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“I Didn’t Always Perceive Myself as a Science Person”: Examining Efficacy for Primary Science Teaching

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"I Didn't Always Perceive Myself as a *Science Person*": Examining Efficacy for Primary Science Teaching

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Abstract: Teacher efficacy has become an important field of research especially in subjects teachers may find challenging, such as science. This study investigates the sources of teachers' efficacy for teaching science in primary schools in the context of authentic teaching situations with a view to better understanding sources of teachers' efficacy beliefs. Twenty-four teachers participated in focus group interviews to enable in-depth exploration of the sources of efficacy for teaching science. Data was analysed using a content analysis approach guided by a conceptual framework for efficacy in science teaching. Findings show efficacy to be influenced by mastery experiences, vicarious experiences, physiological and affective states as well as prior beliefs and experiences of science. Most notably, efficacy for science teaching was found to be enhanced through particular aspects of the teaching context such as opportunities for collaboration and successful participation in science teaching practice. Implications for teaching and teacher educators are discussed.

Introduction

Teacher efficacy has an important influence on teacher behaviour and practices, motivation, and positive student outcomes (Woolfolk & Hoy, 1990). Defined as "the teacher's belief in his or her capability to organise 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), teacher efficacy has been associated with positive attitudes towards students and approaches to classroom management (Ashton & Webb, 1986), student achievement (Anderson, Greene & Loewen,1988), student self-efficacy and motivation (Midgley, Feldlaufer, & Eccles, 1989). Teachers with high efficacy are willing to try new teaching methods (Guskey, 1988) and take risks (Ross, Cousins, & Gadalla, 1996), are less critical of students' mistakes (Ashton & Webb, 1986), support student motivation and self regulation and work harder with students who are struggling (Gibson & Dembo, 1984).

Teacher efficacy is also a situation-specific construct, meaning it is both context specific (Siwatu, 2011; Tschannen-Moran, et al., 1998) and subject matter specific (Tschannen-Moran & Woolfolk Hoy, 2001). Further, teacher efficacy may alter from one subject to another (Ross et al., 1996) as "teachers do not feel equally efficacious for all teaching situations" (Tschannen-Moran, et al., 1998, p. 227). For example, a teacher's sense of efficacy may be influenced by the particular curriculum or subject matter they are required to teach. Some teachers may have higher levels of efficacy for teaching English, rather than Mathematics or Science. Even within a subject such as science, teachers may feel more efficacious when teaching biology related topics rather than physics related topics and vice versa. In general, however, science has been recognised as an area where teachers typically feel less capable, especially at the primary or elementary level (Howitt, 2007). Teacher

educators teaching preservice teachers are familiar with this lack of confidence in science and typically attempt to enhance their students' efficacy for teaching primary science.
A considerable number of studies regarding teaching efficacy for science have focused on preservice teachers (for example Appleton, 1995; Bayraktar, 2011; Carrier, 2009; Liang & Richardson, 2009; Palmer, 2006; 2011). Understanding teacher efficacy for science teaching at the preservice level is important, especially given findings that both formal and informal preservice experiences have a sustained influence on teacher efficacy even after years of teaching (Tuchman & Isaacs, 2011). However, a better understanding of the efficacy for science teaching of practicing teachers, in the context of authentic teaching situations will also help inform teacher educators as they attempt to enhance their students' efficacy. While some studies have found that teachers with high efficacy for science teaching have a strong background in science content and use more child centred teaching strategies (deLaat & Watters, 1995) and that professional development aimed at increasing teachers' science content knowledge has a positive impact on efficacy (Swackhamer, Koellner, Basile & Kimbrough, 2009), efficacy for teaching primary science is still not completely understood. Despite research in this field spanning twenty years, Palmer (2011) contends that lack of efficacy for teaching science is "still very much alive" (p. 2).

The aim of this study is to use an established conceptual model (Tschannen-Moran et al., 1998, p. 228) to investigate teachers' efficacy for teaching science in the context of authentic teaching situations with a view to better understanding sources of teachers' efficacy beliefs.

Conceptual Framework

To examine sources of efficacy for primary science teaching, this study is grounded in social cognitive theory (Bandura, 1986) and based on the cyclical nature of teacher efficacy developed by Tschannen-Moran et al. (1998). Figure 1 below shows this model applied to science teaching in primary schools. The section below explains the sources of efficacy and the process depicted in the model.

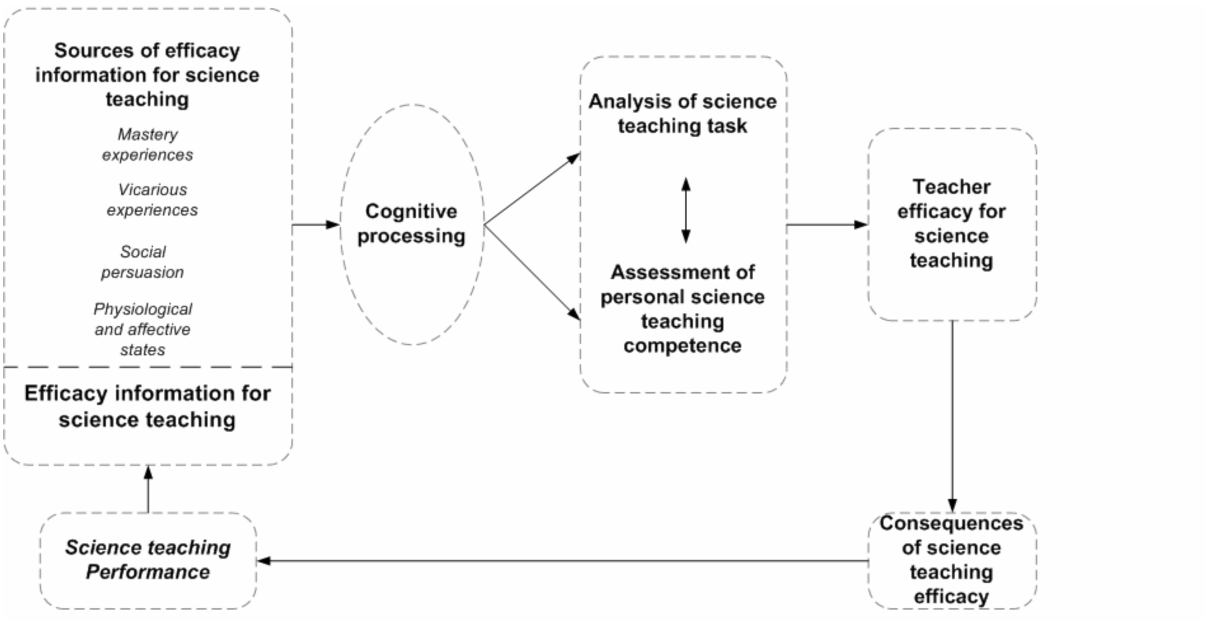

Figure 1: Efficacy for primary science teaching (based on Tschannen-Moran et al., 1998, p. 228)

Sources of Efficacy Information

As shown above, there are four sources of efficacy information for science teaching. Bandura (1986, 1997) describes four main sources of efficacy beliefs as enactive mastery experiences (or performance attainments), vicarious experiences, social persuasion and physiological and affective (emotional) states. Mastery experiences, successful experiences that contribute to increased self-efficacy, have been argued to be the most influential source of efficacy information as they "serve as indicators of capability" (Bandura, 1997, p. 79) and "provide the most authentic evidence of whether one can muster whatever it takes to succeed" (Bandura, 1995, p. 3). For teachers, mastery experiences contribute to positive beliefs about teaching capabilities. Vicarious experiences may also contribute to efficacy beliefs through "transmission of competencies and comparison with the attainments of others" (Bandura, 1997, p. 79). Observing other teachers work successfully or demonstrating particular skills may shape an individual's view of their own capabilities. Social (verbal) persuasion, through teachers encouraging and persuading each other they can perform tasks successfully can also have an effect on efficacy beliefs. Furthermore, social persuasion can "mobilize greater sustained effort" (Bandura, 1986, p. 400), thus influencing motivation and persistence, which in turn may increase possibilities of success and consequent views of capability. Finally, physiological and affective states contribute to efficacy beliefs as individuals interpret feelings of stress or fatigue or on the other hand, excitement, joy and increased energy as indicators of their capability and/or success. Experiencing positive emotions following a particular teaching experience may foster positive views of capabilities.

According to this model, sources of efficacy for primary science teaching may "contribute to both the analysis of the teaching task and to self-perceptions of teaching competence" (Tschannen-Moran et al., 1998, p. 228). For example, these authors explain how vicarious experiences through observing another's teaching may influence an individual's self-perception of competence through comparison with the model. This may involve judgements about knowledge, skills, strategies and personal attributes. In a similar way, mastery experiences can shed light on the complexity of a particular teaching task and its context. For example, efficacy beliefs about capacity to conduct a previously successful science investigation with a new class may be influenced by the particular demands of the task, the particular class of students and the time and resources available. Cognitive processing plays a critical role in this broader process as some experiences are weighted more heavily than others, some forgotten and some interpreted in particular ways. These views result in judgements about teacher efficacy, i.e., the degree to which teachers believe they are capable of performing a task at a desired level in a particular teaching context. Consequences of these efficacy judgements include for example, effort invested, goals pursued and degree of persistence demonstrated. These in turn influence performance, the relative success of which informs future efficacy for similar tasks.

Although the four sources of self-efficacy have been developed in the literature, researchers have argued that more information is still needed about the sources of teacher efficacy beliefs (Hoy & Woolfolk, 1990; Tschannen-Moran & Woolfolk Hoy, 2001) and the ways teachers "acquire or improve their teacher efficacy" (Carleton, Fitch, & Krockover, 2008, p. 47). In a recent review of teacher efficacy, Klassen, Tze, Betts & Gordon (2011) argue that still "little is known about how these sources operate in practice" (p. 24). These authors suggest research further investigating sources of teacher efficacy may "help explain the process by which teacher efficacy develops" and potentially offer "insights into how to better enhance the self- and collective efficacy of teachers" (p. 24). Further insights about efficacy in the context of primary science teaching can help inform teacher educators as they attempt to support the development of efficacy for teaching science in the primary setting.

Efficacy: The Role of Context

As discussed earlier, context plays an integral role in the cyclical model of teacher efficacy. Knoblauch and Woolfolk Hoy (2008), for example, explain that to formulate efficacy judgements, "teachers analyse the teaching task and situation and then assess their personal capabilities to perform the task" (p. 166-167). This analysis of the teaching task and situation may include considering available resources along with the characteristics of the particular group of students. Such information in conjunction with perceptions of their own capabilities given the task may, in part, determine the nature of the learning experiences developed by the teacher. Klassen and Usher (2010) also argue that sources of self-efficacy may be context specific and therefore the role of contexts in providing efficacy related information should be taken into account when investigating efficacy.

The important role of context in teacher efficacy development is also emphasised in research regarding teachers' perceived collective efficacy, or "judgements about the capacity of their school or department to organize and execute the courses of action required to have a positive effect on students" (Goddard, Hoy & Woolfolk Hoy, 2004, p. 4). Sources of collective efficacy may include vicarious experiences through modelling of successful programs or collaboration or mentoring relationships, and mastery experiences through school past performance. Adams and Forsyth (2006) suggest that school characteristics have the potential to influence teacher efficacy and argue that sources of efficacy should be broadened and reclassified "to include not only past experiences but also variables nested within the contextual environment of schools that affect the 'here and now' of teaching" (p. 630). For the purpose of this study 'context' is identified as the environmental conditions located at a particular school including the students, interactions between and among staff members, resources, etc.

Method

Participants

The participants in this study were 24 teachers from three metropolitan primary schools in Western Australia. The teachers included 17 females and seven males and ranged in age from 24 to 55 years. The teachers taught year levels spanning from kindergarten (four year olds) to year 6/7 (11-12 year olds). All participants were volunteers and some were considered science curriculum leaders in their school. Participants were varied in their number of years teaching, which ranged from one to 36 years and averaged 13 years (SD=10.9). In terms of teaching experience, eight of the teachers taught for more than 20 years while five had one to three years of teaching experience. A variety of years experience was necessary to represent the range of teaching experiences in this study since novice teachers have been shown to differ from more experienced teachers in their teaching efficacy (Tschannen-Moran & Woolfolk Hoy, 2007).

Data Collection

Firstly, in order to know participating teachers' general efficacy for teaching we asked teachers to complete a teacher efficacy scale consisting of twelve closed-response items that measured teacher efficacy in the areas of instructional strategies, classroom management and student engagement (Tschannen-Moran & Woolfolk Hoy, 2001). The efficacy scale provided a snapshot of the efficacy level for participating teachers by providing an overall mean and standard deviation for the 24 participants. For these teachers, each of the three areas (instructional strategies, classroom management and student engagement) that constituted the overall mean had similar ratings with a mean of 3.9 out of 5 (SD=.47) for instructional strategies, a mean of 4.4 (SD=.50) for classroom management, and a mean of 4.0 (SD=.40) for student engagement. The teacher participants had an overall mean rating of 4.1 out of 5 (SD=.41) on the teacher efficacy scale which reflected a reasonably efficacious level for teaching.

Focus group interviews where participants were asked to share their experiences, understandings and beliefs about teaching science were used to investigate the sources that contribute to efficacy for teaching primary school science. Focus group interviews were especially suited because they facilitated in-depth exploration and interactions among participants. Interviews in the focus-group setting allowed for more interaction among the interviewees and provided opportunities to share and build on each other's ideas and experiences (Creswell, 2012). The focus groups involved four-five teachers and lasted approximately 45 minutes. Four of the five interviews were held during school time and the fifth interview was held directly after school. In all instances, school administration provided support to cover teachers' duties so they could participate. All interviews were held in the school setting to ensure comfort and convenience for the teacher participants and to allow teachers to refer to science resources or classrooms that may be in adjoining rooms. Two researchers facilitated the focus group interviews. Having two interview facilitators ensured that no one individual dominated the conversation (Creswell, 2012). Further, one researcher has a background in educational psychology, and the other a background in science education so the interview questions reflected a balance of both perspectives. During the interview, participants were asked what they thought makes a good science teacher, how confident they felt about science teaching and the experiences that contributed to their perceived confidence, how confidence for science teaching could be developed with practicing and preservice teachers, their strengths in teaching science, a description of any school or systematic challenges they faced in teaching science and any personal challenges they faced when teaching science. Focus group interviews were audio recorded and transcribed for analysis.

Analysis

Data analysis utilised a deductive and inductive content analysis approach with a coding scheme based on Tschannen-Moran et al.'s (1998) model of the cyclical nature of teacher efficacy. Using QSR NVivo 9, two researchers worked together, coding the data in relation to the model. The researcher backgrounds in educational psychology and science education ensured that the data was viewed from both perspectives. Eighty percent of the data was coded collaboratively with both researchers agreeing on the themes emerging. The remaining twenty percent of the data was coded by one researcher and validated by the other. The analysis occurred in 4 phases.

Phase 1

Focus group interviews were imported into NVivo9 and a coding scheme based on the model was created. Specifically, codes were created for each of the four sources of efficacy. Each interview transcript was reviewed and relevant discourse was coded according to these four sources. In following this process, however we noticed that there were specific comments regarding prior experiences of science (both childhood experiences and university experiences) that seemed to be particularly pivotal for participants. Similarly, there were more recent experiences that had occurred in that particular school which had appeared to influence efficacy for science teaching. The conceptual model, while enabling us to code the sources of efficacy information did not enable us to specifically show the influence of prior experiences or features of school context on efficacy for science teaching.

Phase 2

Based on the findings from phase 1, in phase 2 we analysed the data for additional influences on efficacy for science teaching. In doing so, we coded prior experiences of science (at home, primary and secondary school and university) and aspects of the particular teaching context described (resources, administrative support, student characteristics, timetable, opportunities for collaboration) that were reported to contribute to efficacy for science teaching. The process of identifying these ideas was inductive and collaborative, involving two researchers coding and discussing the data together.

Phase 3

In phase 3 we reviewed the coding and identified themes common across the interviews. Themes coded to 3 or more of the 5 (<60%) interviews were used to inform the adaptation of the original conceptual model. An additional criterion for inclusion in the adapted model was that the coding needed to include statements (more than just ‘yes’) from 2 or more participants in each group.

Phase 4

Phase 4 involved a review of the coding and finalising the adapted framework which is presented in the following section.

Results

Our central purpose in this study was to use an established conceptual model (Tschannen-Moran et al., 1998, p. 228) to investigate practicing teachers’ efficacy for teaching science in primary schools with a view to better understanding the sources of teachers’ efficacy beliefs and how teaching context may influence efficacy for science teaching.

Participants described a range of sources that contributed to their efficacy for teaching primary school science. While these included three of Bandura’s four sources of efficacy (vicarious experiences, mastery experiences and physiological and affective states) they also described the influence of prior experiences of science during school and university years. In addition, participants described how teaching context also contributed to perceived efficacy for teaching science. Each of these is described below, using the structure of the conceptual model (Fig. 1).

Sources of Efficacy for Primary Science Teaching

During the focus groups participants described their experiences of science in their own primary school years and beyond. Positive experiences, such as being involved in 'science' activities at home (*"like if you've been out in the shed experimenting"*) were seen to be positively associated with science teaching. Similarly, school experiences, which included connecting with the broader science community through excursions and having authentic science activities such as creating a class aquarium, were positive. Importantly, especially given the aim of the current study, having inspirational science teachers in school and university also featured in discussion. *"I had this woman who was just absolutely wonderful… She would teach us how to do investigating, and every week we would arrive and be 'ohh, what are we doing today?!'"* University teachers providing *"a quick 5 minute lesson that you could actually take to the classroom"* also contributed to positive efficacy beliefs about ability for teaching science (*"you go 'wicked, I've got that up my sleeve!'").* These positive mastery experiences were recalled by participants in each group.

Even though positive experiences were described, there were also negative experiences, mostly related to poor teaching of science in primary and secondary school. For example, one participant spoke of science being *"soured"* by a teacher who *"didn't answer my small wonder type questions, and who made me feel stupid for asking".* Another participant recalled *"lots of girls crying … like hysterical sobbing"* when a science class involved dissecting a rat. Such experiences were seen to explain why some teachers might feel uncomfortable teaching science. *"I can see and understand why a lot of teachers perhaps don't uh, feel comfortable … because they also had prior experience with science … So they'd come out with that conceptual understanding that science isn't for me."*

Interestingly though, there was the view that prior negative experiences of science did not necessarily translate directly into teaching approaches. *"You can go two ways. You can either dislike it because you didn't like it, or you can learn from it and think, I'm never ever, if I ever teach science, going to make it so god-damn hands off and boring."* This view shows that while prior experiences had the potential to shape efficacy beliefs for science teaching, how these experiences were interpreted was also important. Furthermore, and again, importantly given the context of this study, subsequent positive experiences at university had the potential to over-ride earlier negative experiences. *"I think it is an attitude, but it can be broken, because doing all of those activities at Uni and having to see it, and actually having to do the investigation and do the worksheet and do all of that sort of stuff myself, actually made me go, 'aw, I can do this'."* Comments such as these also highlight the role of cognitive processing in attitudes towards teaching science and efficacy beliefs.

The potential for *vicarious experiences* as a source of efficacy for science teaching was also a common theme across all groups. Participants described how whole school science events provided opportunities to see *"how other people do science"* which inspired their own classroom teaching. In addition, science programs on television were described - *"they're quick 5 minute activities that don't need a lot of materials".* The importance of vicarious experiences was acknowledged as a motivator - "*the key thing for people to be successful … is to see it being done successfully. Because if people see it being done successfully … then they'll be more encouraged to do it. And then they'll be able to think that they can do it."*

Participants also spoke of *physiological and affective states* and how these were associated with science efficacy and teaching experiences in the classroom. For example, the importance of being relaxed, *"because you need to be able to just let them do it. If you're not relaxed in them exploring, you'll just be telling them and they're not discovering".* Some mentioned the positive emotions in the *"passion … that deep wanting to know"* and the *"joy out of seeing the students find out for themselves, especially for the first time".* Interestingly overcoming fear of an activity not going as planned was noted – "*It's about not being* *frightened to give it a go. And if it doesn't work out, it's a learning journey between you and the kids. You know, not everything works out."*

As shown in our adapted model, these sources of efficacy are influenced by both prior experiences and also experiences in particular teaching contexts. Further, such experiences are interpreted and processed to inform beliefs about efficacy to demonstrate a particular task at a particular standard in a particular context. Doing so involves making judgements about personal teaching competence as well as analysing the teaching tasks and context.

Assessment of Personal Teaching Competence

Participants described many aspects of teaching competence that were particularly pertinent to science teaching. A *"fundamental understanding of the concepts"* was important and it was argued that some teachers *"are scared of teaching science because they think that they don't have enough background information, they don't know all the answers"*.

As well as science content knowledge, knowledge about how to teach science was important. Skills such as organisation (*you have to be, unbelievably organised)*, being able to manage time and resources well and being flexible were discussed. Classroom management skills were also deemed important, especially *"if you're already nervous about teaching the subject and then you have to let go …you know sometimes science is loud, sometimes science is messy"*.

Another interesting aspect of teaching pedagogy that emerged was understanding "*how kids learn … if you're actually teaching it then they're transferring it into the real world"*. It was important to be "*flexible in allowing them to discover and not take over and let them try"* and to *"allow that learning to happen"* through being able to *"step back and not have to be so rigid and … in control"*. The ability of teachers to allow students to discover and make mistakes was also noted.

Analysis of Teaching Task and Context

As well as appraising their own teaching competence, teachers also analysed both their teaching tasks and the contexts in which they work. These appraisals influenced decisions about how to teach science for example with particular classes - "*You need to know … those students that you need to stand right next to."*

During the focus groups, participants described the role of teaching context in providing supports for efficacy in teaching science. Mastery experiences developed through opportunities in the context resulting in positive affect were described.

> *"Well I didn't always perceive myself as a science person. I felt that I came there as default … I was asked to take on the role of science coordinator and I said 'okay I can do that' because that involved just making sure materials and resources were available and things like that … I was pretty passionate about people having what people needed to be able to do the science and having all the resources there because I didn't really think of myself as so scientific. And I thought to myself, 'well I know what it's like to be teaching science from a non-scientific background' … by filling that role, I just became more intrigued, more fascinated and having amazing colleagues like I have, who just work together as a team, as a collaborative effort, I just find that it's been brilliant working with science and seeing the response the children have to it, how engaged they are and how excited they are by it, the things that they're learning are high experiences and are just very rewarding."*

In this instance, the mastery experiences in the teaching context were enhanced through effective resource management, collaboration with others and the positive emotions generated by watching children learn. With regard to the conceptual model, this description illustrates how sources of efficacy information (mastery experiences and affective states) may be interrelated and emerge from an assessment of personal competence to manage resources. Such comments highlight the way in which teaching contexts may provide 'hidden' opportunities to support efficacy for science teaching in teachers who may perceive themselves to be 'non-scientific'.

Participants also mentioned their own reactions to particular science topics, for example topics that *"would leave me cold"* and where teachers could select topics for study they would be more likely to select topics they felt comfortable with and liked. *"If it was electricity, … I think I would feel a bit out of my depth, but if it's biology based or Human Biology based then I feel that it is something that I can grasp a lot more easily and understand."*

Opportunities for Collaboration with Colleagues

A theme emerging in all focus groups was that opportunities for collaboration with colleagues were associated with efficacy for science teaching. Successful science teachers, for example, could take a lead role in this process. *"If you've got some members of staff who are passionate that the seed grows through, if there's opportunities to observe and just to listen to somebody talking about it"*. Similarly, team teaching provided support for efficacy through *"the cross pollination with friendships"* and the advantage of having another teacher to follow up and research answers to questions if needed.

A critical part of each teaching context was having leaders who could 'champion' science in the school. *"It is crucial to have someone in your school that is really motivating, 'cause I know when he showed us that way of doing those sheets and moving those sticky notes, I got motivated and thought, aw, I could do that."* In one school the 'champion' was seen to have an extremely positive motivational effect on students.

> *"All the grades were motivated, but because he's kind of instigated it … He had all the boys looking up to him… He's motivated because he does love science… having that whole school focus, and him … going 'okay guys, we're going to create this! Which class can..?' and they all thought 'Wow! We want to be a part of that!'"*.

School science 'champions' were seen to generate enthusiasm which *"rubs off"*. *"By having that core group within a school, it does have that flow on effect, and it can't help but be a positive thing."*

A Model of Efficacy for Primary Science Teaching

Based on the results, the conceptual model in Fig. 1 has been adapted to reflect the data (see Fig. 2 below) and is explained below. The shaded sections indicate where the model has been adapted.

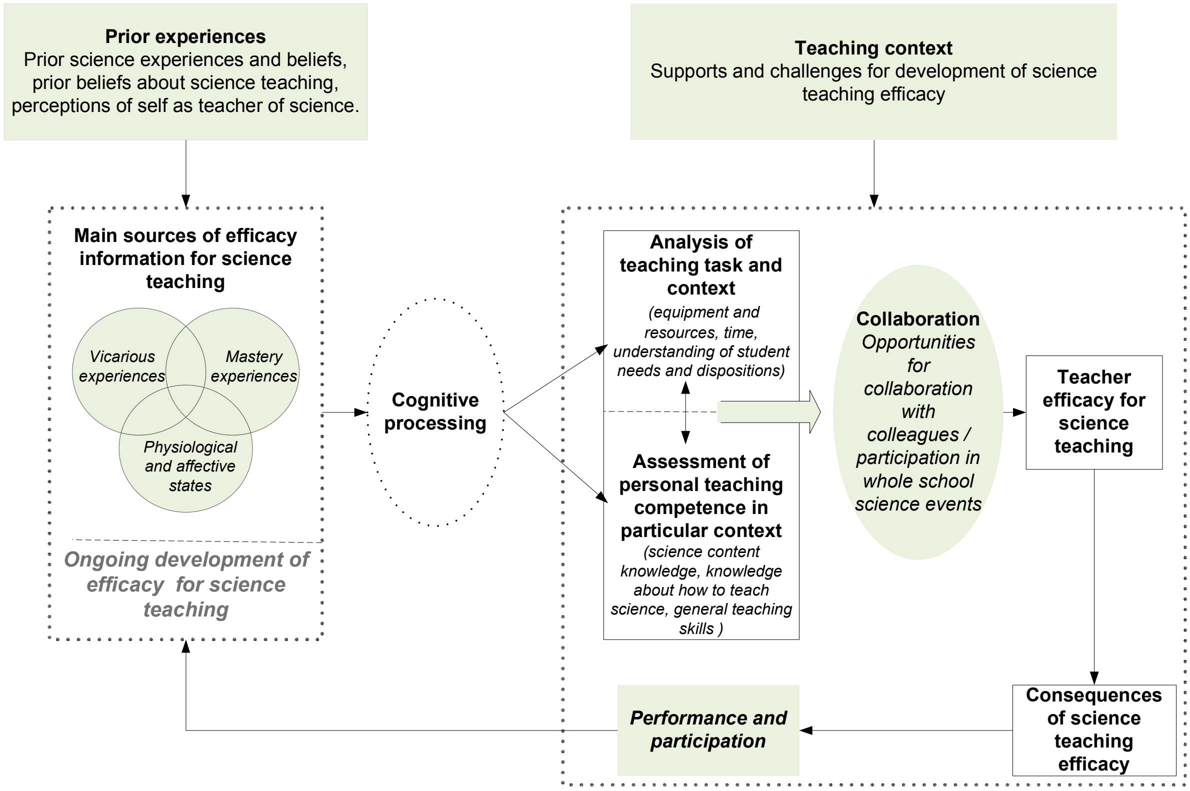

Figure 2: Sources and context influencing efficacy for primary science teaching

The results show participants' prior experiences of science, especially as school students themselves and during teacher education, potentially influenced their efficacy beliefs about teaching science. While there were both positive and negative prior experiences at school, participants explained how these influenced their own approach to science teaching. Similarly, recollections of university experiences seemed to have a positive impact on efficacy beliefs. Even though such prior experiences involve both mastery and vicarious experiences accompanied by positive or negative physiological and affective states, because these occurred prior to actual teaching they are shown in a distinct section of the framework. The next adaptation is regarding the particular sources of efficacy for science teaching. Interestingly, only three of the four sources described in the literature were represented in the data namely, vicarious experiences, mastery experiences and physiological and affective states. Furthermore, in some instances these sources of efficacy information overlapped, thus influencing one another. For example, successful mastery and vicarious experiences were noted as being accompanied by positive emotions (affective states). The sources of efficacy information for science teaching are therefore shown in a Venn diagram.

The third adaptation is the emphasis on teaching context in the large square. Because the original model emphasises the importance of context for general teaching efficacy and because our focus was on a specific teaching context and science we have highlighted this in our model. Within this the particular themes related to the teaching task and context (equipments and resources, time, understanding student needs and dispositions) and assessment of personal teaching competence (science content knowledge, knowledge about how to teach science and general teaching skills) are included. Opportunities for collaboration seemed to be pivotal in influencing efficacy for science teaching and hence we have added this as a feature of the teaching context. The large arrow to 'collaboration' has been placed to indicate that opportunities for collaboration emerge from the teaching context and may play a role in analysis of the teaching task and assessment of personal competence. For example, a teacher who feels inefficacious teaching introductory physics concepts may have their efficacy increased if the teaching task involves team teaching with another more knowledgeable colleague. The final adaptation is the addition of the word "participation" to "performance" in the box leading to "ongoing development of efficacy for science teaching". As the model shows, the influence of collaboration, opportunities to participate as well as perform have the potential to influence efficacy beliefs. In this way participation in successful whole school science activities, for example, can influence efficacy for science teaching.

The cyclical process of efficacy for science teaching shown in Fig. 2 highlights the role of prior experiences and teaching context in contributing to efficacy for science teaching. Furthermore, the model shows how the consequences of teacher efficacy in participation and performance contribute to ongoing development of efficacy.

Discussion

As previously stated, the aim of this research was to investigate teachers' efficacy for teaching science in the context of authentic teaching situations to better understand sources of efficacy. In doing so, the findings both contribute to the literature regarding teacher efficacy and inform ways in which efficacy for science teaching may be enhanced by teacher educators.

Efficacy for Primary Science Teaching: A Model

The unique contribution offered by this study to the field of teacher efficacy is in the adaptation of an established conceptual model (Tschannen-Moran, et al., 1998) to the specific situation of teacher efficacy for primary science teaching. This model was developed to illustrate sources of efficacy beliefs and the influence of teaching context on efficacy for science teaching. The model builds on the framework of the original conceptual model and highlights the influence of prior experiences and collaboration in teaching contexts.
The model shows three main sources of efficacy information, being mastery experiences, vicarious experiences, physiological and affective states. Verbal persuasion is not represented in the model as it was not reflected in the data. Even so, it could be assumed that verbal persuasion may have occurred implicitly through vicarious and mastery experiences where teachers may have encouraged each other. Our position is not that verbal persuasion is entirely absent in this process, but that it was not reflected in this particular data.

The suggestion that sources of efficacy may be interrelated offers new insights into how sources of efficacy may be operationalised in teaching contexts. Interestingly, it has been argued that mastery experiences are the most important source of efficacy information (Bandura, 1977; 1997), however, this data shows evidence that mastery experiences may occur as a consequence of vicarious experiences through collaboration and participation. Thus, observing a successful science teacher while participating in the lesson in a team teaching role may be a forerunner for a future solo mastery experience. While the results are not unique and have been found in other studies (Howitt, 2007), the role of vicarious experience in collaboration should not be disregarded. Using this model as a basis for further investigation of how collaboration can promote efficacy is an important avenue for future research.

Collaboration and Participation

The finding that collaboration and participation in teaching contexts has the potential to provide an ongoing and more immediate source of efficacy for primary science teaching is important for researchers and teachers. Some literature has noted the role of collaborative experiences on teacher efficacy (see for example Chester & Beaudin, 1996) and more recently Nilsson and van Driel (2010) found that confidence in science teaching was increased for teacher mentors and student teachers when they collaborated in science teaching. Tschannen-Moran et al. (1998) argue that participation and collaboration implicitly influence efficacy through vicarious experiences, social persuasion and feedback. The teachers in this study gave specific examples of how participation and collaboration may occur such as through team teaching, through whole school science days and activities. These experiences provided situations where teachers could learn from one another and where less efficacious teachers could learn from more knowledgeable colleagues. Some studies have found that collaboration between teachers has a positive impact on efficacy (see for example Puchner & Taylor, 2006) however micro-analysis of how such collaborative interactions specifically influence efficacy is needed in future research.

This study also reveals that having key individuals, or ‘champions’ with high self-efficacy for primary science teaching, along with passion and motivation, has what one participant described as a “fanning effect” on colleagues, i.e. they were able to inspire and motivate others with ideas and successful demonstrations of science teaching. Certainly teachers reported experiencing a sense of empowerment through collaboration with more skilled and knowledgeable colleagues. From a teaching perspective, it should be noted that in schools where science ‘champions’ may not be readily available, administrators could create the time, space, supports and opportunities for collaboration, from which teachers perceiving themselves to be ‘non-scientific’ may learn and grow to become efficacious science teachers.

Contexts to Support Efficacy for Science Teaching

This study also contributes to the literature by identifying specific aspects of teaching tasks and contexts which were perceived to influence efficacy for science teaching. The schools involved in this study offered administrative support for staff to participate in whole school science activities and encouraged individuals to take leadership roles with science curriculum. Furthermore, the self-reported experiences of some participants highlight that opportunities such as being a science resource coordinator, lead to positive changes in self-reported efficacy over time. Previous studies have found that socioeconomic status, class and level and school structure influence teacher efficacy (see for a review Tschannen Moran, Woolfolk Hoy & Hoy, 1998), however this study also emphasises the important role of collaboration and relationships in providing vicarious experiences and positive affect. The role of such social and emotional contextual interactions on efficacy for science teaching warrants further research.

Implications for Teachers and Teacher Educators

One of the most interesting findings of the study was that efficacy for science teaching can stem from the opportunity for less efficacious teachers to observe and learn from other successful teachers rather than rely solely on explicit teacher professional development. Furthermore, the successful teachers who model effective science teaching are teaching their own students, participating in school wide science activities or team teaching rather than explicitly attempting to improve the efficacy of other teachers. These findings are especially interesting because the source of efficacy for teaching primary science occurs in the school context under the right conditions. This implies that when time and space are available, fostering opportunities to involve successful science teachers who model and scaffold other teachers' learning may have a positive impact. These results would suggest that "a little goes a long way" in terms of efficacy for science teaching and in this way are consistent with Palmer's 2011 findings whereby mastery of a small science teaching subskill "can result in increased self-efficacy for science teaching as a whole" (p.20).

This study's findings reflect an optimistic view of efficacy for practicing teachers with implications for teachers and teacher educators. First, less efficacious teachers can seek out other teachers for collaboration when teaching science. Teacher educators can emphasise this continued professional development for preservice teachers as they begin their teaching careers. Second, teacher educators need to ensure that science teaching opportunities are available for preservice primary teachers even though the current teacher education climate reflects a general shortage of science teaching experiences (Kenny, 2010). Science teaching experiences provide both immediate and long term benefits to preservice teachers by maximising opportunities for vicarious and mastery experiences and providing the opportunity for preservice teachers to collaborate with one another and their mentor teachers. These learning opportunities lay the foundation for ongoing learning and can be potential sources of efficacy for teachers in their future careers. Teacher educators need to emphasise the importance of seeking out collaborative opportunities to preservice teachers as they learn how to teach science. The opportunity for preservice teachers to connect with schools and teachers who can 'model' effective science teaching is confirmed by this study's results while the need for these science teaching experiences is emphasised as a potential source for efficacy in primary science teaching. A third implication for teacher educators is in the area of professional development. The results imply that it would be beneficial for teacher educators to spend time helping teachers and schools develop collaborative relationships when they facilitate professional development activities for practicing teachers. At the same time, the results also point to the importance of providing models of effective science teaching to practicing teachers as they proceed through the cyclical model of efficacy for teaching primary science.

When interpreting this study's findings it is advisable to keep in mind its limitations. The exclusive use of focus group interviews and teacher self-reports for data collection, while leading to a deeper understanding of these teachers' experiences, limits the generalisability of the results. Furthermore, only primary school teachers were involved in this study so the model cannot be applied to specialist secondary school science teachers. Additionally, the participants were generally efficacious in teaching science, and the factors affecting relatively efficacious primary school teachers may not be the same as those that affect less efficacious teachers in general. These limitations point to further studies that will add to our understanding of efficacy for teaching science. Specifically, in future studies it would be interesting to use the model in analysing teachers with low efficacy for teaching science as well as specialist secondary science teachers.

Conclusion

Through investigating practicing teachers' efficacy for science teaching, this study responds both to the recent call for further research regarding teacher efficacy (Klassen et al., 2011) and to the ongoing need "to develop the science teaching self-efficacy of practicing elementary teachers" (Palmer, 2011, p. 2). The findings enable further development of Tschannen-Moran et al.'s (1998) model showing the cyclical nature of teacher efficacy, to illustrate sources of efficacy for teaching science and the critical role of context and collaboration in this process. This study has important implications for teacher educators attempting to enhance their students' efficacy as well as practicing and preservice teachers actively seeking support and collaborating with fellow staff to create a culture of science learning in schools.

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