Mentors and modelling primary science teaching practices

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Introduction

There are concerns about the science performance of Australian primary school students (Goodrum, Hackling & Rennie, 2001), which requires a "major set of initiatives that focus on teacher beliefs and practices in the teaching and learning of science" (Sharpley, Tytler & Conley, 2000, p. 1). The science education community is calling for a "new approach" to science education in American schools, with an approach where a "mentor models, then coaches, then scaffolds, and then gradually fades scaffolding" (Barab & Hay, 2001, pp. 74, 90). The mentor, as modeller of practice, appears to be a key factor for enhancing science teaching, which may assist towards implementing science education reform.

Mentors' modelling of practice

Mentors are defined as experts who model practice (Berliner, 1986, p. 7; Galvez-Hjoernevik, 1986, p. 6; Barab & Hay, 2001, p. 74), as teaching can be learnt more effectively through modelling (Ackley & Gall, 1992, p. 10; Jean & Evans, 1995, p. 25; Bellm, Whitebook & Hnatiuk, 1997, p. 103; Hodson & Hodson, 1998, p. 20; Carlson & Gooden, 1999, p. 7). Modelling of practices can aid preservice teachers towards understanding their own practices (Moran, 1990, p. 212). Preservice teachers enter professional experience programs to develop their knowledge, skills and self-efficacy for teaching, and as Bandura (1981) argues, self-efficacy for teaching can be enhanced through modelling. Enochs, Scharmann and Riggs (1995, p. 73) also emphasise the importance of developing self-confidence "among preservice elementary teachers for teaching science", but to do so requires well-planned and modelled science lessons. "Good" mentors model science teaching, which may include a variety of learning approaches such as constructivism (Birse, 1996) or inquiry/investigative (Fleer & Hardy, 1996). It is argued in this study that mentoring in primary science education requires modelling effective modelling of practice (Ganser, 1996; Edwards & Collison, 1996; Barab & Hay, 2001; Carlson & Gooden, 1999).

Specific mentoring

The literature (Feiman-Nemser & Parker, 1992; Crowther & Cannon, 1998) shows that mentors need to model effective teaching practices, and this includes science teaching. Such modelling aims to demonstrate for the mentee teaching knowledge (Jean & Evans, 1995), the teaching of science (Feiman-Nemser & Parker, 1992), and the syllabus language for teaching science (Abu Bakar & Tarmizi, 1995). The mentor also needs to display enthusiasm for science teaching (Bybee, 1978; Van Ast, 2002), and model ways of coping with teaching demands (Corcoran & Andrew, 1988).

Preservice teachers need considerable scaffolding to enable the transition from learner to teacher. A key component for teaching science is having pedagogical knowledge, and mentoring in science requires modelling of practice to assist the mentee's pedagogical understandings. Pedagogical knowledge may be different from one subject to the next (Peterson & Williams, 1998, p. 732) and, therefore, mentoring must address specific issues (Feiman-Nemser & Parker, 1990, p. 42), in which modelling of practices can aid the process. The inability of a mentor to model science teaching practices may call into question the mentor's skills as a mentor in this field. Indeed, problems can occur in mentoring relationships if there is a "lack of mentoring skills on the part of the mentor" (Soutter, Kerr-Roubicek & Smith, 2000, p. 6). The experienced mentor needs to demonstrate *how* to teach primary science, as this is a crucial element of the mentoring partnership.

Before entering the teaching profession mentees need "coaching" to transform idealistic concepts about teaching into more operational practices (Veenman, 1995, pp. 4-12). Talking about science teaching is essential, however without modelling practices mentees may not be able to visualise effective teaching. Modelling teaching practices allows the mentor to "coach" though practical demonstrations. For example, an effective tennis coach will show tennis pupils how to structure a serve by demonstrating each sequential stage of serving. Likewise, there are sequential stages for developing effective science teaching (e.g., planning, preparation, implementation, assessment, evaluation), and mentors who model these may provide mentees with stronger conceptual frameworks for teaching science.

Five factor mentoring model

Five factors have been identified for mentoring, namely: personal attributes, system requirements, pedagogical knowledge, modelling, and feedback, that may have associated mentoring attributes and practices linked to the development of preservice teachers' primary science practices (see Hudson & Skamp, 2003). This study focuses on developing pedagogical knowledge through modelling science teaching practices. This study argues that the mentor must model teaching practices that are consistent with current educational system requirements. This will require mentors to have enthusiasm for science, and involve mentees, not only in teaching science, but also teaching it effectively with well-designed hands-on lessons that display classroom management strategies and exemplify a rapport with students. It is further argued that the discourse used by the mentor when modelling science teaching needs to be consistent with the current syllabus, as this may aid the mentee's understanding of teaching primary science.

Data collection methods and analysis

The first study involved administering a survey to 383 final year preservice teachers from nine Australian universities (58% response rate; n=331, no missing data, 284 females, 47 males). Confirmatory factor analysis (CFA) provided analysis of the data identifying the five factors and associate variables (see Hudson, Skamp & Brooks, 2003 for full details of the methodology and instrument).

The second study involved administering the same survey to 72 final year preservice teachers (100% response rate; n=60, no missing data) at the conclusion of their four-week professional experiences at another regional university one year later.

The survey instrument (which was amended after an initial pilot study of 59 final year preservice teachers, see Hudson & Skamp, 2003) was literature based, and aimed at exploring the mentees' perceptions of their mentors' modelled practices in primary science. Survey items had Likert scales for each response category, namely, "strongly agree", "agree", "uncertain", "disagree", "strongly disagree". Scoring was accomplished by assigning a score of one to items receiving a "strongly agree" response, a score of two for "agree" and so on through the five response categories. Survey items were checked for missing or improbable values and were deleted (see Hittleman & Simon, 2002). Descriptive statistics were derived using SPSS10. Data analysis included: frequencies of each survey item under specified categories, means, and standard deviations, which give the average distance between the mean and all the other scores (see Hittleman & Simon, 2002, p. 174). The two studies (n=60, n=331) provided an indication of the degree of modelling of primary science teaching that mentors provided to final year preservice teachers. However, reporting the findings mainly focuses on the second study (n=331).

Results

Modelling primary science teaching (n=60)

Survey items associated with "Modelling" indicated that mentors (n=60) did not generally model science teaching practices for their mentees (mean range: 2.63 to 3.62, SD range: 1.21 to 1.30, grand mean=3.18, see Table 1). Although 62% of mentors modelled a rapport with students and 55% demonstrated at least one hands-on lesson, less than half the mentors modelled: enthusiasm for teaching science (48%), science syllabus language (45%), science teaching (43%), classroom management (42%), effective science teaching (35%), and well-designed science lessons (35%, see Table 1).

Table 1

"Modelling" primary science teaching

Mentoring Practices	n=331			n=60		
	%	Mean	SD	%	Mean	SD
Modelled rapport with students	58	3.36	1.24	62	3.62	1.17
Displayed enthusiasm	48	3.08	1.23	48	3.37	1.21
Modelled a well-designed lesson	44	3.09	1.26	35	2.98	1.26
Modelled science teaching	44	2.68	1.25	43	3.15	1.16
Modelled classroom management	43	2.96	1.30	42	3.05	1.17
Modelled effective science teaching	42	3.11	1.22	35	2.63	1.30
Demonstrated hands-on	41	3.01	1.26	55	3.45	1.28
Used syllabus language	40	3.04	1.22	45	3.20	1.21
Grand mean	45	3.04	1.25	46	3.18	1.22

Modelling primary science teaching (n=331)

Modelling teaching provides mentees with visual and aural demonstrations of how to teach, yet other than modelling a rapport with their students (58%) less than half the mentors "Modelled" the associated science teaching practices (n=331, grand mean=45%, see Table 1). Mentees indicated that 48% of mentors displayed enthusiasm for science teaching and only 44% modelled science teaching, which included having a well-designed science lesson. It may be that those who modelled science teaching may have modelled classroom management (43%), and most of these mentors may have modelled effective science teaching (42%) or demonstrated a hands-on lesson (40%). Yet, 60% of mentors did not model the use of science syllabus language, which develops the mentee's language towards articulating science teaching practices. Mean item scores (range: 2.68 to 3.41; SD range: 1.22 to 1.41, see Table 1) further indicated that the majority of mentees were "uncertain" to "disagreeing" that their mentors modelled primary science teaching practices.

Comparing results

If the main study (n=331) were to be used as a guide (or "norm") for the level of modelling provided by mentors, then other final year cohorts may be measured against these results. For example, Table 1 shows that mentees (n=60) received approximately the same mentoring as the main study mentees in the areas of displaying enthusiasm, modelling teaching and modelling classroom management. However, this smaller cohort received considerably less mentoring in demonstrating well-designed lessons and modelling effective science teaching practices; yet they received more mentoring in modelling a rapport with students, demonstrating hands-on lessons, and using science syllabus language. These results may assist educators (or mentors) to target professional development areas for mentors.

Discussions

According to Carlson and Gooden (1999, p. 7) effective ways to encourage assimilation of teaching skills is to model skills. Eight mentoring practices (variables that involve modelling: enthusiasm, teaching, effective teaching, a rapport with student, hands-on lessons, well-designed lesson, classroom management, and syllabus language) were identified with "Modelling" effective primary science teaching, and each variable associated to the factor "Modelling" was found to be statistically significant (see Hudson, Skamp & Brooks, 2003). This research argues that the mentor's modelling of primary science teaching allows the mentee to experience the teaching beliefs of the mentor and provides the mentee with a reference point and an immersion of practice. The following will be discussed with a breakdown of each "Modelling" practice referenced to literature sources, the associated findings with the main study (n=331), implications, and research questions that may be linked to each practice.

Displays enthusiasm when teaching science

As mentees view their mentors as inspirations (Moran, 1990, p. 212), and may emulate many of the mentor's positive attributes (James & Hord, 1988; Matters, 1994, p. 4), enthusiasm modelled by a mentor can be infectious and may positively influence the mentee (Van Ast, 2002, p. 13). Enthusiasm in working with students is reported as an important attribute of an "ideal" primary science teacher (Bybee, 1978), and is considered an important quality for mentors (Hulshof & Verloop, 1994, p. 28). Some researchers (e.g., Abell & Bryan, 1999, p. 124) purposefully select science teaching enthusiasts for their studies, so as to help “understand more about preservice teacher thinking about science teaching and learning.”

This study argues that mentors who are enthusiastic when teaching primary science may influence the mentee’s learning about science teaching, and modelling enthusiasm for science teaching may elicit enthusiasm from the mentee. The findings indicated that nearly half the mentors displayed enthusiasm for science teaching (see Table 1). This does not necessarily mean that these mentors were enthusiastic about teaching science themselves; it may mean that mentors were enthusiastic about the mentees’ teaching of science. Regardless, the enthusiasm exhibited by these mentors may contribute towards developing positive attitudes in their mentees. Conversely, if enthusiasm is infectious then 52% of mentors who did not model enthusiasm for science teaching may have “dampened the spirits” of mentees for teaching primary science.

How is the mentor’s enthusiasm related to the mentee’s confidence to teach primary science? What constitutes enthusiasm for science teaching? What specific mentoring strategies might mentors’ employ to demonstrate enthusiasm for teaching science? How can a mentee’s enthusiasm for science and science teaching be measured?

Models and effectively models science teaching

Mentors have been defined as models (Galvez-Hjoernevik, 1986, p. 6; Enochs, Scharmann & Riggs, 1995, p. 73). To illustrate, Berliner (1986, p. 7) states that experienced teachers in the mentoring process are “models who lead the novice to some sort of competency in teaching.” Even though modelling demonstrated by mentors in professional experiences assists mentees with teaching practices and pedagogical discourse (Little, l990, pp. 301-302) such practices may not be effective; therefore this research argues that mentors also need to model effective science teaching practices. Monk and Dillon (1995, p. 8) claim that modelling effective science teaching and then observing the mentee’s science teaching enhances practices.

There is a difference between modelling science teaching and modelling effective science teaching. A mentor who models science teaching may not demonstrate skilful teaching, however, this may assist the mentee to decide on what not to do and make decisions towards conceptualising “best” practices. Modelling effective science teaching provides mentees with a fuller understanding of how to teach science. The findings in this research indicated that mentors who modelled science teaching generally modelled effective science teaching; nevertheless more than half the mentors did not model science teaching (see Table 1). Definitions that include mentors as modellers of practice implies that mentors who do not model practice may not be mentors at all. The findings indicated that opportunities to observe a more experienced teacher does not occur for most mentees in the field of primary science education and mentees who have not observed other science teaching practices will rely on their own experiences as a student in science classes, which will have an affect on primary science education reform.

What primary science teaching skills does a mentor need to model in a science lesson? As professional experience programs may be short and need to cover a range of curriculum areas in primary education, how many science lessons will mentors need to model to adequately assist mentees? What is a "modelled" science lesson? Do mentors require examples of effective science lessons in order to model "best" practice?

Demonstrates a rapport with students during science lessons

Part of the rationale of primary science teaching is meeting the needs of the students, which requires "understanding their world and the things that influence it" (NSW Board of Studies, 1993, p. 5). Meeting the needs of students require teachers (and mentors) to demonstrate and model a rapport with students, as this facilitates the engagement of students' learning about science (Ramirez-Smith, 1997, p. 4). This research argues that mentees can learn classroom management from mentors who model teacher/student rapport during their demonstrated science lessons. Mentees who develop a rapport with their students can develop a sense of self as a necessary part of learning how to become a teacher (Krasnow, 1993).

This study argues that when mentors demonstrate a rapport with students during science lessons, they exhibit a key component of classroom management that aids in engaging students. Most mentors in this research demonstrated that they had a rapport with their students during science lessons (see Table 1). Conflicting with these results is that although 58% of mentors modelled a rapport with students during science lessons, only 40% of mentors taught primary science. This data implies that 18% of mentors who did not teach science demonstrated a rapport with the students during the mentees' primary science lessons, which is not the same as modelling a rapport with students while teaching science. This may mean that 18% of mentors in this study were willing to be involved in science lessons, which may imply that some or all of these mentors are seeking professional development for their own science teaching.

Why would mentors who do not model a science lesson model a rapport with students during the mentee's science lesson? Can an instrument be developed to measure the rapport that mentors or mentees may have with students during science lessons? How do primary science teachers interact with students in schools? Are there differences in the rapport a teacher may have with students in science compared with another subject area?

Demonstrates well-designed science lessons

Well-designed activities engage students in learning (Ramirez-Smith, 1997). Ball and Feiman-Nemser (1988, p. 421) claim that good primary science teachers design their own lessons and "make their own curricular decisions." Lesson designs may incorporate the viewpoints of the mentor that are materials-centred to encourage the formulation and testing of predictions (Fraser, 1988, p. 36).

The findings indicated that the percentage of mentors who demonstrated well-designed science lessons were the same or similar to those who modelled science teaching and classroom management (see Table 1). The results also indicated that there were more well-designed lessons than hands-on lessons, which infers that well-designed lessons may not necessarily involve hands-on experiences for students, as such lessons may include teacher directed or teacher demonstrated lessons. However, well over half the mentors in this research had not provided an opportunity for mentees to observe science lessons that were well-designed. This implies that many preservice teachers about to enter the workforce may not have conceptualised effective science lesson designs.

What types of science lessons may be considered well-designed lessons? How can mentors measure the effectiveness of their lesson design? What do primary science reformers advocate as “well-designed” lessons that may be demonstrated by mentors? How can mentors receive cost-effective professional development opportunities for designing effective science lessons?

Demonstrates hands-on science lessons

Science education reformers promote hands-on learning (see Raizen & Michelson, 1994; Skamp, 1998). Even though science syllabi strongly advocate investigative hands-on lessons (e.g., NSW Board of Studies, 1993), primary teachers request continuous support in the area of improving their teaching methods, especially with hands-on activity planning (Asunta, 1997; Bybee, 1978; Dickinson, et al., 1997, p. 305).

Findings in this research show that mentors who model effective science teaching practices generally model hands-on science lessons; yet 59% of final year preservice teachers claimed that their mentors did not demonstrate a hands-on science lesson (see Table 1). This study argues that modelling a hands-on lesson would allow a mentee the opportunity to observe the mentor's "Pedagogical Knowledge" including preparation, planning, and classroom management techniques. It is unlikely that preservice teachers would receive this experience with primary students in the university setting, and consequently, professional experiences may be the only opportunity for preservice teachers to witness hands-on science lessons. As most mentees have three professional experiences during their teacher education (see Hudson, Skamp & Brooks, 2003), if the previous two professional experiences provided no demonstration of hands-on science lessons, a significant number of beginning teachers may not know how to plan and teach a hands-on primary science lesson.

What types of hands-on primary science lessons do mentors choose to model? How many times might a preservice teacher observe hands-on science lessons during a teaching degree? What might hinder a mentor from modelling a hands-on science lesson?

Models effective classroom management when science teaching

Classroom management is considered a vital component of professional experiences (Corcoran & Andrew, 1988), which mentees regard as a need (Carpenter, Foster &

Byde, 1981; McCahon, 1985). Mentors need to model classroom management (Gonzales & Sosa, 1993; Williams, 1993), as the mentees' classroom observations of classroom management can assist with specific management needs; however a mentee needs to have time allocated to observe experienced classroom management (Smith & Huling-Austin, 1986, p. 47).

Behaviour appears to be largely based on observing the modelling of practice. Anecdotally, classroom management appears to be the most difficult area for teachers who are experiencing problems with teaching, and so mentees need to learn how to manage a class when teaching, which includes science teaching. Findings in this research show that less than half the mentees observed mentors modelling effective classroom management when teaching science (see Table 1). Classroom management is a high priority for preservice teachers, yet 57% of final year preservice teachers did not experience this as a modelled mentoring practice during the course of their professional experience program. Hence, mentees may not be able to visualise effective classroom management strategies, and without substantial experience they may not be able to address management needs when they arise.

How is modelling of classroom management in primary science teaching related to instilling positive attitudes and confidence in mentees? How often have final year preservice teachers observed the modelling of classroom management in science teaching before entering the profession? What are effective management strategies associated with various types of science lessons, and can these be tested with mentors?

Uses language from the science syllabus

There is a need to develop professional discourse (Darling-Hammond, 1998) because a common shared language is apparent in successful professional experiences (Schlechty, 1985; Williams & McBride, 1989, p. 15). Discussions between mentor and mentee allow the mentee to use the language of practice to examine teaching within the "zone of proximal development" (Nilssen, Gudmundsdottir & Wangsmocappelen, 1998). It is also important that mentors assist mentees to "assist young children's language development of labelling and descriptive vocabulary as well as enabling them to address the problem that many words have both everyday and specialist scientific meaning" (Jarvis, McKeon, Coates, & Vause, 2001, p. 10). A science syllabus provides the basis for developing such language (e.g., see NSW Board of Studies, 1993).

Developing the language of science teaching may enhance mentees' understandings for teaching science; yet this was the practice least modelled by mentors (see Table 1). Sixty percent of final year preservice teachers claimed that the mentor had not modelled science language used within the syllabus. These results need to be considered in light of the knowledge that mentees may have of the syllabus language, and what mentees constitute to be science language. However, these mentees were in their final year of teacher education and need to be exposed to the language of science teaching in order to articulate science teaching needs and ultimately assist students with their scientific literacy.

How much science language is necessary in order to adequately mentor in science teaching? To what degree are mentees prepared for the discourse used to develop science teaching practices and with what science teaching vocabulary do mentees enter professional experiences? Indeed, what science language is required of preservice teachers before entering a professional experience? What are the levels of science teaching vocabulary exhibited by preservice teachers in each year of their teacher education? Can a sequential vocabulary list be developed that may facilitate the mentee's learning of science teaching? How is the mentee's development of science teaching discourse related to conceptual understandings for science teaching?

Summary and conclusion

Observing the modelling of primary science teaching practices is considered a powerful tool for assisting mentees' development of primary science teaching (Riggs & Sandlin, 2002). This study argues that a mentor who can model enthusiasm for teaching science by simply teaching science, showing how to program, and displaying ways of addressing curriculum mandates may visually aid the mentee's understanding of primary science teaching. Furthermore, a mentor who can discuss the necessary primary science teaching knowledge and skills, and use language from the primary science syllabus may provide an auditory model for the mentee's understanding of how to teach primary science.

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