the development of students' positive attitudes towards science and scientific literacy yet to date little attention has been given to studies of experienced teachers of primary science and development of their self-efficacy (SE) beliefs. The aim of this study was to explore how two experienced teachers of primary science built their SE beliefs and outcome expectancy. Bandura's (1977) SE framework provided the conceptual lens to understand participants' experiences and beliefs. Findings suggest that teachers' SE beliefs had developed over time, creating a foundation for a strong expectancy outcome. Each of the sources of influence made a significant contribution to their beliefs about their science teaching capability and the value of science. Seemingly, their strong outcome expectancy enabled them to be persistent and resilient, overcoming challenges as they arose. We argue that a strong expectancy outcome is necessary to ensure SE does not weaken over time.

Introduction

Science education is important in the preparation of the next generation of scientists and in the development of children's scientific literacy (Organisation for Economic Co-operation and Development [OECD], 2008). *The New Zealand Curriculum* [NZC] (Ministry of Education [MoE], 2007) mirrors this latter goal in particular, stating that children will be able to "… participate as critical, informed, and responsible citizens in a society where science plays a significant role." (p. 17). Primary science teachers are instrumental in delivering on these goals of teaching science to achieve the development of children's early positive attitudes towards science and their growth towards becoming scientifically literate citizens (Bull, Gilbert, Barwick, Hipkins, & Barker, 2010; Hodson, 2011). Arguably, robust self-efficacy (SE) beliefs are critical if teachers are to teach primary science in the ways imagined given that highly efficacious teachers are more likely to use student-centred teaching strategies (Plourde, 2002).

Specifically in New Zealand, primary teachers are generalists responsible for delivering the wider primary school curriculum (Anderson, 2015; Garbett, 2011). Given the magnitude of such a task, it is unsurprising that teachers will feel more comfortable teaching particular subject areas over others. In relation to the teaching of science, whilst some practitioners teach primary science well, most do not or avoid teaching it altogether (Appleton, 2003; Lumpe, Czerniak, Haney, & Beltyukova, 2012). Considering that many teachers experience low levels of SE in teaching primary science (Anderson, 2015; Plourde, 2002), the challenge facing New Zealand is to consider ways in which the SE beliefs of teachers can be raised so that more teachers are committed to building their science teaching capability.

There is a body of research that documents the teaching SE of both student teachers and those with more experience. However, these studies have been mostly quantitative in nature (Knoblauch & Woolfolk Hoy, 2008; Palmer, 2006), utilising existing SE scales to determine how efficacious teachers feel about teaching science (Azar, 2010). While on one hand these scales provide informative numerical and statistical data, they fail to provide a rich picture of what teachers' responses mean or where support is needed (Wheatley, 2005). As others have argued, there is the need to move beyond the use of surveys and SE scales and to adopt qualitative methods that will help "develop a better understanding of the contextual pathways and experiences that promote teacher efficacy" (Blonder, Benny & Jones, 2014, p. 11). Despite these calls for an alternative methodological focus, studies investigating teacher self-efficacy through the use of SE scales are still prominent in the literature. Responding to the call for research that provides rich detail in relation to the factors that influence teacher self-efficacy (Blonder, et al., 2014; Morris, Usher, & Chen, 2017; Wheatley, 2005) the study reported in this article investigated how two experienced primary science teachers built their SE beliefs. To explore their SE beliefs we framed our study using Bandura's theory of self-efficacy (1977), particularly in relation to the four sources of influence.

Self-efficacy

Future-oriented in nature, SE can be described as an expectancy belief that is goal-, task- and situation-specific. It pertains to an individual's belief in his/her capability to "… organise and execute courses of action required to deal with prospective situations that contain many ambiguous unpredictable and often stressful elements" (Bandura, 1981, p. 200). Those with a strong efficacy expectation believe they have the capability to succeed. Associated with this efficacy expectation is an individual's outcome expectancy, that is, his/her beliefs related to the consequences of actions taken. Those with a strong outcome expectancy will believe there will be desirable outcomes as a result of their actions. Whilst there has been debate within the field about the relationship between efficacy and outcome expectancies, we believe they are interrelated and reciprocal. Without a strong efficacy expectation, an individual is unlikely to take action, even if it is believed that the required behaviour will lead to a desirable outcome. Conversely, without a strong expectancy outcome it is doubtful that an individual will strive to reach a particular goal even if they have the necessary knowledge and skills to do so.

SE operates across three dimensions: magnitude, generality and strength. As such, it is not a stable trait. It can strengthen or weaken in the light of the nature and magnitude of a task, task familiarity, whether or not one's experiences provide confirming or disconfirming information about personal capability and how this information is interpreted and used. Moreover, given that SE has more to do with perception than an *actual* level of competence (Woolfolk Hoy & Burke Spero, 2005) an under-estimation of the magnitude of a task, coupled with an over-estimation of personal capability can lead to a lack of calibration between SE beliefs and actual performance (Linnenbrink & Pintrich, 2003).

Known as the "sources of influence", there are four major sources of information that individuals draw upon when forming judgements about their capabilities (Bandura, 1977). Of the four, *mastery experiences* are considered the most powerful source of efficacy beliefs. Mastery or direct experience "provide(s) the most authentic evidence of whether one can muster whatever it takes to succeed" (Bandura, 1995, p. 3). Built up over time, mastery develops from experiences that enable individuals to build the requisite knowledge and skills necessary to perform a given task successfully. Repeated performance successes build robust SE levels in individuals, subsequently engineering expectations of future successes with similar tasks unless it is believed the perceived effort cannot be sustained (Pajares, 2002). Conversely, a succession of performance failures can weaken SE, undermining belief in one's ability to successfully accomplish a given task, stifling any possibility of attempting similar tasks (Pajares, 2002). *Vicarious experience*, in the form of social models, is generally considered the second most influential source of SE. It can be strengthened when a demanding task is performed more successfully than by peers, or it can potentially plummet if one is outperformed by similar others (Schunk, 1991). Although *social persuasion* can strengthen SE, it is easier to weaken beliefs through negative appraisal than to strengthen them through encouragement (Pajares, 1996). However, when coupled with successful mastery experience, social persuasion can be highly effective (Labone, 2004; Schunk, 1991). Finally, individuals pay attention to their *physiological and emotional states* when judging their capabilities to complete any given task. Positive physiological and emotional states such as exhilaration or joy can strengthen SE. Conversely, a difficult task perceived as daunting can weaken SE by triggering feelings such as anxiety or stress, in turn affecting one's willingness to persevere (Wyatt, 2014).

Teacher efficacy (TE), a form of SE (Ross, Cousins, & Gadalla, 1996) pertains to a "teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998, p. 233). Developed early in a teaching career when beliefs are malleable and susceptible to change, TE does not develop linearly (Klassen & Chui, 2011). Instead, acquisition of complex teaching skills and knowledge develops in flux over time before teachers reach stable levels of TE when the match between anticipated skills and actual skills increases (Morris et al., 2017). Given that TE is a powerful predictor of performance (Velthuis, Fisser, & Pieters, 2014) it is unsurprising that teachers gravitate towards teaching subjects they feel confident and competent in teaching (Wenner, 2001). It can also be argued that teachers will be more committed to the development of their teaching capabilities in subjects that they value and see as important to the students they teach.

Methodology

To examine how two experienced teachers of primary science built their SE beliefs, we carried out a qualitative instrumental case study (Stake, 1994). By limiting the research to one case study, replicated in two different schools, we were able to examine two experienced primary school science teachers' SE beliefs and how they fostered student self-efficacy through their science teaching. We were also able to explore ways in which teachers can be supported to develop SE in teaching primary science. These broad aims demanded different data collection methods which included semi-structured interviews, classroom observations and the collection of teacher and student generated artefact. However, in this article we pay particular attention to one aspect of this larger project. Specifically we report on how teachers' self-efficacy and outcome expectancy beliefs developed overtime and in doing so consider the sources of influence that impacted on these beliefs. Given the purpose and scope of the two semi structured interviews, conducted at the beginning and end of the project, these datasets provided rich data set in regard to gaining insights into how efficacy beliefs had been constructed and the significant influences on their construction. Consequently, we have only focussed on data garnered from these interviews.

Sampling Procedures

Non-probability sampling is mainly employed to recruit required participants in small-scale qualitative studies (Babbie, 2007; Punch & Oancea, 2014). For this study, non-probability sampling was the most suitable method for participant selection because the researchers required a small number of participants to gain in-depth information and insight into their worlds as primary science teachers.

The current study employed two sampling methods: purposive and snowballing (Babbie, 2007). Purposive sampling is deliberate because it specifies a clear set of criteria to meet the purpose of the study (Merriam & Tisdell, 2016; Punch & Oancea, 2014). With regard to purposive sampling, the criteria required the teachers to be:

- regarded as competent and confident primary science teachers;
- in possession of at least five years' primary science teaching experience;
- teaching currently within Year 5 (9 years of age) to Year 8 (12 years of age) of *The New Zealand Curriculum*.

The aforementioned criteria were set because experienced primary science teachers are likely to be more confident and competent practitioners of primary science (Garbett, 2011). It is also likely that their SE in teaching primary science will have developed over at least five years of regular primary science teaching (Appleton, 2002). Year 5 to 8 teachers were selected as teaching primary science has been reported to be more problematic (Education Review Office [ERO], 2012) yet this group of teachers are important in developing early positive children's attitudes towards science (Harlen, 2012; Slavin, Lake, Hanley, & Thurston, 2012).

Once the criteria were established, one of the researchers approached Patricia (pseudonym) who was perceived as a confident and competent science teacher within the primary science education community. She also met the purposive criteria noted above. Snowballing was used to find the other teacher. Snowballing involves finding one or a few key participants understood to easily meet the criteria established for a study. The key participants are then asked to recommend further candidates who they understand will fit the study criteria (Merriman & Tisdell, 2016). They give the name of the researcher to further candidates who they deem suitable and ask them to make direct contact with the researcher if they wish to participate in the study (Babbie, 2007). The researcher asked Patricia if she knew of anyone else who might be interested in participating, that would also meet the purposive criteria. Patricia contacted a colleague, Elizabeth (pseudonym) who then contacted the researcher to express her interest in being a participant. Once both teachers had agreed to participate in the research study, contact was made with the principal of each of the two schools to gain site access.

The Participants and Case Site

Elizabeth and Patricia had each taught in the New Zealand education system for approximately 15 years. The current workplaces of the teachers were the case sites for the research. Elizabeth's school was a co-educational school comprising Years 1 to 6 (5 to 10 years of age), and Patricia's school was an all-boys' school comprising Years 1 to 8 (5 to 12 years of age). Both schools were located in high socio-economic status areas within a large city in New Zealand. At the time of data collection, Elizabeth, a generalist teacher, was teaching Simple Machines for two sessions a week over 10 weeks to her Year 6 class. Patricia taught Years 5, 6, and 8 as a science specialist teacher. In Term 2, Patricia was teaching a topic on the Electromagnetic Spectrum to five separate classes for three sessions a week over five weeks.

Data Collection

Two one-on-one interviews were carried out with each teacher by one of the authors at the start of Term 2. A semi-structured interview format was used to enable the interviewer to re-order, deviate, and expand questions as the conversation unfolded (Darlington & Scott, 2002; Guba & Lincoln, 1994). Each interview lasted 60 minutes and was audio-recorded. The purpose of the initial interview was to gain insight into their science-related experiences from their early life through to adulthood. Examples were asked such as: Can you tell me a good/not so good memory you had in science at primary school? Can you tell me a good/not so good memory you had in science at secondary school, and why? What out of school experiences or activities can you think of that help you to enjoy being a teacher of primary science? Has there been anyone else that has been an inspirational role model in your science teaching career? Why?

The final interview enabled the researcher to build greater understanding of information gathered during the initial interview and after the observations. While there was a set of generic questions that were asked of both teachers, questions were also asked specifically for Patricia and Elizabeth to gain a deeper understanding of each of the participants. The interview included questions about their teaching experience and teaching related to the classroom observations. Questions about unit planning and teaching practice in relation to feelings experienced, successes experienced and challenges faced, were explored. Examples of questions to uncover both teachers' perceptions included: Can you tell me any early experiences in teaching for science as a novice teacher that made you feel competent and confident? Why? How would you describe the levels of fluctuation in your confidence and competence in teaching primary science over the years? Why? Can you think back to when you taught this science unit, how did you feel when you were teaching it? What went really well with the teaching? What might be something in particular that you underestimated or overestimated in teaching for this unit that you subsequently discovered?

Data Analysis

A thematic approach was employed, its flexibility enabling a rich, detailed, and complex account of the data to occur (Punch & Oancea, 2014). To analyse the data, a three-step coding process was employed: open coding; axial coding; and selective coding (Punch & Oancea, 2014). Initially, both sets of interview transcripts were open-coded for each participant by "breaking open" the raw data and imposing it onto pre-defined categories drawn deductively from Bandura's (1977) SE framework. Following open coding, axial codes were established. Axial codes put open-coded categories back together again, but in conceptually different ways, thus showing relationships between groups of open codes and their interrelating properties (Punch & Oancea, 2014). Finally, interrelationships between themes and sub-themes were identified and selective codes were established.

Findings

Early Experiences: Developing Passion and Curiosity for Science

Both teachers had little recollection of being taught science in their early primary school years and had no memory of "doing" science. However, they were able to remember vividly science-related activities, which they engaged in out of school. These early out-of-school activities involved the teachers developing their enthusiasm and curiosity for science by engaging with the natural world around them. Patricia reflected fondly on childhood memories of collecting tadpoles from nearby ponds. "We would get a whole lot of spawn … and just watch them turn into tadpoles," she recollected (Interview 1). Fuelled with curiosity for her environment she recalled climbing and playing on a volcano in her neighbourhood, and examining the layers of dirt—"I didn't think about it as science. I loved it and I loved being there ..." (Interview 1). Through this interaction with the natural world she began to develop her passion for science.

Both their fathers were instrumental in contributing to their early experiences of science, some of which were positive and others that shaped their views in a more negative manner. Elizabeth recalled her father, a customs officer, assisting her using his knowledge and resources about drugs to complete a science fair project. Patricia grew up in an environment in which "…we had possums and we had lots of birds and in my garden my father built aviaries so we bred birds"(Interview 1). She remembered the awe and wonder of watching her father and brother build a hot air balloon, and explained, "… they put a cup of tin foil and meths and then … set it on fire. … the balloon … just sailed off—disappeared into the horizon" (Interview 1). Her father introduced her to the scientific community when she accompanied him to visit a scientist friend at work. While this visit had the potential of providing access to the work of scientists it dampened her enthusiasm for science. She recalled as a young girl:

> *If I was thinking about scientists or science in general, my attitude towards science at that stage was that they wore lab coats, they were quite socially inept and that they worked in these big clinical buildings where it wasn't very social … (Interview 1)*

Experiences, both positive and negative, continued through into intermediate (Year 7–8) school and junior secondary school. Elizabeth drew attention to the enjoyment of contextually rich, hands-on learning activities she experienced at intermediate school when completing a study on sail boats: "Yeah, it was really fun … you got to do stuff … it was hands on" (Interview 1). As a young person, her curiosity was piqued as she made something, learnt how to make it work, and learnt about science concepts. In contrast, she recalled her embarrassment at intermediate school when she had incorrectly interpreted the parameters around completing a science fair project. She also explained a time in junior secondary school when she was meant to make a small hole in a spider's web for homework and check if the spider had repaired its web the following day. She explained how devastated she was having actually destroyed the web: "… the idea that I had done something wrong was very, very upsetting to me … I was scared of [the teacher] as well" (Interview 1).

Patricia had no recollection of being taught science at intermediate school but she loved science at secondary school, stating, "It was one of my favourite subjects. I enjoyed going to class. … I like learning about science and actually I think that I was tending to want to go towards the medical profession because of it" (Interview 1). Patricia also recalled experiencing a sense of enjoyment when learning about the human body and "thinking that it all made so much sense. It was real" (Interview 1).

Midway through secondary school, Elizabeth (Interview 1) found science "exciting" because "it was different". She enjoyed the fact "we got to use all these things and do all this stuff" including "risky" aspects such as using a Bunsen burner. On the negative side, she found there was a lot of writing and "more boring stuff" that was taught as well. She was stimulated by inspiring science specialist teachers who facilitated interesting hands-on experiments. Elizabeth recalled her wonder in chemistry, experiences that "vividly stick in my head". As she explained, "We put these two liquids together and it made this beautiful bright blue … and it was just YEAH! … it turned into a solid … It was just mind-blowing!" (Interview 1).

In the national exams in Year 11, Elizabeth achieved her best mark in science but decided not to study science in senior secondary school. She found it difficult to choose a science subject and there were other subjects she wanted to study instead. After leaving school, she went on to study for a Bachelor of Arts degree. Later she decided she wanted to pursue a career in teaching and completed a one-year Initial Teacher Education (ITE) programme to become a primary school teacher.

Like Elizabeth, Patricia had a love for biology and chemistry but unlike Elizabeth, she chose to study both subjects in senior secondary school. Justifying her choices she explained "… it was biology that I really, really enjoyed—learning about animals and humans and plants" (Interview 1). Her biology teacher's passion for science was considered inspiring given, "she loved scuba diving and she loved everything in and around the water" (Interview 2). Patricia considered her science teachers to be "scientists" and during an out-of-school, non-science activity in which her biology teacher taught her how to water ski, her view of scientists changed. It was then that she decided, "… scientists can be cool, too!" (Interview 1). She was also interested in chemistry "because of the practicals" but was less inspired by the amount of work she "had to learn off by heart" - as she explained we weren't taught the logic, we were taught rote and that was hard for me, too" (Interview 1).

Patricia left school at 16 years of age, worked in the hospitality industry for a year before taking up work as a laboratory assistant working in haematology. She had considered nursing but, in her own words, did not "aim high"(Interview 1). She found the lab work repetitive and boring so left to work in banking and publishing. She was given the opportunity to train people in their work and had her first encounter with teaching people. At age 36, she decided she wanted to become a primary school teacher and enrolled in a Bachelor of Education (Teaching) degree.

Building Primary Science Teaching Commitment and Capability Through Persistence and Resilience

When recalling their ITE science-related experiences, both teachers could only remember an assessment task which involved teaching small groups of children about particular scientific concepts. Opportunities to observe primary teaching whilst on practicum were recalled as minimal for Elizabeth and non-existent for Patricia. Despite this lack of primary science teaching experience during ITE, Patricia still felt she "could do okay in science" (Interview 2) whereas Elizabeth "… didn't feel that I came out of it [ITE] with enough teaching knowledge full stop!" (Interview 2).

While Elizabeth was "keen on [teaching science]", feelings of unpreparedness and a lack of confidence in her own capabilities resulted in her feeling particularly disappointed when she realised she was to receive little support or encouragement in the teaching of science during her time as a beginning teacher:

> *I was so excited about being a teacher and my tutor teacher was in charge of science and I was like, 'Oh I really want to come and watch you do science because I decided it is really my thing' and she was like 'Oh, I'm just in charge of it because I drew the short straw. Stink!' (Interview 1)*

Despite these feelings of inadequacy and the lack of support experienced during her first year of teaching, Elizabeth still found science and the teaching of science exciting. For this reason she made the decision to go back to university part-time to complete a Bachelor of Science degree. Seeking opportunities to improve their science knowledge and skill through formal avenues of study was typical of both teachers as they sought to build capability.

Following encouragement from her school principal to apply, midway through her career Patricia was awarded a six-month Royal Society Fellowship in a Science faculty at a local university. From a positive perspective, she had opportunities to attend science lectures, engage with scientists, and work alongside expert teachers in a variety of schools. She also undertook a science project which helped her feel as though she was able "to operate as a scientist really" (Interview 1). On the negative side, she recalled a time when her confidence plummeted when she was unable to answer Year 13 students' questions about gel electrodes, made worse when a fellow educator made comments about her lack of content knowledge. While Patricia felt she had "got knocked back a little" as a result of this experience, it also strengthened her resolve to increase her science knowledge and skills. To this end she made the decision to return to academic study so as to "learn the stuff and … get good at it!" (Interview 2). Subsequently, Patricia undertook a Master of Education degree with a focus on science education.

While important, formal study was not considered the sole source of professional learning and enthusiasm for science. Elizabeth talked about exposure to inspiring speakers at science teaching conferences, hands-on learning activities and innovative teaching ideas gained from presenters during primary science workshops, and opportunities to engage with, and learn from, like-minded others. Likewise, Patricia told how she frequently attended museum lectures and symposiums, undertook professional reading, communicated with scientists at the university, and engaged in conversations with experts in areas of personal scientific interest, such as conservation. Recognising that they could learn from expert others in indirect ways, both teachers engaged with works of inspirational contemporary scientists. Through reading and listening to these experts, the two teachers said they began to grapple with some of the complex ideas underpinning the teaching of science.

Observing teachers similar to themselves was considered another useful learning opportunity. Patricia, in particular, spoke of the opportunities she had to observe some inspiring teachers over time. As she explained, "… you get a lot from looking at other teachers" not only in picking up some "tricks and tips" (Interview 1),but also as a source of motivation. Recognising their potential, Elizabeth was frustrated that she had not been afforded such opportunities to observe others.

Feedback from parents and students was inherently motivating for the teachers. Feedback from parents that students were coming home talking about gamma rays, radio waves, and microwaves was interpreted as students being "really motivated" (Interview 2). Hearing about student in-school and out-of-school interest in and engagement with science was a source of encouragement and pleasure. In Patricia's case, the provision of hands-on, exciting, science-focused learning experiences and activities was seen as making a significant impact on students' attitudes towards science. From her perspective, in a short space of time those who had once considered science boring became engaged which gave her a sense of satisfaction. Receiving positive comments from students before, during, and after lessons was perceived as evidence of student engagement and hence a continuing source of pleasure. As a generalist teacher, Elizabeth’s challenge was meeting the needs of students of different age groups. However, working closely with her students and thus gaining knowledge of their capabilities, helped her to plan and deliver lessons that would interest and engage students.

Discussion

Efficacy beliefs focus on what individuals believe they are capable of, regardless of the competencies, capabilities or skills they might possess. As such self-efficacy is a future orientated judgement more to do with perception than an actual level of competence (Woolfolk Hoy & Burke Spero, 2005). As explained earlier there are four sources of information that individuals draw upon when forming these efficacy beliefs: mastery experience, vicarious experience, social persuasion and physiological and emotional states. Albeit focused on two teachers only, the findings from the current study demonstrate the influence of these various sources of information on their efficacy beliefs and expectancy outcome.

Early years’ in-school and out-of-school mastery experiences, together with exposure to a range of credible role models sparked the teachers’ interest in science and fostered a growing awareness of the value of science. As such, it can be argued that the foundations of a strong expectancy outcome were laid early in life which, in turn, assisted and sustained the teachers when they were faced with both learning science and latterly, teaching primary science. Seemingly, their strong outcome expectancy sustained the teachers’ efforts, enabling them to persist and overcome difficulties encountered along the way. Adopting a proactive stance, they took personal responsibility for improving their science knowledge and skills believing that increased effort on their part would eventually lead to success. As Bandura (1989) has argued, initial conceptions of a masterful performance are rarely translated into action during first attempts. Indeed, as he has argued it is to be expected that obstacles will be encountered as individuals attempt to master a complex set of tasks. Critically, both teachers were able to cope with disconfirming experiences, not allowing these to weaken their desire to continue learning science and to teach primary science.

While both teachers recognised the importance of role models to the improvement of their practice, the limited opportunities to observe credible others was seen as a temporary setback. Cognisant that science education goes beyond the parameters of the school, they sought exposure to symbolic models (Bandura, 1997) represented by the wider scientific community such as scientists and science education experts. In doing so, teachers gained what they considered to be useful skills and knowledge, enabling them to keep pace with current science issues and developments whilst sustaining and raising belief in their capabilities as committed teachers of primary science (Abd-El-Khalick & Lederman, 2000).

While it appeared that the teachers had received some negative messages of social persuasion during their primary science teaching careers, supportive talk, positive feedback, and positive actions communicated by relevant others such as colleagues, parents, and students outweighed. Enthusiasm shown by the students both for in-school and out-of-school science experiences was a continued source of satisfaction and motivation for teachers. As Schunk (1991) has argued, students who respond to lessons enthusiastically enhance teacher SE, which motivates teachers to plan exciting lessons. This was seemingly the case in the current study.

Conclusions and Looking to the Future

As this study has shown, self-efficacy beliefs develop over time with early experiences creating a solid foundation for a strong expectancy outcome. Through an examination of two teachers' science-related experiences and opportunities it can be concluded that, over time, each of the four sources of influence contributed to their beliefs about their personal capability relative to the teaching of science as well as highlighting to them the importance of science in their lives and for the students they taught. We would argue a strong expectancy outcome is needed to ensure SE does not weaken over time.

Albeit small scale in nature, the current study has highlighted the influence of early experiences in the development of positive attitudes towards science which, in turn, acted as a motivational source to continue learning about science and the teaching of it. To develop such positive attitudes early in life, it is therefore paramount that children are exposed to both in-school and out-of-school experiences that foster an interest in science and highlight the value of science to their lives (ERO, 2012; Hechter, 2011). While this is possible through delivery of early and continuous, positive, science-related experiences in primary schools (National Research Council [NRC], 1996), such experiences alone are insufficient. Just as important is the role that parents can play during these early years. As this study has demonstrated, parents can play an influential role in the development of positive attitudes towards science by exposing children to science talk and rich, science-related experiences at home and within the wider community (Plourde, 2002). It is the combination of both in- and out-of-school experiences that is likely to help sustain students' interest in science, give them a base to extend their SE in learning science and, in turn, help them become self-efficacious primary science teachers if they choose a primary teaching career.

However not all those who enter Initial Teacher Education (ITE) programmes will have the requisite knowledge or experience that will support a high level of self-efficacy either in terms of learning science or the teaching of it. Therefore, the task ahead of Teacher Educators in fostering self-efficacious teachers of science is complex and one that will not be achievable quickly or easily (Carleton, Fitch, & Krockover, 2007). Given the importance of SE to teaching and the learning in any school subject and its influence on levels of student achievement (Schunk & Pajares, 2010) then learning about SE must be an important component of an ITE curriculum. In a general sense, student teachers need to understand how SE influences behaviour and motivation (from both theoretical and personalised perspectives) and how the four sources of influences work in combination to either strengthen or weaken beliefs. They also need to understand how SE can be fostered in the students they teach and its importance to student outcomes and achievement.

In relation to science, future teachers require a wide range of abundant experiences that draw from Bandura's (1977) four sources of efficacy (Dembo & Gibson, 1985; NRC, 1996). Such experiences should foster learning about science as well as the teaching of it thereby creating positive attitudes about the value of science and the teaching of it (Ramey-Gassert & Shroyer, 1992). Given the significance of vicarious and mastery experiences on the formation of positive SE beliefs student teachers need substantial opportunities to observe good science teaching practice (Garbett, 2011; ERO, 2017). There is also the need for student teachers to have authentic, meaningful and multiple opportunities to teach science within the practicum context (Bull, Gilbert, Barwick, Hipkins, & Baker, 2010). A combination of positive mastery experiences and access to supportive and credible role models will support students to expand their knowledge bases, procedural skills and teaching strategies (Hechter, 2010). In turn the acquisition of relevant knowledge and skills has the potential to mitigate against the influence of negative physiological and emotional states on performance by reducing levels of stress and anxiety when faced with teaching science,

In a similar manner those more experienced teachers also require sustained and substantial authentic mastery experiences that will help them gain a clear understanding of the magnitude of the task in hand and enable them to acquire the necessary knowledge and skills to achieve success in teaching science. From a professional learning perspective such experiences should bolster teachers' content knowledge, curriculum knowledge, knowledge of learners and pedagogical content knowledge (Shulman, 1987). To complement their mastery experiences, teachers also need access to a range of credible role models who can inspire and motivate them to persevere and succeed. These role models may be within or outside of the school environment. Given that people rely on "their physiological and emotional states in judging their capabilities," (Bandura, 1995, p. 4) it is critical that in-service professional learning environments are positive, supportive, collaborative, and trusting to maximise teacher opportunities to take risks in their learning (Timperley, Wilson, Barrar, & Fung, 2007). We would argue that, together, these experiences can increase science teaching SE, resulting in positive attitudes about science and teaching primary science.

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