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Toward Identifying Pedagogical Knowledge for Mentoring in Primary Science Teaching

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Final year preservice teachers' perceptions of their mentoring in primary science teaching were gathered through surveys from three separate studies. The three studies ($n = 59$, $n = 331$, $n = 60$) provided an indication of the degree of mentoring preservice teachers perceived they received with mentoring practices linked to "Pedagogical Knowledge." This research argues that mentors require pedagogical knowledge of primary science for guiding mentees with planning, timetabling, preparation, implementation, classroom management strategies, teaching strategies, science teaching knowledge, questioning skills, problem-solving strategies, assessment techniques, and developing viewpoints on science pedagogy. The key study findings ($n = 331$, from nine Australian universities involved in primary teacher education) indicated that 55% or more mentees had not received "Pedagogical Knowledge" for primary science teaching in each of the associated mentoring practices (mean score range: 2.60–2.91, standard deviation range: 1.10–1.32). The study concludes that mentors require further professional development to ensure that preservice teachers (mentees) receive adequate pedagogical knowledge for teaching primary science, which will involve significant collaboration between universities and schools.

KEY WORDS: mentoring; science teaching; pedagogical knowledge; primary; elementary.

PEDAGOGICAL KNOWLEDGE

Research (Abell and Bryan, 1999; Bishop, 2001; Bishop and Denley, 1997; Bybee, 1997; Czerniak, 1990; von Glasersfeld, 1998) has shown that developing effective primary science teaching requires the acquisition of particular knowledge, including mastery of content knowledge (Ganser, 1996; Patriarca and Kragt, 1986). Bishop (2001), for example, argues the necessity for professional practical knowledge, which subsumes practical knowledge, teacher practical knowledge, personal practical knowledge, and knowing-in-action. Similarly, pedagogical content knowledge, as articulated by Shulman (1986, p. 27), presents an understanding for developing teaching practices; however the general term *pedagogical knowledge* is frequently used when referring to the teaching knowledge for primary science (e.g., Briscoe and Peters, 1997; Coates *et al.*, 1998; Watters *et al.*, 1995). Pedagogical knowledge includes understandings of science concepts, strategies for teaching, curriculum, and implementations of content that help the learner to learn (Smith, 2000).

Educators (Fairbanks *et al.*, 2000; Galbraith, 2003; Jonson, 2002; Odell, 1989) agree that mentoring programs are intended to provide preservice teachers with mentors who are more knowledgeable about teaching. Pedagogical knowledge makes "understanding of science usable in the classroom" (Mulholland, 1999, p. 26), and is essentially developed by preservice teachers (mentees) within the school setting (Allsop and Benson, 1996; Brown and McIntyre, 1993; Hulshof and Verloop, 1994). Mentees who are engaged in reforming primary science education need mentors to have pedagogical knowledge to guide their practices (Kesselheim, 1998), which requires mentors to have clear expectations and

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goals (Ganser, 2002). Specifically, mentors need to provide the pedagogical knowledge for planning for teaching (Gonzales and Sosa, 1993; Jarvis *et al.*, 2001); timetabling lessons (Burton, 1990; Williams, 1993); teaching strategies (Lappan and Briars, 1995; Tobin and Fraser, 1990); preparation for teaching (Rosaen and Lindquist, 1992; Williams, 1993); problem solving (Ackley and Gall, 1992; Breeding and Whitworth, 1999); classroom management (Corcoran and Andrew, 1988; Feiman-Nemser and Parker, 1992); questioning skills (Fleer and Hardy, 1996; Henriques, 1997); implementing effective teaching practice (Beck *et al.*, 2000; Briscoe and Peters, 1997); and assessment (Corcoran and Andrew, 1988; Jarvis *et al.*, 2001). For developing the mentee's primary science teaching, mentors also need to provide pedagogical viewpoints such as constructivism (Fleer and Hardy, 1996) and appropriate content knowledge (Jarvis *et al.*, 2001; Lenton and Turner, 1999).

SPECIFIC MENTORING

Effective mentoring includes having clear standards and a specific subject focus (Curran and Goldrick, 2002). Preservice teachers are not prepared to teach science at a level that adequately promotes science education reform (e.g., Roth *et al.*, 1998). A key component for teaching science is having pedagogical knowledge, and mentoring in science will require specific knowledge. For example, Feiman-Nemser and Parker (1990, p. 42) have shown that pedagogical knowledge can have differences from one subject to the next and, therefore, mentoring must "address content-related issues in content-specific terms." Peterson and Williams (1998) also claim that unique mentoring processes are required for specific subject teachers. To illustrate, Hodge (1997, p. 183) provides mentoring perspectives for preservice physical education teachers to develop specific physical education teaching skills, which recognizes the need to develop mentoring skills in specific educational areas.

Problems can occur in mentoring relationships if there is a "lack of mentoring skills on the part of the mentor" (Soutter *et al.*, 2000, p. 6), in which pedagogical knowledge is key to developing teaching practices. A mentor's pedagogical knowledge of primary science must be more advanced than a mentee's primary science teaching knowledge if the mentor is to provide feedback that aims at progressing the mentee. The mentor should be able to articulate the primary science teaching skills required of the mentee. If the mentor's pedagogical knowledge of primary science teaching falls below a mentee's knowledge, then the mentor's credibility and suitability may come into question. Preservice teachers may have science content knowledge superior to the mentor's science content knowledge for any given topic, which can be expected as science is such a broad field. Nevertheless, a mentor must have greater knowledge on *how* to teach primary science, and this is the crucial element of the mentoring partnership, indeed, the mentor's role is to prepare, negotiate, and enable the mentee's teaching practices towards higher levels of teaching competencies (Zachary, 2002).

The teacher's task is to "build progressively on the teaching experience and pedagogical knowledge" (Booth cited in Allsop and Benson, 1996, p. 17) and, similarly, the mentor's task should be to do the same with the mentee. Beginning teachers lack the "tricks of the trade" gained from experience (Moran, 1990, p. 211), and so before entering the teaching profession mentees need "coaching" to transform idealistic concepts about teaching into more operational practices (Veenman, 1995, p. 4). Those who receive coaching perform better than the "uncoached," particularly in teaching instruction and classroom management skills (Veenman, pp. 11–12). Mentoring is a means of enhancing teacher efficacy (Yost, 2002), and hence must be included in preservice preparation programs at subject-specific levels.

Further research is needed on determining the effectiveness of mentoring in primary science teaching (Jarvis *et al.*, 2001). Indeed, there is little evidence that mentors encourage mentees to think critically about their pedagogical practices, and this is why mentoring needs to be planned in a similar way as teachers plan for students' learning (Edwards and Collison, 1996). More research is also needed to determine if mentoring influences preservice teachers' pedagogical behaviors and professional development (Burry-Stock and Oxford, 1994), particularly in subject-specific contexts; however mentors need to prepare themselves by understanding pedagogical knowledge essential to the mentoring processes.

DEFINITIONS

Mentor in this study will be defined as one who is more knowledgeable on teaching practices and through explicit mentoring processes develops pedagogical self-efficacy in the mentee towards autonomous teaching practices. The mentor–mentee relationship in this study focuses on guiding reflection-on-practice within a collaborative partnership for developing pedagogical knowledge in the field of primary 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 *et al.*, 2004; Hudson and McRobbie, 2003; Hudson and Skamp, 2003a). This paper focuses on pedagogical knowledge, as by articulating the associated practices linked to pedagogical knowledge for mentoring in primary science teaching and providing strategies that may assist this process, it may be possible to more clearly define the mentor's role for developing effective primary science teaching.

DATA COLLECTION METHODS AND ANALYSIS

This research combines key elements about pedagogical knowledge from three separate studies. The first study involved administering a survey to 59 first-year preservice teachers (100% response rate) from the same New South Wales regional university at the conclusion of their 4-week professional school experiences. Data were subjected to an exploratory factor analysis (EFA) to assess the unidimensionality for each of the five factors suggested from the literature. EFA was used to define possible relationships and then using multivariate technique in SPSS10 to estimate these relationships (see Hair *et al.*, 1995; see also Hudson and Skamp, 2003b for further methods used in this study). These preliminary EFA statistics provided an indication of this study's theoretical proposition for establishing the relationship between the factor pedagogical knowledge and associated practices for mentoring in primary science teaching (among other factors and associated practices). The "method and data define the nature of the relationships," which is appropriate in EFA (Hair *et al.*, 1995, p. 619).

The second study involved administering a survey in 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 *et al.*, 2004 for full details of the methodology and results).

The third study involved administering the same survey from the third study to 72 final year preservice teachers (100% response rate; $n = 60$, no missing data) at the conclusion of their 4-week professional experiences at the same university 1 year later (see Hudson and McRobbie, 2003 for full details of this study).

SURVEY INSTRUMENT

A literature-based survey instrument, which was refined after the pilot study ($n = 59$) (e.g., including items about planning, implementation, and viewpoints and adjusting some items for syntax), aimed to explore the mentees' perceptions of their mentoring experiences for teaching primary science. Survey items had Likert scales for response for each category, namely, "strongly agree," "agree," "uncertain," "disagree," "strongly disagree." Scoring was accomplished by assigning a score of 1 to items receiving a "strongly agree" response, a score of 2 for "agree" and so on through the five response categories. Survey items were checked for missing or improbable values and were deleted (Hittleman and Simon, 1997). Descriptive statistics were derived using SPSS10. Data analysis included frequencies of each survey item under specified categories, means and standard deviations (SD), which give the average distance between the mean and all the other scores (Hittleman and Simon, 1997). The three studies ($n = 59$, $n = 331$, $n = 60$) provided an indication of the degree of mentoring preservice teachers perceived they received with the mentoring practices linked to pedagogical knowledge; however reporting the findings mainly focuses on the second study ($n = 331$).

RESULTS AND DISCUSSION

Pedagogical Knowledge ($n = 59$)

In this pilot study, a small majority of mentors (51%) discussed the preparing for science teaching with the mentee. However, such assistance appears to be limited as only 32% of mentors assisted the mentee's problem-solving strategies. Only 44% of

Table I. Pedagogical Knowledge for Mentoring Primary Science Teaching

Mentoring practices	$n = 59$			$n = 331$			$n = 60$		
	%**	Mean score	SD	%	Mean score	SD	%	Mean score	SD
Guided preparation	51	3.29	1.30	45	2.87	1.27	45	2.91	1.39
Assisted with timetabling	41	3.12	1.40	44	2.91	1.27	63	3.35	1.33
Assisted with classroom management	44	3.42	1.21	44	2.85	1.32	53	3.10	1.37
Assisted with teaching strategies	37	3.47	1.29	41	2.86	1.23	37	2.80	1.27
Assisted in planning	*	*	*	37	2.72	1.23	38	2.85	1.30
Discussed implementation	*	*	*	35	2.70	1.19	50	3.05	1.33
Discussed knowledge	41	3.51	1.09	35	2.73	1.19	35	2.76	1.24
Provided viewpoints	*	*	*	35	2.81	1.23	32	2.73	1.21
Discussed questioning techniques	25	3.41	1.18	31	2.67	1.21	40	2.95	1.27
Discussed assessment	30	3.41	1.26	31	2.64	1.22	21	2.47	1.21
Discussed problem solving	32	3.69	0.95	25	2.60	1.10	33	2.67	1.24

Note. * = initial pilot study survey with missing survey items.
**Percentage of mentees who either "agreed" or "strongly agreed" their mentor provided that specific mentoring practice.

mentees claimed that the mentor had assisted them to develop classroom management strategies. Mean item scores (range: 2.98–3.69; SD range: 0.95–47) indicated that the majority of mentees "disagreed" that the mentor displayed pedagogical knowledge; in their mentoring practices for science teaching. Fundamental teaching strategies such as discussing assessments (30%) and questioning techniques (25%) were given a low priority by mentors (see Table I).

Pedagogical Knowledge ($n = 60$)

Only two items associated with pedagogical knowledge received a greater than 50% rating from the 60 mentees (mean range: 2.47–3.35, SD range: 1.21–1.39, Table I; mean score = 2.88). Mentoring aspects involving preparation (45%), questioning techniques (40%), planning (38%), teaching strategies (37%), knowledge (35%), problem solving (33%), providing viewpoints (32%), and discussing assessment (21%) were exercised by less than half the mentors (Table I). Pedagogical knowledge is considered an essential reason for involving preservice teachers in professional experiences, yet most mentors did not provide this knowledge in the area of primary science.

Pedagogical Knowledge ($n = 331$)

It is argued in this research that mentoring can be used as an agent of change toward influencing preservice teachers' beliefs in teaching primary science by developing pedagogical knowledge through guided practices. The literature indicated 11 mentoring practices (variables) that may be used to represent pedagogical knowledge." Pedagogical knowledge for mentoring encompasses planning for teaching primary science, which requires timetabling, preparation, teaching strategies, and classroom management toward implementing practice. However, it also covers other elements for effective primary science teaching including developing questioning skills, assisting in problem solving, and providing content knowledge and guidance for assessment, which all appeared to be statistically significant (see Hudson *et al.*, 2004). Such mentoring necessitates clear articulation of expectations for teaching practices, as well as providing the mentee with viewpoints on teaching primary science.

The following will be discussed with a breakdown of each pedagogical knowledge mentoring practice referenced to literature sources, the associated findings and implications, and further research questions that may be linked to each practice.

Guides the Planning for Science Teaching

Pajares (1992) found that there was a "strong relationship between teachers' educational beliefs and their planning, instructional decisions, and classroom practices" (p. 326). Unquestionably, the largest percentage of mentoring occurs in the area of instructional assistance and planning (Corcoran and Andrew, 1988; Gonzales and Sosa, 1993). Indeed, mentoring requires "guidance for planning individual science lessons" (Jarvis *et al.*, 2001, p. 9), and mentors are the ones to facilitate the learning process, which requires thoughtful mentoring for science teaching (Burry and Bolland, 1992; Rhoton and Bowers, 1996). Mentees can enhance their education by talking about planning for teaching (Rosaen and Lindquist, 1992).

Mentors have been identified as guides for developing mentees' education in teaching including guiding the mentee's planning for teaching. The findings in this research indicated that the largest percentage of mentoring occurred with planning to teach (Table I), which supports Corcoran and Andrew's (1988) findings. However, for the final year preservice teachers this was practised by only 37% of mentors. This means that considerably more than half the mentees in this research may not know how to plan to teach primary science, and if this research is representative of previous professional experiences, there may be a significant number of preservice teachers without planning knowledge for science teaching. This implies that many beginning teachers may not be adequately educated on science teaching; this does not take into account the preservice teachers' previous years of tertiary science education or previous professional experiences. However, a significant number of mentees (42%) had only two previous professional experiences and either one (36%) or two (41%) science methodology units at university. Moreover, 51% of mentees were not required to teach science by their university; hence mentees who are not confident in teaching science may not feel compelled to plan for teaching science.

Further research questions: What are the elements for planning a science lesson that a mentor needs to articulate so that mentees can devise effective teaching practices? How often do mentors need to articulate how to plan for teaching science before mentees are successful at planning? What education have final year preservice teachers received from previous professional experiences and university science methodology units on planning to teach science before entering their final professional experience?

Timetables for the Mentee's Science Teaching

Williams (1993) shows that assisting mentee's timetabling of science is fundamental towards teaching science. Button (1990) also explains that a mentor has a role in coordinating a mentee's classroom and planning experiences by timetabling science lessons. Designing a school plan or timetabling science provides for each student "substantial access to the Key Learning Area" (NSW Board of Studies, 1993, p. 53).

Timetabling the mentee's science lessons appears to be a key element of planning for teaching. The findings indicated that more mentors timetabled for the mentees' primary science lessons than most of the other pedagogical knowledge" practices (Table I). This implies that many mentors may be keen for mentees to teach science and will timetable accordingly. Still, this initial step toward facilitating the mentee's science teaching experiences was omitted by more than half the mentors in this research. If mentors have not timetabled for their mentees to teach science then mentees' opportunities for teaching may be reduced in this early planning stage. This implies that most final year preservice teachers appear to be denied access to teach science.

Further research questions: As mentees are at different stages in their teacher education degree, how can mentors sequentially timetable their mentees' science teaching for effective teaching? Is science "easier" to teach at certain parts of the school day and should first year preservice teachers teach at "easier" times of the day? What ways are available for mentees to initiate timetabling for teaching science?

Guides Science Lesson Preparation

Preparation for science teaching is considered essential toward implementing well-informed lessons (Beisenherz and Dantonio, 1991; Bybee, 1993; Ganser, 1996; Ramsey, 2001). Mentees can enhance their education by talking about preparation for teaching (Rosaen and Lindquist, 1992), and mentors are generally confident in assisting with the mentee's preparation (Williams, 1993).

The research results indicated that primary science lesson preparation was the highest ranked pedagogical knowledge of mentors (Table I), which also supports William's (1993) findings. Mentees who received guidance with their science lesson preparation had an opportunity of being well informed for implementing lessons. However, 55% of mentees who had not received guidance toward science lesson preparation may not have enhanced their own science teacher education. This implies that many beginning teachers may be unaware of the processes required to prepare for teaching science, which may hinder the initiation of science lessons.

Further research questions: What is the essential science preparation knowledge required of mentors? What are effective mentoring methods of articulating science preparation requirements for mentees?

Develops Science Teaching Strategies

Effective teaching strategies promote scientific literacy (Roberts *et al.*, 2001). Tobin and Fraser's

(1990) case studies show that exemplary science teachers are motivators who use effective teaching strategies within a favorable learning environment. Without doubt, preservice teachers need to understand a range of science teaching strategies in order to provide appropriate and purposeful science lessons (Bruner, 1996; Howe, 1987; Jarvis *et al.*, 2001; Skamp, 1998). For example, understanding science teaching strategies associated with the inquiry approach aims toward achieving more successful science lessons (Skamp, 1998; Wise, 1996).

The research findings show that most mentors do not develop primary science teaching strategies in their mentees (Table I); therefore science lessons may not be appropriate or purposeful for students. Mentees who are not educated on effective science teaching strategies may not be able to create a favorable learning environment or adequately motivate their students; hence scientific literacy, as a key goal of science education, may not be promoted. As science educators and the science community are continuously in debate over effective science teaching strategies, mentors, who may not be experts in science teaching, may feel inadequate if these strategies are not clear to them.

Further research questions: What science teaching strategies need to be articulated by mentors that link with primary science education reform? How can mentors be provided with a set of science teaching strategies to aid them in their mentoring program? How adequate or inadequate do mentors feel about selecting effective science teaching strategies? What causes these adequacies and inadequacies?

Assists With Classroom Management Strategies for Science Teaching

Classroom management has long been a concern of beginning teachers (e.g., McCahon, 1985). Preservice teachers also need to consider classroom management strategies toward achieving successful lessons (Corcoran and Andrew, 1988). Generally, mentees regarded classroom management as essential to their professional experiences (Gonzales and Sosa, 1993), particularly as good classroom management can lead toward being effective teachers (Feiman-Nemser and Parker, 1992). Complementing this need, mentors are usually confident in assisting mentees develop their classroom management strategies (Williams, 1993).

Classroom management is probably the area of greatest need for mentees, especially as society has changed dramatically over the last 40 years. Preservice teachers need effective classroom management strategies that assist them to cater for the students of today. Findings in this research indicated that classroom management strategies for primary science teaching were provided by a significant number of mentors, although the majority of mentors had not provided these strategies (Table I). As 74% of mentors observed mentees teach science, these results do not take into account why 30% of mentors did not provide mentoring on classroom management. Nevertheless, classroom management needs to be discussed as a component of planning to teach primary science, which was done by only 37% of mentors (Table I).

Further research questions: Why would mentors who observe mentees teach primary science not discuss classroom management? Are inadequate classroom management strategies for teaching science a key reason for teachers leaving or wanting to leave the profession? What classroom management strategies in primary science teaching can be used for the students of today? How can effective classroom management strategies in science teaching be listed and ranked for mentors to provide to mentees?

Assists Implementation of Science Teaching

In general, research in education aims at improving the implementation of teaching, whether it is the analyzing of self-efficacy toward implementing more effective practices (e.g., Beck *et al.*, 2000; Crowther and Cannon, 1998; Enochs and Riggs, 1990), providing new methods of collaboration for implementing practice (e.g., Briscoe and Peters, 1997; Odell, 1989), or reflection on practices for enhancing the implementation of teaching (e.g., Schon, 1987). A key part of the mentor's role is to guide mentees toward implementing teaching practice (Ganser, 1996; Little, 1990; Motz, 1997; Riggs and Sandlin, 2002).

A little more than a third of mentors in this research assisted the mentees' implementation of primary science teaching, which means nearly two-thirds of mentors had not provided this essential mentoring practice (Table I). This implies that most mentors involved in final year professional experience programs have not fulfilled their roles as mentors in science teacher education. If this is a key goal of mentoring, then mentoring in primary science teaching falls considerably short of the mark. Other interlocking components for teaching science emanate from implementing practice. For example, assisting a mentee to implement primary science teaching includes planning and preparation, and at the conclusion of implementing science teaching the mentee may reflect on practices toward further improvement.

Further research questions: To what degree do mentors need to assist mentees for implementing science teaching? What are the different stages of mentoring assistance required for the different years of tertiary education completed by mentees? How may university and schools determine the level of mentoring required for each stage of a mentee's education?

Provides Problem-Solving Strategies for Teaching Science

Problems vary from preservice teacher to preservice teacher (Bullnough, 1989). Problem-solving issues for beginning teachers are mainly on strategy sharing, classroom discipline, and facilities and supplies (Breeding and Whitworth, 1999; Veenman, 1984). The "good" mentor assists in this learning process by addressing problems that arise from practice, which requires active engagement and opportunities to practise what was learnt (Loucks-Horsley *et al.*, 1998). Ackley and Gall (1992) conclude that problem solving with mentees was the strategy most used by mentors, which occurs generally as a result of mentors' observations of mentees' classroom practices (Odell, 1989). Collaborative problem solving can aid in development of professional discourse toward understanding the complex nature of teaching (Darling-Hammond, 1998).

The findings indicated that only a quarter of mentors provided problem-solving strategies for teaching primary science, and this was the pedagogical knowledge least practised by mentors (see Table I), which appears to conflict with Ackley and Gall's (1992) assertions. However, problem solving is interconnected with all of the pedagogical knowledge practices and Ackley and Gall's findings incorporate other elements as components of problem solving. Nevertheless, three-quarters of mentors in this research had not provided problem-solving strategies for their mentees. This implies that mentoring for these preservice teachers may comprise of a "sink or swim" approach.

Further research questions: What types of collaborative problem solving for primary science teaching are mentors and mentees involved in? How may mentors effectively provide problem-solving strategies for science teaching within a short professional experience program?

Discusses Questioning Skills Needed for Teaching Science

Questioning techniques may be used to develop science understandings (Skamp, 1998), particularly probing questions that aim to clarify understandings and challenge students' thinking (Henriques, 1997). Fraser (1988) claims that achieving successful and exemplary primary science classes requires the formulation and testing of predictions through astute teacher questioning. The mentor's role is linked to developing questioning skills in an effort to enhance the mentee's instructional effectiveness (Feiman-Nemser and Parker, 1992).

Less than one-third of mentors in this research discussed questioning skills needed for teaching primary science (Table I). This means that over two-thirds of mentees may reduce their instructional effectiveness if they have not developed these skills. In addition, students' clarification of science understandings and providing challenges for students' thinking may be lacking if mentees have not utilized effective questioning techniques.

Further research questions: What are the reasons for mentors not providing mentoring in questioning skills for teaching science? What essential questioning skills for science teaching should a mentor know? What questioning skills in primary science teaching are taught at the university that need to be reinforced with mentors in schools?

Discusses Knowledge for Teaching Science

Content knowledge is a key issue in teacher education (Abu Bakar and Tarmizi, 1995; Feiman-Nemser and Parker, 1990; Ganser, 1996; Lenton and Turner, 1999; Patriarca and Kragt, 1986), yet despite the paramount importance placed on gaining content knowledge (Dennick and Joyes, 1994), primary science teaching mentors are likely to see their role as one of analyzing and debriefing lessons and are less likely to provide content knowledge (Bishop and Denley, 1997). Learning subject matter is important for the mentee in order to build a content knowledge repertoire (Huberman, 1995). Although generally impracticable as there may be insufficient expert mentors for primary science, Kennedy (1992) advocates that mentors should be selected on their content knowledge, because if mentors struggle with science knowledge then their mentees are likely to have problems (Jarvis *et al.*, 2001). However, mentors are well positioned to enable mentees to "deal with the realities of classrooms and have the knowledge and skills dictated by the nature of children in these classroom" (Roth, 1994, p. 266 cited in Long, 1995).

Mentors may be well positioned to present content knowledge about teaching primary science: however about two-thirds of the mentors in this research had not discussed the knowledge for teaching science with their mentees (see Table I). Building a science content repertoire requires time and effort, which needs to occur as part of teacher education in readiness for mentees first years of teaching. As there appears to be insufficient mentors who articulate the knowledge for teaching primary science, selecting mentors on their science content knowledge may limit the number of mentees able to be involved in professional experiences. Therefore, mentors will need further education on the knowledge required for science teaching.

Further research questions: What are the reasons for mentors not discussing the content knowledge for teaching primary science with their mentees? What content knowledge does a mentee require for teaching science? What is the pool of mentors available for mentoring in primary science teaching, and what is the expertise of these mentors? Does the lack of content knowledge for teaching primary science contribute to teachers leaving the profession early in their careers?

Outlines Assessments for Students' Science Learning

Studies (e.g., Gilbert and Qualter, 1996) and syllabi (e.g., NSW Board of Studies, 1993) emphasize the importance of assessment for teaching and learning activities within the science curriculum. Indisputably, conducting an assessment of students' learning is addressing a system requirement (Bybee and Champagne, 1995; Corcoran and Andrew, 1988; Kahle, 1999), as this process aids the teacher for further planning (NSW Board of Studies, 1993). A mentor with knowledge of assessment methods for teaching can assist the mentee to sequentially and purposefully plan teaching experiences for students (Corcoran and Andrew, 1988). Mentors need to help mentees "use and respond to a variety of appropriately designed assessments at the beginning of new science topics as well as throughout the teaching process" (Jarvis *et al.*, 2001, p. 10).

Less than one-third of mentors had outlined assessment procedures for students' learning of primary science (Table I). Without adequate knowledge of conducting assessments, mentees will not be able to plan to cater sufficiently for the students' needs; yet more than two-thirds of mentors had omitted this as a pedagogical knowledge practice. This means that mentees may not understand the practical applications of assessments, and that assessment needs to occur at various stages within a unit of work.

Further research questions: When and how should mentors provide assessment strategies to mentees? What assessment strategies are currently being advocated by science educators for mentoring in primary science education? What are the most effective assessment strategies being used by primary science teachers and how can these be incorporated in mentoring programs?

Provides Viewpoints on Teaching Science

Viewpoints for teaching science differ from mentor to mentor and it is argued in this research that mentors need to provide their opinions on effective ways to teach science. For example, the process skills approach to teaching science emphasizes the scientific method and adopts the view that "science is about discovering the truth" (Fleer and Hardy, 1996, p. 69). However, a transmission approach places emphasis on the science knowledge to be learnt (Fleer and Hardy, 1996). A discovery approach aims at "providing a rich 'hands-on' environment" (Fleer and Hardy, 1996, p. 93), and a constructivist approach scaffolds learning from prior knowledge and experiences (Crotty, 1998; Skamp, 1998). These approaches are "primarily about achieving conceptual change in children" (Fleer and Hardy, 1996, p. 118). It is therefore argued that mentor's viewpoints are an integral element of the mentoring process.

Time is a factor for mentors; however articulating viewpoints on teaching primary science may provide a fuller understanding for mentees on the science teaching possibilities. Viewpoints may aim at achieving change yet nearly two-thirds of mentors had not provided viewpoints on science teaching (Table I). Reasons for this may include insufficient time, and/or lack of knowledge of science teaching viewpoints. There may also be some confusion as to what are the current viewpoints for teaching science possibly because of the differing views between educators themselves. Nevertheless, a mentor has significant influence on a mentee's practices and so the mentor's opinions can affect the mentee's teaching of primary science.

Further research questions: What are mentors' viewpoints for teaching primary science? How and when do mentors provide viewpoints on science teaching? What are the primary science education reform viewpoints and how can these be incorporated into the mentoring process? To what degree do mentors' viewpoints for teaching science complement current primary science reform views?

SUMMARY AND CONCLUSION

In general, mentees in this study indicated that they had not received adequate pedagogical knowledge from their mentors. This research argues that mentors require pedagogical knowledge of primary science for guiding the mentee with planning, timetabling, preparation, implementation, classroom management strategies, teaching strategies, science teaching knowledge, questioning skills, problem-solving strategies, and assessment techniques. A mentor would be able to assist the mentee to improve primary science teaching practices by focusing on these aspects. Expressing various viewpoints on teaching primary science may also assist the mentee to formulate a pedagogical philosophy for teaching science.

Having the confidence to teach primary science effectively requires the mentee to have pedagogical knowledge of primary science, which appears to be based on teaching beliefs, that is beliefs about how and what to teach in primary science. Enochs *et al.*, (1995, p. 73) emphasize the importance of developing self-efficacy "among preservice elementary teachers for teaching science," and highlight the need for well-planned and modelled science lessons and for opportunities to teach primary science successfully. This means that the mentor must be able to guide the mentee's development of pedagogical knowledge toward instilling confidence in the montee for teaching primary science. It is also argued in this study that more effective mentoring may occur if a mentor is knowledgeable on how and what to mentor in primary science teaching. Effective mentoring may influence a mentee's primary science teaching beliefs and, consequently, develop the mentee's self-efficacy in primary science teaching practices. In addition, equipping a mentor with specific pedagogical knowledge for mentoring in primary science teaching may reduce the number of potential concerns or problems experienced by mentees. Undoubtedly, mentors will require further professional development to ensure that mentees receive adequate pedagogical knowledge for primary science teaching, which will involve significantly more collaboration between universities and schools.

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