COVER SHEET

This is the author version of article published as:

Hudson, Peter B. and Skamp, Keith and Brooks, Lyndon (2005) Development of an instrument: Mentoring for effective primary science teaching (MEPST). *Science Education* 89(4):pp. 657-674.

Development of an Instrument: Mentoring for Effective Primary Science Teaching (MEPST)

Peter Hudson[1], Keith Skamp[2], & Lyndon Brooks[2]

Queensland University of Technology[1], Southern Cross University[2]

Abstract: Perceptions of mentors' practices related to primary science teaching from nine Australian universities (*n*=331 final year preservice teachers) were gathered through a literature-based instrument. Five factors that characterise effective mentoring practices in primary science teaching were supported by confirmatory factory analysis. These factors, namely, personal attributes, system requirements, pedagogical knowledge, modelling, and feedback had Cronbach alpha coefficients of internal consistency reliability of .93, .76, .94, .95, and .92 respectively. Final model fit indices were χ^2=1335, df=513, CMIDF=2.60, IFI=.922, CFI=.921, RMR=.066, RMSEA=.070 (p<.001). Specific mentoring interventions for improving primary science teaching practices may be implemented by measuring preservice teachers' perceptions of their mentoring with a valid and reliable instrument.

Introduction and Literature Review

"*Science for all* is a key goal of contemporary reform in science education" (Gallagher, 2000, p. 509). Science for all aims at increasing scientific literacy, as scientific literacy has implications for economic gain and for empowering citizens (Jenkins, 1990). Up-to-date and capable science teachers, and this includes the primary school level, are at the forefront of ensuring a scientifically literate public. Yet, the quality of science education has proved disappointing and still requires further major reform efforts (Willis, 1995), especially as many teachers' practices in primary science have not changed (Bybee, 1993; Goodrum, Hackling, & Rennie, 2001). To achieve the goal "science for all" requires a focus on the science needs of teachers that must commence at the primary level (e.g., Ratcliffe, 1998), and so educators must seek new angles for reform. Preservice teachers *are* very interested in practical primary science opportunities and theories of learning (Meadows, 1994), and so must be targeted as key instigators of implementing reform in primary science teaching.

Mentoring as a Way Forward

Delivering and implementing effective programs for creating change requires collaborative processes. Briscoe and Peters (1997, p. 63) conclude, "collaboration was not only essential, but very desirable to support the change process, to lessen the fear of risk taking, and to provide a forum for analysis of what works and what does not." Mentoring is a collaborative process that can be used to guide improvement in primary science teaching practices, which requires the preservice teacher and the mentoring teacher to have active and productive roles. Teachers, in their collaborative roles as mentors, are an essential component for developing preservice teachers' practices in primary science. This acknowledges the assertion that primary "teachers, whether or not they have a specialized background in science, hold the key to understanding how science is presently working in schools" (Lunn & Solomon, 2000, p. 1043). Hence, realistic and comprehensive reform processes must incorporate both preservice teachers and teacher-mentors within school settings. Professional experience programs (i.e., field experiences or practicum) with preservice teachers implementing pedagogical practices provide the context for mentoring to occur.

There is extensive research into professional school experiences for preservice teachers, as it is recognised as a vital component for improving teaching practices (Gaffey, Woodward, & Lowe, 1995; Jasman, 2002; Power, Clarke, & Hine, 2002). Mentoring in such programs provides "improvement in what happens in the classroom and school, and better articulation and justification of the quality of educational practices" (Van Thielen, 1992, p. 16). Sinclair (1997) explains how preservice teacher education has become more school-based, which has increased the responsibilities assigned to mentors. The mentors organise for the preservice teachers' professional development, "advising on effective practices, making the theory-practice link overt, and evaluating and reporting upon their practicum performance" (p. 309). This would then require mentors to be involved in developing more effective practices, particularly if reform measures are to infiltrate a whole system. In reforming science education, the problem exists that, as there are insufficiently skilled primary science teachers, there will be insufficiently skilled mentors for primary science teaching.

Many studies have researched aspects of generic (non subject-specific) mentoring of preservice and novice teachers (e.g., Ganser, 1996; Little, 1990; Manthei, 1992) and these studies have suggested, among other findings, the attributes of effective mentors as perceived by the key players. Even so, there were very few in-depth studies of generic mentoring (Little, 1990). This is still the case for mentoring studies related to the teaching of specific subjects at the primary level (e.g., Peterson & William [1998] in mathematics, and Hodge [1997] in physical education). Moreover, the in-school context has been argued to be pivotal to the development of preservice teachers as teaching professionals, and this has been argued specifically for primary science (Anderson & Mitchener, 1995; Mulholland, 1999; Skamp & Mueller, 2001a,b).

Effective teaching is at the heart of effective learning, and it is believed that unique mentoring processes are required for effective teaching in specific subject areas (Peterson & Williams, 1998), which is the assumption that underpins this research on mentoring preservice teachers for effective primary science teaching. There are reports (Coates, Vause, Jarvis, & McKeon, 1998; Jarvis, McKeon, Coates, & Vause, 2001) that have investigated mentoring for more effective primary science teaching. Still, comprehensive analysis and verification of factors that may contribute to specific mentoring in primary science teaching are yet to be identified and validated.

Attributes and Practices of Effective Mentors of Primary Science

A review of the literature suggests that there are five key factors underpinning effective mentoring in primary science teaching. The five factors are: personal attributes, system requirements, pedagogical knowledge, modelling, and feedback. Each factor has associated mentoring attributes and practices that may aid preservice teachers' development of effective primary science teaching and will be discussed in the following as a means for developing items on an instrument that measures mentees' perceptions of their mentoring in primary science teaching.

Personal attributes.

Learning takes place within the social context (Kerka, 1997), and in a profession that has a focus on social interaction, interpersonal skills are seen as a basic requirement for effective performance as a teacher (Bybee, 1978; Loucks-Horsely, Hewson, Love, & Stiles, 1998) and, therefore, the mentor's personal attributes are essential for mentoring preservice teachers (Ackley & Gall, 1992; Ganser, 1996). Mentoring involves complex personal interactions "conducted under different circumstances in different schools" (Wildman, Magliaro, Niles, & Niles, 1992), and so a mentor must be prepared to shape, through holistic immersion, a mentee's personal skills in teaching science in a two-way communication (Dynak, 1997; Rosaen & Lindquist, 1992). More specifically, the mentor needs to be supportive and attentive to the mentee's communication (Ackley & Gall, 1992; Kennedy & Dorman, 2002). The mentor must also assist the mentee to reflect on specific teaching practices (Abell & Bryan, 1999; Upson, Koballa, & Gerber, 2002). Finally, instilling positive attitudes (Feiman-Nemser & Parker, 1992; Matters, 1994) and confidence (Beck, Czerniak, & Lumpe, 2000; Enochs, Scharmann, & Riggs, 1995) for teaching science appears reliant upon the mentor's personal approach.

System requirements.

Teaching frameworks must emanate from a common source if primary science teaching is to be collectively uniform and aim towards the "science for all" theme. Bybee (1997) discusses the need to have systemic reform, which must stem from a central system. Indeed, without including system requirements as a key factor, the argument for systemic reform and the development of primary science syllabuses would be pointless. System requirements for primary science education provide a direction for teaching (Lenton & Turner, 1999; Peterson & Williams, 1998), and present a framework for regulating the quality of primary science teaching practices. This requires mentors to provide for their mentees clear and obtainable goals (Abu Bakar & Tarmizi, 1995; Harlen, 1999), relevant school policies (Luna & Cullen, 1995; Riggs & Sandlin, 2002), and most importantly the science curriculum (Bybee, 1997; Jarvis et al., 2001; Woolnough, 1994) in order to present the fundamental requirements of an education system.

Pedagogical knowledge.

Educators (Kesselheim, 1998; Odell, 1989) agree that mentoring programs are intended to allow preservice teachers to interact with someone more skilful and knowledgeable. Research (e.g., Abell & Lynn, 1999; Bishop & Denley, 1997; Bybee, 1978; Dennick & Joyes, 1994) has also shown that developing effective primary science teaching requires the acquisition of particular knowledge. 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. Shulman presented a limited view of the term "pedagogical knowledge" as a "concern for reinstating content as a critical facet of teacher knowledge" (Morine-Dershimer & Kent, 1999, p. 21). Instead, he coined the term "pedagogical content knowledge", as a way of "representing and formulating the subject that makes it comprehensible for others" (Shulman, 1986, p. 9). However, the general term *pedagogical knowledge* is frequently used when referring to the knowledge for teaching primary science (e.g., Briscoe & Peters, 1997; Coates et al., 1998). Pedagogical knowledge makes "understanding of science usable in the classroom" (Mulholland, 1999, p. 26). Such pedagogical knowledge, which is developed within the school setting (Allsop & Benson, 1996; Hulshof & Verloop, 1994), is essential for supporting effective primary science teaching (Roth, 1998).

Preservice teachers who are engaged in reforming primary science education need mentors to have pedagogical knowledge to guide their practices (Kesselheim, 1998). Specifically, mentors need to provide the pedagogical knowledge for: planning for teaching (Gonzales & Sosa, 1993; Jarvis et al., 2001); timetabling lessons (Burton, 1990; Williams, 1993); teaching strategies (Lappan & Briars, 1995; Tobin & Fraser, 1990); preparation for teaching (Rosaen & Lindquist, 1992; Williams, 1993); problem solving (Ackley & Gall, 1992; Breeding & Whitworth, 1999); classroom management (Corcoran & Andrew, 1988; Feiman-Nemser & Parker, 1992); questioning skills (Fleer & Hardy, 1996; Henriques, 1997); implementing effective teaching practice (Beck et al., 2000; Briscoe & Peters, 1997); and assessment (Corcoran & 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 & Hardy, 1996) and appropriate content knowledge (Jarvis et al., 2001; Lenton & Turner, 1999).

Modelling.

Mentors are defined as experts who model practice (Barab & Hay, 2001; Galvez-Hjoernevik, 1986); also it is argued that the skills for teaching are learned more effectively through modelling (Bellm, Whitebook, & Hnatiuk, 1997; Carlson & Gooden, 1999). Preservice teachers view the mentor as a model to develop a greater understanding of their own strengths and weaknesses (Moran, 1990); additionally self-efficacy for teaching can be enhanced by observing the modelling of practice (Bandura, 1981). Enochs et al (1995) 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. Apart from displaying enthusiasm for teaching (Feiman-Nemser & Parker, 1992; Van Ast, 2002), mentors need to model: a rapport with their students (Krasnow, 1993; Ramirez-Smith, 1997); lesson planning (Ball & Feiman-Nemser, 1988; Fraser, 1988); syllabus language (Jarvis et al., 2001; Williams & McBride, 1989); hands-on lessons (Asunta, 1997; Raizen & Michelson, 1994); and classroom management (Gonzales & Sosa, 1993; Smith & Huling-Austin, 1986). In particular is the distinction drawn between modelling teaching practices (Enochs et al., 1995; Little, l990) so that mentees may observe what works and what does not, and modelling *effective* teaching practices (Monk & Dillon, 1995), which demonstrate high levels of teaching competency.

Feedback.

Finally, numerous researchers (e.g., Bishop, 2001; Little, 1990; Riordan, 1995; Haney, 1997; Bellm et al., 1997; Bishop & Denley, 1997) have reported that constructive feedback in preservice teacher education is a vital ingredient in the mentoring process. Feedback allows for the preservice teacher of primary science to reflect and improve teaching practice, in what Schon (1987, p. 157) calls the “reflective practicum”. Specifically, mentors need to observe practice in order to provide oral and written feedback on aspects associated with the mentor’s pedagogical knowledge (Ganser, 1995; Rosaen & Lindquist, 1992), which also includes reviewing plans (Monk & Dillon, 1995), and assisting in developing the mentee’s evaluation of teaching (Long, 1995). Linked to the provision of feedback is the mentor’s articulation of expectations (Klug & Salzman, 1990; Koki, 1997).

The picture that emerges from the literature are five key areas for effective mentoring in primary science, namely, personal attributes that the mentor needs to exhibit for constructive dialogue, system requirements that focus on curriculum directives, competent pedagogical knowledge for articulating best practices, modelling of specific teaching practices, and feedback for the purposes of reflection to improve teaching performance. It could also be argued that these five areas are generic mentoring factors. However, for developing the Mentoring for Effective Primary Science Teaching (MEPST) instrument, specific primary science related items were linked to each of these five factors and the associated attributes and practices.

Purpose of this Study

Mentoring is occurring within professional experience programs. However, research is needed to determine the quality and degree of specific mentoring of primary science teaching. The purpose of this study is to develop an instrument that measures mentees' perceptions in their mentoring in primary science teaching. This instrument is not intended to show the level of expertise a preservice teacher has reached in teaching primary science; instead it aims to show the mentoring preservice teachers perceive they have received in the field of primary science teaching and those they have not. The development of this instrument arises from the need to identify current mentoring practices as mentoring is considered a key for developing primary science teaching practices. Such an instrument may provide information towards developing more effective mentoring practices in primary science teaching by identifying areas of need. Furthermore, professional experience programs may be assessed through the instrument in terms of specific mentoring practices, which may then lead to professional development for mentors so as to enhance preservice teachers' professional experiences, and ultimately, the quality of primary science teaching.

Two research aims guided this study, namely to:

1. explore and identify factors and associated variables for mentoring preservice teachers of primary science; and
2. develop an instrument to measure mentees' perceptions of their mentoring in primary science teaching.

Data Collection Methods and Analysis

An instrument to determine mentees' perceptions of their mentoring experiences when teaching primary science has been developed using the above research related to mentoring. Current thinking in science education, preliminary investigations, and pilot tests were also used in the development of the MEPST instrument. On these bases and literature on confirmatory factor analysis (Hair, Anderson, Tatham, & Black, 1995; Kline, 1998; Stevens, 1996) a five-factor model was hypothesised. Moreover, the literature and experience suggests that the five factors would be correlated and that mentoring for effective primary science teaching would be less effective if one of these key factors was absent.

Developing the MEPST Instrument

The MEPST instrument in this study evolved through preliminary investigations and pilot tests on mentoring for effective primary science teaching. Steps for developing and validating the instrument included small-scale interviews with mentors and mentees (*n*=10) on their perceptions of mentoring preservice primary science teaching at the conclusion of a three-week professional experience. Development of the instrument, based on the literature and previously discussed interviews, was pilot tested on 21 first-year preservice teachers (Hudson, 2003) and later with 59 final year preservice teachers (Hudson & Skamp, 2003) at the conclusion of their professional experiences. Analysis of data from these pilot tests guided the refining of the instrument. This refined instrument was then administered to 331 final year preservice teachers.

For each of the aforementioned five factors or latent variables, multiple indicators that reflected the findings from the reviewed literature were hypothesised to be associated with each factor. The indicators, which were items on the MEPST survey to determine mentees' perceptions of their mentoring experiences for teaching primary science, represented the mentor characteristics considered to be associated with each factor. The 45 survey items used a Likert scale for response categories, namely, Strongly disagree, Disagree, Uncertain, Agree, Strongly agree (see Appendix 1). Scoring was accomplished by assigning a score of one to items receiving a "Strongly disagree" response, a score of two to "Disagree" and so on through the five response categories. The content of each item had to include a statement that: (1) contained a literature-based mentoring skill or practice or behaviour that could be recognised in a word or phrase; and (2) allowed a complete response to the item within the 5-point scale. To further substantiate the instrument's validity, five specialists (one in the field of science education, one in the field of mentoring, one in the field of survey construction, and two statistical analysts) examined the items on this survey. Some items were adjusted for syntax, discourse, and lexical cohesion.

In the initial MEPST instrument, the underlying hypothesised model assumed that each of the five latent variables would directly contribute to the responses to those indicators with which each factor was associated. The five factors are hypothesised to covary with each other. The initial hypothesised model in Table 1 was analysed using the Structural Equation Modelling (SEM) technique, confirmatory factor analysis (CFA), which is a model fitting approach. It assumes a strong theoretical and empirical base, that the number of factors (latent variables) can be fixed a priori, and that variables (indicators) are predetermined to load on a specific factor or factors (Stevens, 1996). CFA assumes that all the latent variables covary with one another (Kline, 1998; Stevens, 1996). These assumptions are consistent with the MEPST hypotheses advanced earlier. CFA can test the hypothesised underlying factor structure, which includes an evaluation of the construct validity, i.e., whether the indicators actually measure the hypothesised latent variables (Kline, 1998; Stevens, 1996). AMOS conducted the structural equation modelling (CFA) analysis, while SPSS10 provided the general statistical analysis for the three models shown in Table 1.

(Insert Table 1 about here)

Various assumptions need to be met in order to interpret the CFA with more confidence (Tabachnick & Fidell, 1996). The sample size should preferably exceed 200 especially where there is increased model complexity, and a ratio of 10:1 for the number of subjects to the number of parameters is considered acceptable (Kline, 1998). In this study the ratio of participants to parameters was approximately 9:1. Standard errors of skewness and kurtosis were both less than ± 2 (Piovanelli, 2000), and for the final model (see Figure 1) skewness ranged from 0.013 to 0.797 and kurtosis ranged from 0.061 to 1.354; hence, sampling distributions may be within acceptable ranges. The scales of the variables were all the same (Tabachnick & Fidell, 1996). Other assumptions include independent observations, and the linearity of all relationships (Hair et al., 1995).

(Insert Figure 1 about here)

Establishing Fit Measures and Indices for CFA

It is recommended (Hair et al., 1995) that SEM research employs at least one fit measure from each of the three types of goodness of fit measures (i.e., absolute, incremental, and parsimonious). The likelihood-ratio Chi-square index is a basic absolute fit measure (Hair et al., 1995), and the chi-square to degrees of freedom ratio (CMIDF or χ^2/df) can also function as an absolute fit measure with measures less than 3 as acceptable (see Kline, 1998). AMOS provides an Incremental Fit Index (IFI), with values closer to 1 indicating a better fitting model, and a Comparative Fit Index (CFI), which "may be less affected by sample size" compared to some other incremental fit indexes (Kline, 1998), indicating the percentage of fit better than the null hypothesis. Favourable values of the Root Mean Square Residual (RMR), which is based on the standardised covariance residuals, need to be less than .10 (Kline, 1998). Root Mean Square Error of Approximation (RMSEA) is another fit measure with an acceptable range of .08 or less (Hair et al., 1995).

Results

The initial MEPST survey was distributed to 14 Australian universities and nine replied. The 331 complete responses (284 female; 47 male) received from the nine universities represented a response rate of 58%. The following are key descriptors of the participants (*n*=331) and their mentors.

Fifty-six percent of the preservice teachers entered teacher education straight from high school, with 52% completing biology units at school. Thirty-six percent of students had completed only one science methodology unit at university, while 64% had completed more than one such unit at a tertiary level. All students had completed at least three block practicums with 28% completing five practicums. There were no practicums under a three-week duration, and 66% were of a five-week duration or more. Only 12% of these practicums were in “small” schools (<160 students), which would have more to do with the location of the university. Although 49% of respondents were required to teach science during practicum as part of their university obligations, 85% of students taught science during their practicum. However, the number of science lessons taught by mentees during their practicum varied considerably (11% taught one lesson; 6% two lessons; 22% three or four lessons; 38% six lessons or more; and 15% did not teach science at all).

Mentors also varied in their background and behaviours. Most mentors were over 40 years old, although 17% were under 30 years of age. Mentees indicated that 27% of mentors did not have an “interest” or a “strong interest” in science. Forty percent of mentors did not model a science lesson during their mentees’ practicum experiences, which may equate to the 40% of mentees who considered science not “a strength” of the mentors. Eleven percent of mentors did not talk about science during the total practicum, and 45% of mentors spoke to their mentees about primary science teaching a maximum of three times during their last practicum.

In this study, CFA was estimated by assigning items to factors for analysing and assessing four models, including a null hypothesis model. The measurement models met the requirements for identification in that they had less parameters (*n*=100) than observations (*n*=1035), each latent variable had a scale (where one indicator per factor is fixed to equal 1), and there were two or more indicators per factor (Kline, 1998).

Model respecifications were necessary to determine the most statistically relevant variables assigned to each factor (see Hair et al., 1995). The hypothesised model, the respecified model, and the final model, with the observed variables under each of the five factors, are presented in Table 1 (also refer to Appendix 1, which indicates the number of each item in the initial instrument).

The independence model and the initial model.

The independence model, which tests the null hypothesis that all observed variables are uncorrelated, was easily rejected (i.e., χ^2=11966, df=527, CMIDF=22.7, IFI & CFI=.000, RMR=.883, RMSEA=.237, Table 2). The initial hypothesised model proposed that the five factors covary and are associated with each indicated item (Table 1). However, respecifications were necessary to improve the initial hypothesised model χ^2=3078, df=935, CMIDF=3.29, IFI=.842, CFI=.841, RMR=.097, RMSEA=.083, Table 2).

(Insert Table 2 about here)

The respecified model.

Respecifications aim to develop a better fitting model (Tabachnick & Fidell, 1996; Hair et al. 1995). Further analysis of the SEM statistics, combined with additional reflections on the relationship between the latent variables and the meaning of each item on the survey, provided insights towards respecifications. The following discussion relates to the items on the initial hypothesised survey, where for example “support43” refers to the forty-third item on the survey “was supportive of me for teaching science”.

In the initial model, the item “content1” appeared to be duplicated through the combination of some pedagogical knowledge items (e.g. “knowledge22”, “strategies21”). It was also considered that “confidence4” was duplicated to some degree in “confidence39”, and “encourage9” was duplicated by items “support43” and “enthuse15”. Consequently, in the first respecified model the items “content1”, “confidence4”, and “encourage9” were dropped. Other items were dropped because they had squared multiple correlations of less than .50 (“programs2” [.449], “coping6” [.474], “assign26” [.131], “approachable27” [.226], “teachoften37” [.227], “flexible40” [.416]; Kline, 1998).

AMOS has analysed the data as a five-factor model; however, “System Requirements” had two items (“policy10” & “curriculum14”) with square multiple correlations of less than .50 that were retained, as “System Requirements” is theoretically integral to the model (see fit indices in Table 3), and each latent variable requires at least two indicators (see Kline, 1998, p. 190). Similarly, “assessment44” was less than the .5 rule of thumb but was also retained on theoretical grounds (e.g., Corcoran & Andrew, 1988; Jarvis et al., 2001; Van Ast, 2002). Further reflection and analysis of data provided justification for relocating one variable, “articulate45”, initially considered to be pedagogical knowledge but was more characteristic of providing effective feedback, (e.g., Berliner, 1986); therefore it was removed from pedagogical knowledge and assigned to feedback. Variables were initially hypothesised not to correlate; nevertheless AMOS indicated that it was appropriate to correlate four pairs of item residual variances (i.e., “teaching11” & “manage class18”; “planning13” & “implementation14”; “observation20” & “oral23”; “attentive42” & “supportive43”; $p<.001$, standard errors [SE] range: .030 to .048). These respecifications improved the model (Table 2 “Respecified model”), particularly the Incremental Fit Index (IFI=.900) and the Comparative Fix Index (CFI=.909).

(Insert Table 3 about here)

The final model.

In the final analysis of the results and the intended meaning of each survey item, two more reassignments to the “respecified model” were applied to complete the final model: one item, “implementation14” (which aligned more with a mentor’s practical knowledge of implementing teaching) was removed from the modelling factor and assigned to pedagogical knowledge; and, another item, “reflect3” (which appeared more characteristic of a mentor’s personal attributes and ability to encourage reflection on practice) was removed from feedback and assigned to personal attributes (Table 1). After respecifying the two items, better goodness of fit indexes and a lower CMIDF were indicated (i.e., χ^2=1335, df=513, CMIDF=2.60, IFI=.922, CFI=.921, RMR=.066, RMSEA=.070, p<.001, see Table 2).

In the final model, Cronbach alphas for each key factor, namely, personal attributes (mean score=2.86, sd=1.08), system requirements (mean=3.44, sd=0.93), pedagogical knowledge (mean=3.24, sd=1.01), modelling (mean=2.91, sd=1.07), and feedback (mean=2.86, sd=1.11) were .93, .76, .94, .95, and .92, respectively. Correlations and covariances of the five factors were substantial and significant (p<.001, Table 3). Regression weights, which provide an indication of the relative contribution each variable makes to the specified factor (Agresti & Finlay, 1997), were significant (range: 0.80 to 1.13). Standardised regression weights ranged from .67 to .89, and all standard errors, which is a measure of how much the value of a test statistic varies from sample to sample, were minimal for all items (≤1, Table 4). The final model is illustrated in Figure 1, where circles represent the five latent variables (factors), and rectangles represent the measured variables (indicators).

(Insert Table 4 about here)

Discussion and Conclusions

The MEPST instrument producing five factors was developed through an extensive literature search on mentoring and science education, critiques by experts in the field, and a study of 331 final year preservice primary teachers from nearly half the universities involved in primary teacher education in Australia. Although confirmatory factor analysis supported the reliability and partial validation of the initial instrument, the model required respecification of particular items. The main finding of this study was the formulation of a five-factor model for determining effective mentoring of primary science teaching. This resulted in the development of an instrument (MEPST) for determining mentees' perceptions of mentoring practices in primary science teaching, in which there were highly significant correlations between the five factors and associated variables.

The five factors and the associated attributes and practices were derived from the literature and comprise an integrated system. Cronbach alphas, mean scores, correlations, and covariances all indicated acceptable levels for the final model.

Factor 1: Personal attributes.

Mentors' personal attributes play a significant role in the mentoring process. Attributes to instil positive attitudes and confidence for teaching primary science and to assist mentees to reflect on their primary science teaching practices require mentors to be affable, attentive, and supportive.

Factor 2: System requirements.

Most education systems have curriculum requirements for each school subject, including primary science. The primary science curriculum, its aims, and the related school policies for implementing system requirements are fundamental to any educational system. They provide uniformity and direction for implementing primary science education. Mentors need to be familiar with the content of current system primary science curricula and how it can be implemented in the school.

Factor 3: Pedagogical knowledge.

The mentor's pedagogical knowledge of primary science is required 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. It is implied that the mentor would be able to assist the mentee to improve science teaching practices because of a focus on these aspects. Expressing various viewpoints on teaching primary science may also assist the mentee to formulate a pedagogical philosophy of science teaching.

Factor 4: Modelling.

The mentor must model planning and teaching primary science (consistent with current system requirements). This will require mentors to have enthusiasm for science, and not only modelling the teaching of science, but also teaching it effectively with well-designed hands-on lessons that display classroom management strategies and exemplify a rapport with students. The discourse used by the mentor when modelling science teaching needs to be consistent with the current syllabus.

Factor 5: Feedback.

Mentors need to review the mentee's primary science lesson plans and programs. Observing the mentee's primary science teaching provides content for the mentor to express oral and written feedback on the mentee's science teaching. The mentor must show the mentee how to evaluate primary science teaching, so that the mentee can more readily reflect upon practice as a step towards improving practice.

There is considerable weight placed on the interactions occurring between mentors and mentees for developing knowledge and skills in any particular field. The idea that a planned, well-structured mentoring program for teaching primary science may have a positive effect on primary science education reform is not only well worth exploring but must be a consideration for developing more effective primary science teaching. Identifying current mentoring practices in primary science teaching provides information for developing more effective mentoring practices. Professional experience programs in primary science teaching may be assessed through this instrument in terms of specific mentoring, which can provide the basis for professional development for mentors. This instrument can also provide educators with information for designing specific mentoring strategies for mentors to use towards improving their mentees' teaching. If science education reform is to succeed, mentors will need to be involved in the process with stronger and more specific focuses on mentoring preservice teachers in teaching science.

Further research.

The MEPST instrument, which may be used to evaluate mentoring strategies developed for mentors of preservice primary science teachers, may also be used as a tool for measuring the success of such mentoring programs. In addition, the application of the MEPST instrument may be applied with existing practitioners who require further professional development in primary science teaching; for example, it may be possible for primary science consultants, principals, or primary science experts within the school settings to act as mentors for developing teachers in the area of primary science and, by using this instrument, gather data to assist towards improving the quality of this mentoring. There is a further possibility for the MEPST instrument to be adapted for studying mentoring for effective secondary science teaching. It is hoped that through further studies on specific mentoring experiences for the development of primary science teaching the quality of mentoring will improve, aiming towards more effective teaching in primary science and a chance for successful primary science education reform.

Postscript: Validation of the final MEPST instrument was further supported through additional application and this instrument was used to assess a mentoring intervention based on the instrument's items (see Hudson & McRobbie, 2003).

References

Abell, S. K., & Bryan, L. A. (1999). Development of professional knowledge in learning to teach elementary science. *Journal of Research in Science Teaching, 36*(2), 121-139.

Abu Bakar, K., & Tarmizi, R. (1995, January). *Teacher preparation concerns: Professional needs of Malaysian secondary science teachers.* Paper presented at the annual meeting of the Association for the Education of teachers in Science. Charleston, WV.

Ackley, B., & Gall, M. (1992). *Skills, strategies and outcomes of successful mentor teachers.* Paper presented at the Annual Meeting of the American Educational Research Association. San Francisco, CA. ERIC ED 346 046.

Agresti, A., & Finlay, B. (1997). *Statistical methods for the social sciences.* New Jersey: Prentice-Hall.

Allsop, T., & Benson, A. (Eds.). (1996). *Mentoring for science teachers.* Bristol, PA: Open University Press.

Anderson, R., & Mitchener, C. (1995). Research on science teacher education. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 3-44). New York: MacMillan.

Bandura, A. (1981). Self referent thought: A development analysis of self-efficacy. In J. H. Flavell & L. Ross (Eds.), *Social cognitive development frontiers and possible futures* (pp. 200-239). Cambridge, MA: Cambridge University Press.

Barab, S. A., & Hay, K. E. (2001). Doing science at the elbows of experts: Issues related to the science apprenticeship camp. J*ournal of Research in Science Teaching, 38*(1), 70-102.

Beck, J., Czerniak, C. M., & Lumpe, A. T. (2000). An exploratory study of teachers' beliefs regarding the implementation of constructivism in their classrooms. *Journal of Science Teacher Education, 11*(4), 323-343.

Bellm, D., Whitebook, M., & Hnatiuk, P. (1997). *The early childhood mentoring curriculum: Trainer's guide.* Washington, DC: National Center for the Early Childhood Work Force.

Berliner, D. C. (1986). In pursuit of the expert pedagogue. *Educational Researcher, 15*(7), 5-13.

Bishop, C. (2001). *Case-based learning and the construction of professional practical knowledge in teacher education.* Ed. D dissertation, Sydney, Faculty of Education, University of Sydney.

Bishop, K., & Denley, P. (1997). The fundamental role of subject matter knowledge in the teaching of science. *School Science Review, 79*(286), 65-71.

Briscoe, C., & Peters, J. (1997). Teacher collaboration across and within schools: Supporting individual change in elementary science teaching. *Science Teacher Education, 81*(1), 51-64.

Burton, L. (1990). *Gender and mathematics: An international perspective*. London: Cassell Educational.

Bybee, R. W. (1978). Science educators' perceptions of the ideal science teacher. *School Science and Mathematics, 78*(1), 13-22.

Bybee, R. W. (1993). Reforming science education: Social perspectives and personal reflections. New York: Teachers College Press.

Bybee, R. W. (1997). *Achieving scientific literacy.* Portsmouth, NH: Heinemann.

Carlson, R. D., & Gooden, J. S. (1999). *Mentoring pre-Service teachers for technology skills acquisition.* Paper presented at the Society for Information Technology & Teacher Education International Conference, San Antonio, TX.

Coates, D., Vause, J., Jarvis, T., & McKeon, F. (1998). *Mentoring in Primary Science.* Leicester: SCI Centre, School of education, University of Leicester.

Corcoran, E., & Andrew, M. (1988). A full year internship: An example of school-university collaboration. *Journal of Teacher Education, 39*(3), 17-23.

Dennick, R., & Joyes, G. (1994). New science teachers' subject knowledge. *School Science Review, 76*(275), 103-108.

Dynak, J. (1997). Refining the general education student teaching experience through the use of special education collaborative teaching models. *Action in Teacher Education, 19*(1), 64-74.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 9*0(8), 694-706.

Enochs, L. G., Scharmann, L. C., & Riggs, I. M. (1995). The relationship of pupil control to preservice elementary science teacher self-efficacy and outcome expectancy. *Science Education, 79*(1), 63-75.

Feiman-Nemser, S., & Parker, M. B. (1992). *Los Angeles Mentors: Local guides or educational companions?* National Center for Research on Teacher Learning, Michigan State University, U.S., Michigan. (ERIC Document Reproduction Service No. ED350301)

Fleer, M., & Hardy, T (1996). *Science for children.* Sydney: Prentice Hall.

Gaffey, C. S., Woodward, H., & Lowe, K. (1995). Improving school experience: An Australian perspective. *Action in Teacher Education, 17*(2), 7-17.

Gallagher, J. J. (2000). Advancing our knowledge in order to achieve reform in science education. *Journal of Research in Science Teaching, 37*(6), 509-510.

Galvez-Hjornevik, C. (1986). Mentoring among teachers: A review of the literature. *Journal of Teacher Education, 37*(1), 6–11.

Ganser, T. (1996). What do mentors say about mentoring? *Journal of Staff Development, 17*(3), 36-39.

Gonzales, F., & Sosa, A. (1993). How do we keep teachers in our classrooms? *The TNT response. Idra Newsletter, 1*. ERIC ED 364 549.

Goodrum, D., Hackling, M., & Rennie, L. (2001). *The status and quality of teaching and learning in Australian schools.* Canberra: Department of Education, Training and Youth Affairs.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis with readings.* (4th Ed.). New York: Prentice-Hall.

Haney, A. (1997). The role of mentorship in the workplace. In M. C. Taylor (Ed.), *Workplace education* (pp. 211-228). Toronto: Culture Concepts.

Harlen, W. (1999). *Effective teaching of science. A review of research. Using Research Series, 21*. Edinburgh: Scottish Council for Research in Education.

Henriques, L. (1997). *Constructivist teaching and learning: A study to define and verify a model of interactive-constructive elementary school science teaching.* Unpublished Ph.D. Dissertation, University of Iowa, Iowa City, IA. Retrieved 14 June 2001, from http://www.educ.uvic.ca/depts/snsc/temporary/cnstrct.htm

Hodge, S. R. (1997). Mentoring: Perspectives of physical education graduate students from diverse cultural backgrounds. *Physical Educator*, *54*(4), 181-195.

Hudson, P. (2003, in press). Mentoring first-year preservice teachers in primary science education. *Action in Teacher Education*.

Hudson, P., & McRobbie, C. (2003, November). *Evaluating a specific mentoring intervention for preservice teachers of primary science.* Paper presented at the Australian Association of Research in Education (AARE) Conference, Auckland, NZ.

Hudson, P., & Skamp, K. (2003). Mentoring preservice teachers of primary science. *The Electronic Journal of Science Education,* *7*(1). http://unr.edu/homepage/jcannon/ejse/ejse.html

Hulshof, H., & Verloop, N. (1994). The collaborating teacher as co-educator in teacher education. *Australian Journal of Teacher Education*, *19*(2), 25-29.

Jarvis, T., McKeon, F., Coates, D., & Vause, J. (2001). Beyond generic mentoring: Helping trainee teachers to teach primary science. *Research in Science and Technological Education*, *19*(1), 5-23.

Jasman, A. (2002). *Initial teacher education: Changing curriculum, pedagogies and assessment.* Paper presented at Challenging Futures Conference, University of New England, Armidale.

Jenkins, E. (1990). Scientific literacy and school science education. *School Science Review*, *71*(256), 43-51.

Kennedy, J., & Dorman, J. (2002). *Development and validation of the extended practicum learning environment inventory.* Sydney: Australian Catholic University.

Kerka, S. (1997). *Constructivism, workplace learning and vocational education.* ERIC Digest, No.181. Columbus: ERIC Clearinghouse on Adult, Career and Vocational Education.

Kesselheim, C. (1998). *The assistance relationship between content-specialist science facilitators and their constituent teachers.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. San Diego, CA.

Kline, R. B. (1998). *Principles and practices of structural equation modeling.* New York: The Guildford Press.

Klug, B. J., & Salzman, S. A. (1990, April). *Formal induction vs. informal mentoring: Comparative effects and outcomes.* Paper presented at the annual meeting of the American Educational Research Association. Boston, MA.

Koki, S. (1997). *The role of teacher mentoring in educational reform. PREL Briefing Paper*. Honolulu, Hawaii: Pacific Resources for Education and Learning.

Krasnow, M. H. (1993, April). *Waiting for Thursday: New teachers discover teaching.* Paper presented at the annual meeting of the American Educational Research Association. Atlanta, GA.

Lappan, G., & Briars, D. (1995). How should mathematics be taught? In National Research Council. *National science education standards.* Washington, DC: National Academy Press.

Lenton, G., & Turner, G. (1999). Student-teachers' grasp of science concepts. *Journal for Science Education, 81*(295), 67-72.

Little, J. (1990). The mentor phenomenon and the social organisation of teaching. In C. Cazden (Ed.), *Review of Educational Research* (pp. 297-351). Washington, DC: American Educational Research Association.

Long, J. (1995, September). *The challenge for change. Mentoring for school based teacher education.* Paper presented at the ATEA Conference, Australian Catholic University, North Sydney.

Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Luna, G., & Cullen, D. L. (1995). Empowering the faculty: Mentoring redirected and renewed. ERIC Digest. *ERIC Clearinghouse on Higher Education*, Washington, D.C. George Washington Univ., Washington, DC: Graduate School of Education and Human Development. (ERIC Document Reproduction Service No. ED399888)

Lunn, S., & Solomon, J. (2000). Primary teachers' thinking about the English national curriculum for science: Autobiographies, warrants, and autonomy. *Journal of Research in Science Teaching, 37*(10), 1043-1056.

Manthei, J. (1992). *The mentor teacher as leader: The motives, characteristics and needs of seventy-three experienced teachers who seek a new leadership role.* Paper presented at the Annual meeting of the American Educational research Association. San Francisco, CA.

Matters, P. (1994, January). *Mentoring partnerships: Keys to leadership success for principals and managers.* Paper presented at the International Conference in Education. Melbourne University, Victoria.

Meadows, J. (1994). Science students on teaching practice. *Primary Science Review, 31*, 7-10.

Moran, S. (1990). Schools and the beginning teacher. *Phi Delta Kappan, 72*(3), 210-213.

Morine-Dershimer, G., & Kent, T. (1999). The complex nature and sources of teachers' pedagogical knowledge. In J. Gess-Newsome & N. G. Lederman (Eds.), *Pedagogical content knowledge and science education.* Netherlands: Kluwer Academic Publishers.

Mulholland, J. A. (1999). *Beginning teachers and primary science: learning and teaching science in the preservice to inservice transition.* Unpublished PhD thesis. Perth: Curtin University.

Odell, S. (1989). Developing support programs for beginning teachers. In L. Huling-Austin (Ed.), *Assisting the beginning, teacher* (pp. 19-38). Reston, VA: Association of Teacher Educators.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307-332.

Peterson, B. E., & Williams S. R. (1998). Mentoring beginning teachers. *Mathematics Teacher, 91*(8), 730-734.

Piovanelli, M. (2000). *SPSS10.0 for Macintosh: Release 10.0.7a, Standard version.* WASTE text engine.

Power, A., Clarke, M., & Hine, A. (2002). *The internship: A journey of professional learning through reflection.* Paper presented at Challenging Futures Conference, University of New England, Armidale.

Ramirez-Smith, C. (1997). *Isolation to interaction: implications for preparing preservice educators.* Virginia, US. (ERIC Document Reproduction Service No. ED414258)

Ratcliffe, M. (1998) The purposes of science education. In R. Sherrington (Ed), *ASE Guide to primary science education* (pp. 3-12). Cheltenham: Stanley Thornes.

Riggs, I. M., & Sandlin, R. A. (2002, July). *Professional development of mentors within a beginning teacher induction program: How does the garden (mentors) grow?* Paper presented at the annual meeting of the Educational Research Association. New Orleans, LA.

Riordan, G. (1995). *Teachers' perceptions of collaboration and clinical supervision.* Paper presented at the annual meeting of the American Educational Research Association. San Francisco, CA.

Rosean, C., & Lindquist, B. (1992). Collaborative teaching and research: Asking 'What does it mean?' *Elementary Subject Centre Series No.73.* Michigan: Institute for research on Teaching, MSU.

Roth, W-M. (1998). Science teaching as knowledgability: A case study of knowing and learning during coteaching. *Science Teacher Education, 82*(3), 357-377.

Schon, D. (1987). *Educating the reflective practitioner.* California: Jossey Bass.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Sinclair, C. (1997). Redefining the role of the university lecturer in school-based teacher education. *Asia-Pacific Journal of Teacher Education, 25*(3), 309-324.

Skamp, K., & Mueller, A. (2001a). A longitudinal study of the influences of primary and secondary school, university and practicum on student teachers' images of effective primary science practice. *International Journal of Science Education, 23*(3), 227-245.

Skamp, K., & Mueller, A. (2001b). Student teachers' conceptions of effective primary science practice: A longitudinal study. *International Journal of Science Education, 23*(4), 331-351.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences.* New Jersey: Lawrence Erlbaum Associates.

Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics.* New York: HarperCollins College Publishers.

Tobin, K., & Fraser, B. J. (1990). What does it mean to be an exemplary science teacher? *Journal of Research in Science Teaching, 27*(1), 3-25.

Upson, L., Koballa, T., & Gerber, B. (2002, January). *Preparing science specific mentors: A look at one successful Georgia program.* In proceedings of the annual international conference of the Association for the Education of Teachers in Science. Charlotte, NC.

Van Ast, J. (2002). *Community college mentoring program mentor-mentee handbook.* Iowa: Iowa State University of Science and Technology, Ames, College of Education.

Van Thielen, B. (1992). *Tutoring beginning teachers through a mentor teacher program.* Monograph No. 16. Canada, Saskatchewan. (ERIC Document Reproduction Service No. ED 354 222)

Wildman, T. M., Maggliaro, S. G., Niles, R. A., & Niles, J. A. (1992). Teacher mentoring: An analysis of roles, activities, and conditions. *Journal of Teacher Education, 43*(3), 205-213.

Williams, A. (1993). Teacher perceptions of the needs as mentors in the context of developing school-based initial teacher education. *British Educational Research Journal, 19*(4), 407–420.

Willis, S. (1995). Reinventing science education: Reformers promote hands-on, inquiry-based learning. *Curriculum Update. Sum.*

Woolnough, B. E. (1994). *Effective science teaching. Developing science and technology education.* U.S., Pennsylvania: Open University Press.

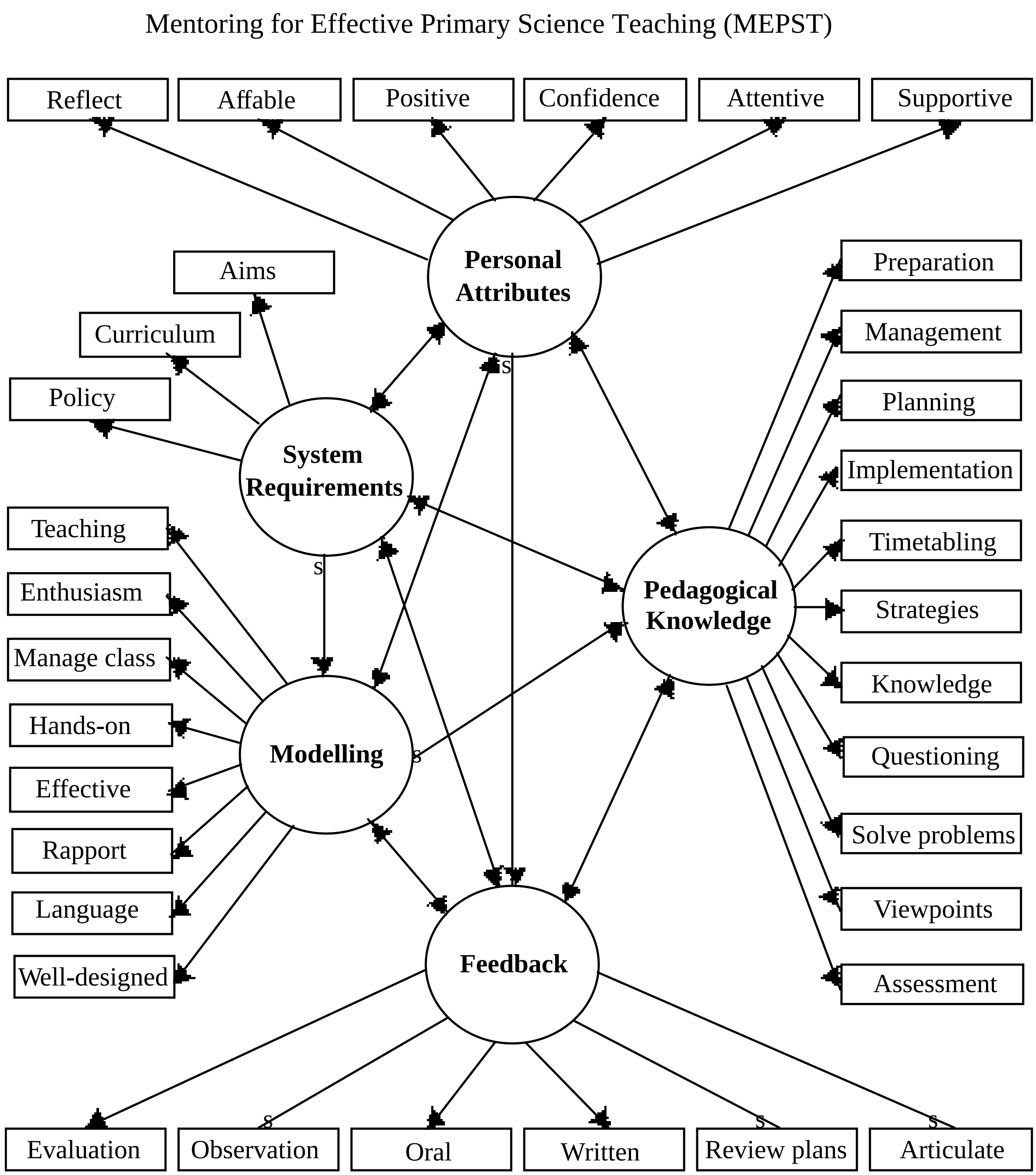
Table 1: *Three tested models for a five-factor analysis*

Hypothesised Model	Respecified Model	Final Model
Personal Attributes		
		reflect3
confidence4		
encourage9		
affable24	affable24	affable24
approachable27		
positive32	positive32	positive32
teachoften37		
confidence39	confidence39	confidence39
flexible40		
attentive42	attentive42	attentive42
supportive43	supportive43	supportive43
System Requirements		
content1		
aims5	aims5	aims5
policy10	policy10	policy10
curriculum17	curriculum17	curriculum17
assign26		
Pedagogical Knowledge		
preparation8	preparation8	preparation8
management12	management12	management12
planning13	planning13	planning13
		implementation14
timetabling16	timetabling16	timetabling16
strategies21	strategies21	strategies21
knowledge22	knowledge22	knowledge22
questioning25	questioning25	questioning25
solve problems36	solve problems36	solve problems36
viewpoints41	viewpoints41	viewpoints41
assessment44	assessment44	assessment44
articulate45		
Modelling		
programs2		
coping6		
teaching11	teaching11	teaching11
implementation14	implementation14	
enthusiasm15	enthusiasm15	enthusiasm15
manage class18	manage class18	manage class18
hands-on28	hands-on28	hands-on28
effective31	effective31	effective31
rapport33	rapport33	rapport33
language34	language34	language34
well-designed35	well-designed35	well-designed35
Feedback		
reflect3	reflect3	
programming7		
evaluation19	evaluation19	evaluation19
observation20	observation20	observation20
oral23	oral23	oral23
written29	written29	written29
review plans38	review plans38	review plans38
	articulate45	articulate45

NB: Numbers after each item relate to its position on the initial instrument (see Appendix 1).

Figure 1

Final model after re-specifications



NB: Two-way arrows indicate factor covariances.
Error variances, squared multiple correlations, regression weights, standardised regression weights, and standard errors are in Table 2.
Factor correlations, covariances, and standard error covariances are in Table 3.
Correlated variables: "Teaching" & "Manage Class", "Planning" & "Implementation", "Observation" & "Oral", "Attentive" & "Supportive".

Table 2

Fit indices for independent, initial, and respecified models (n=331)

Model	χ^2	df	CMIDF	IFI	CFI	RMR	RMSEA
Independence model	11966	527	22.7	.000	.000	.883	.237
Initial model (see Table 1)	3078	935	3.29	.842	.841	.097	.083
Respecified model (see Table 1)	1460	513	2.85	.900	.909	.075	.075
Final model (see Figure 1)	1335	513	2.60	.922	.921	.066	.070

* Each model tested was significant (p<.001)

Table 3

Factor correlations and covariances for final model

Factors	Correlations	Covariances	*SE cov.
Personal attributes & System requirements	.772	0.653	.077
Personal attributes & Pedagogical knowledge	.956	1.113	.105
Personal attributes & Modelling	.879	1.120	.110
Personal attributes & Feedback	.946	1.112	.105
System requirements & Pedagogical knowledge	.863	0.707	.080
System requirements & Modelling	.761	0.682	.082
System requirements & Feedback	.697	0.577	.073
Pedagogical knowledge & Modelling	.855	1.056	.107
Pedagogical knowledge& Feedback	.904	1.030	.101
Modelling & Feedback	.762	0.950	.102

Note: All correlations and covariances were substantial and significant (p<.001)

* SE cov. – Standardised errors for covariances

Table 4

Factors and associated item measurements for the final model

Factors and items	*EV	SMC	RW	SE (RW)	SRW
Personal attributes					
reflect3	0.31	0.580	0.865	0.051	0.762
affable24	0.23	0.694	0.924	0.047	0.833
positive 32	0.22	0.701	0.941	0.047	0.837
confidence39	0.19	0.736	1.000		0.858
attentive42	0.30	0.644	0.914	0.049	0.919
supportive43	0.21	0.688	0.986	0.050	0.972
System requirements					
aims5	0.35	0.612	1.128	0.091	0.782
policy10	0.47	0.449	0.930	0.086	0.670
curriculum17	0.42	0.486	1.000		0.697
Pedagogical knowledge					
preparation8	0.23	0.696	1.000		0.835
pk.management12	0.30	0.653	1.003	0.055	0.808
planning13	0.21	0.711	0.978	0.042	0.843
implementation14	0.31	0.719	0.952	0.049	0.848
timetabling16	0.36	0.555	0.890	0.055	0.745
strategies21	0.25	0.716	0.980	0.050	0.846
knowledge22	0.36	0.578	0.854	0.052	0.760
questioning25	0.29	0.667	0.928	0.050	0.817
solve problems36	0.26	0.668	0.849	0.046	0.817
viewpoints41	0.27	0.665	0.944	0.051	0.815
assessment44	0.43	0.477	0.793	0.055	0.690
Modelling					
teaching11	0.38	0.527	0.727	0.052	0.726
enthusiasm15	0.31	0.601	0.823	0.050	0.775
manage class18	0.35	0.550	0.833	0.054	0.742
hands-on28	0.25	0.681	1.000		0.825
effective31	0.18	0.799	0.943	0.046	0.894
rapport33	0.23	0.735	0.910	0.047	0.858
language34	0.33	0.665	0.856	0.048	0.816
well-designed35	0.21	0.761	0.946	0.048	0.872
Feedback					
evaluation19	0.26	0.677	0. 984	0.054	0.817
observation20	0.24	0.634	1.015	0.046	0.796
oral23	0.20	0.705	1.000		0.840
written29	0.31	0.606	1.003	0.059	0.779
review plans38	0.34	0.623	0.971	0.056	0.789
articulate45	0.33	0.641	0.916	0.052	0.801

* EV - Error variances or measurement errors SMC – Squared multiple correlations RW - Regression Weights SE(RW) - Standard Errors (Regression Weights) SRW - Standardised Regression Weights

Appendix 1: Initial hypothesised survey instrument

Mentoring Preservice Teachers of Primary Science

The following statements are concerned with your mentoring experiences in primary science teaching during your last practicum/internship (i.e., two weeks or more). Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate number to the right of each statement.

Key

SD = Strongly Disagree **D** = Disagree **U** = Uncertain **A** = Agree **SA** = Strongly Agree

During my final professional school experience (i.e., internship/practicum) in primary science teaching my <u>mentor</u>:

	SD	D	U	A	SA
1. displayed science content expertise. ……..…………………………..	1	2	3	4	5
2. showed me examples of how to program for science teaching.	1	2	3	4	5
3. assisted me to reflect on improving my science teaching practices.	1	2	3	4	5
4. increased my confidence to teach science. …………..…………….	1	2	3	4	5
5. discussed with me the aims of science teaching. …………………	1	2	3	4	5
6. coped with the demands of the most recent science curriculum. …	1	2	3	4	5
7. discussed my program for teaching science. ………….…………..	1	2	3	4	5
8. guided me with science lesson preparation. …………..………….	1	2	3	4	5
9. encouraged me to teach science. …………………………………	1	2	3	4	5
10. discussed with me the school policies used for science teaching.	1	2	3	4	5
11. modelled science teaching. ………………………………………	1	2	3	4	5
12. assisted me with classroom management strategies for science teaching.	1	2	3	4	5
13. gave me clear guidance for planning my science teaching. ……	1	2	3	4	5
14. assisted me with implementing science teaching strategies. ……	1	2	3	4	5
15. displayed enthusiasm for teaching science. …………………..……	1	2	3	4	5
16. assisted me with timetabling my science lessons. ……………….	1	2	3	4	5
17. outlined state science curriculum documents to me. …………….	1	2	3	4	5
18. modelled effective classroom management when teaching science.	1	2	3	4	5
19. discussed evaluation of my science teaching. …………………….	1	2	3	4	5
20. observed me teach science. ……………………………………..	1	2	3	4	5
21. developed my strategies for teaching science. ……………………	1	2	3	4	5
22. discussed with me the knowledge I needed for teaching science. ..	1	2	3	4	5
23. provided oral feedback on my science teaching. …………………..	1	2	3	4	5
24. seemed comfortable in talking with me about science teaching. ….	1	2	3	4	5

25. discussed with me questioning skills for effective science teaching.	1	2	3	4	5
26. assisted me with my university science assignments. ……………	1	2	3	4	5
27. was approachable. ………………………………………………	1	2	3	4	5
28. used hands-on materials for teaching science. …………………….	1	2	3	4	5
29. provided written feedback on my science teaching. …………………	1	2	3	4	5
30. addressed my science teaching anxieties. ………………………….	1	2	3	4	5
31. was effective in teaching science. …………………………………	1	2	3	4	5
32. instilled positive attitudes in me towards teaching science. ………	1	2	3	4	5
33. had a good rapport with primary students doing science. …………	1	2	3	4	5
34. used science language from the current primary science syllabus.	1	2	3	4	5
35. had well-designed science activities for the students. ……………	1	2	3	4	5
36. provided strategies for me to solve my science teaching problems. …….	1	2	3	4	5
37. allowed me to teach primary science as often as I wanted. ……..	1	2	3	4	5
38. reviewed my science lesson plans. ………………………………	1	2	3	4	5
39. made me feel more confident as a teacher of primary science. …	1	2	3	4	5
40. allowed me flexibility in planning for teaching science. …………	1	2	3	4	5
41. gave me new viewpoints on teaching primary science. ………….	1	2	3	4	5
42. listened to me when discussing science teaching practices. …….	1	2	3	4	5
43. was supportive of me for teaching science. ………………………	1	2	3	4	5
44. showed me how to assess the students' learning of science. ……..	1	2	3	4	5
45 clearly articulated what I needed to do to improve my teaching of primary science.	1	2	3	4	5

Items "content1", "programs2", "confidence4", "coping6", "programming7", "encourage9", "assign26", "approachable27", "anxiety30", "teachoften37", and "flexible40" were deleted from the final instrument (see text and Table 1)