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Developing an instrument to examine preservice teachers' pedagogical development

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Abstract

National and international reform documents have forged blueprints for science education in the immediate and long-term future. It is essential that preservice teachers' education programs correspond to the intentions of reform documents by providing learning experiences that develop preservice teachers' capabilities to plan and implement reform measures. Using a pretest-posttest design, responses from 59 second-year preservice teachers from the same university were compared after involvement in elementary science pedagogy coursework. The survey, which was linked to the course outcomes (constructs) and multiple indicators, measured the preservice teachers' perceptions of their development towards becoming elementary science teachers. ANOVA results indicated statistically significant *z*-scores ($p<.001$) and mean score differences for each of the four constructs (i.e., Theory=1.04, Children's Development=0.86, Planning=1.06, Implementation=1.02). It is argued that a pretest-posttest survey linked to course outcomes derived from the literature may aid in assessing the pedagogical development of preservice elementary science teachers and the standard of their preparation for teaching science. In addition, a survey linked to course outcomes can be used to inform further teaching practices and evaluate preservice teachers' level of preparation for teaching science based on reform agendas.

Many reform programs have been implemented to assist the facilitation of science education in elementary schools (Harlen, 1999; Hord & Huling-Austin, 1986; House, 1974). Despite these efforts, teachers' abilities, their prior views of the nature of students' learning, science teaching, and the science discipline impede teachers from adopting new approaches (Chang, 1998). It appears that the quality of science education and the number of teachers implementing elementary science education is less than adequate in the United States (Crowther & Cannon, 1998), England and Wales (Lunn & Solomon, 2000), and Australia (Goodrum, Hackling, & Rennie, 2001). However, preservice teachers are interested in learning about elementary science education and current theories of learning (Meadows, 1994; Rice & Roychoudhury, 2003). Indeed, preservice teacher education appears to hold the key for changing practice towards the inclusion of education reform (Briscoe & Peters, 1997), and may be the most influential stage to target towards achieving effective elementary science teaching practices (Appleton & Kindt, 1999; Watters & Ginns, 2000).

Preservice teachers' pedagogical knowledge for science teaching

The American Association for the Advancement of Science (AAAS, 1993) advocates science education standards that require systemic change involving the development of teachers' perceptions of science teaching. The Australian National Science Standard Committee (2002) is also calling for professional knowledge, professional practice, and professional attributes as standards for recognising accomplished teachers of science. Addressing these "standards" will require considerable educational reform, particularly in elementary science education. However, "education reform can succeed only if it is broad and comprehensive, attacking many problems simultaneously. But it cannot succeed at all unless the conditions of teaching and teacher development change" (National Commission, 1996, p. 16).

System requirements for elementary science education provide a direction for teaching, and present a framework for regulating the quality of elementary science teaching practices (Hudson, Skamp, & Brooks, 2005). If system requirements are necessary for informing science education reform in schools then this should also occur for preservice teacher education. Universities involved in preservice teacher education provide science education courses with outcomes that are promoted as obtainable goals, and the content of such courses aims to present current theories and practices for teaching science education. The development of preservice teachers' skills for teaching in elementary science education requires considerable scaffolding with focused attention on the acquisition of particular knowledge (Abell & Bryan, 1999; Bishop & Denley, 1997; Bybee, 1978). 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. The term "pedagogical knowledge" is frequently used in place of pedagogical content knowledge when referring to the knowledge for teaching elementary science (e.g., Briscoe & Peters, 1997; Coates, Jarvis, McKeon, & Vause, 1998; Hudson et al., 2005). Pedagogical knowledge is essential for effective elementary science teaching (Roth, 1998) as it makes understandings of science "usable in the classroom" (Mulholland, 1999, p. 26). Pedagogical knowledge for educating preservice elementary science teachers includes understanding:

1. theoretical underpinnings used for developing a science curriculum.
2. the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes.
3. effective planning for science teaching and learning.
4. the implementation of effective science teaching practices, including successful management of the learning environment. (Fleer & Hardy, 2001)

To be adequately prepared for elementary science teaching, preservice teachers need to analyse and understand current theories that underpin a science curriculum. Constructivism is one such theory advocated for elementary science teaching as it promotes hands-on learning with consideration of prior knowledge and students' misconceptions (Skamp, 2004). The development of a science syllabus generally draws upon current theories (e.g., Queensland School Curriculum Council, 1999), hence, part of understanding the theories that underpin a science syllabus (and potential science curriculum for a classroom) will also require preservice teachers to understand key components of the relevant syllabus.

Preservice teachers need to be provided with a variety of approaches for teaching elementary science, such as inquiry, interactive, and discovery approaches (Fleer & Hardy, 2001). Science teaching models are also readily available. For example, Bybee's Five Es model (1997), which highlights engagement, exploration, explanation, elaboration, and evaluation as a learning process, and Gunstone and White's (1981) reworked three-step predict-observe-explain (POE) model provide ways for teaching science. However, there is no "correct" approach or model for teaching science. These approaches and models aim to provide a framework for implementing effective elementary science lessons, and preservice teachers need to be able to compare approaches and models for teaching science in order to implement the most appropriate lesson design. Hence, articulating viewpoints about theories, approaches, and models for teaching science may demonstrate a preservice teacher's propensity for developing effective elementary science education lessons. In addition, greater exposure to different theories, approaches, and models may enable preservice teachers to be more comfortable in talking about elementary science teaching, which may enhance teaching practices (Hudson et al., 2005). Such communication requires a social capability to participate and work both independently and collaboratively in science education (Briscoe & Peters, 1997).

The American Association for the Advancement of Science (1993) describes science teachers' roles which include facilitating inquiry-based learning environments with effective teaching and assessment strategies to support student development in science education. Hence, providing an inclusive and relevant science education with knowledge of equitable opportunities for students requires preservice teachers to understand the conditions conducive for developing quality science education. Furthermore, in order to teach science effectively, preservice teachers need to understand elementary students' development of science concepts and scientific reasoning. Part of this understanding involves considering student misconceptions appropriate to the age group (Fleer & Hardy, 2001). Understanding the students' prior knowledge can provide a basis for targeting students' needs, and can justify the implementation of a science education program. In addition, students' manipulative skills and attitudes vary from grade to grade, hence, understanding their manipulative skills and attitudes may also assist in facilitating science lessons at appropriate levels (Abruscato, 2004).

Preservice elementary teacher education must include understanding how to plan for effective science education (Gonzales & Sosa, 1993; Jarvis, McKeon, Coates, & Vause, 2001), with key components of a science education program clearly outlined. For example, a rationale, based on theory and classroom context, establishes the program's parameters and provides justification for teaching the proposed science education content. The presence of a scope and sequence ensures that planning is not short sighted and provides a framework for forward thinking on the long-term science education plans. As science education now competes with an "overcrowded curriculum", integrating science with other key learning areas needs to be part of the planning process (Hudson, 2000). Such planning may occur by using concept maps that provide visual connections to other key learning areas (Fleer & Hardy, 2001). In addition, outcomes-based education for planning, implementing, and assessing elementary science education provides a stronger focus on students' achievements (e.g., AAAS, 1993; Board of Studies, 1999; Queensland School Curriculum Council, 1999). Furthermore, designing a program for science teaching requires consideration of teaching strategies (Tobin & Fraser, 1990); preparation for teaching (Rosaen & Lindquist, 1992); classroom management (Corcoran & Andrew, 1988; Feiman-Nemser & Parker, 1992); questioning skills

(Fleer & Hardy, 2001; Henriques, 1997); and assessment and evaluation procedures (Corcoran & Andrew, 1988; Jarvis et al., 2001). Without doubt, science content knowledge is essential in the planning process (Jarvis et al., 2001; Lenton & Turner, 1999), and is an area requiring development in preservice teachers (Hudson et al., 2005; Mulholland, 1999).

Addressing ethical and attitudinal issues can be a consideration as instruction aims to cater for all students regardless of ability (AAAS, 1993; Fleer & Hardy, 2001). As education is becoming more globalised (Global Perspectives, 2002), elementary science teachers entering the profession will need to demonstrate a level of confidence and competence for teaching elementary science in other states or countries. Most importantly, preservice teachers need to critically reflect on becoming effective teachers of elementary science in order to develop their pedagogical practices (e.g., Jarvis et al., 2001; Schön, 1987).

System evaluations of preservice teacher education courses are generally generic in nature. Such evaluations may lead to improvement of teaching practices at a broader level. However, specific evaluations are needed to identify strengths and weaknesses in relation to the microteaching components of the course and the learning preservice teachers perceive they had attained. Such identification may assist the development of educational practices. This study aimed to evaluate a science curriculum and methods course that was implemented with second-year preservice teachers. It was the objective of this study to examine these preservice teachers' elementary science pedagogical development and that they had demonstrated the attainment of outcomes equated with essential reform directions. Hence, an instrument needed to be developed in order to gather data on preservice teachers' pedagogical development.

Data collection methods and analysis

A pretest-posttest survey instrument was used to assess 59 second-year preservice teachers' elementary science pedagogical development at the conclusion of a science pedagogy course at one Australian university. Pretest-posttest data can provide a means for analysing changes that have occurred (Hittleman & Simon, 2002). The 37 survey items had a five-part Likert scale, namely, "strongly disagree", "disagree", "uncertain", "agree", "strongly agree". Scoring was accomplished by assigning a score of one to items receiving a "strongly disagree" response, a score of two for "disagree" and so on through the five response categories.

The statements on the survey sought students' perceptions of their development towards becoming elementary science teachers. The items on the survey represented relevant indicators of four course outcomes (constructs). For example, the course outcome "understands theoretical underpinnings used for developing a science curriculum", identified in subsequent discussion as the construct *Theory*, was linked to the following indicators on the survey: articulate the key components of the science syllabus; provide a rationale based on theory for designing and implementing an effective science program; describe and analyse the theoretical base of science curriculum development; articulate constructivist principles for teaching science; compare existing approaches for teaching science; articulate different viewpoints on teaching science; and, talk comfortably about teaching science. The remaining constructs were identified as follows: *Children's Development* (Understanding of the development of children's concepts, abilities, skills, and attitudes); *Planning* (Understanding effective planning for science teaching and learning); and *Implementation* (Implementing effective science teaching practices). To further substantiate the instrument's validity, four elementary science teacher educators examined the items on the proposed survey. Survey responses with missing or improbable values were deleted (Hittleman & Simon, 2002).

Descriptive statistics were derived using SPSS12. Data analysis included: frequencies of each survey item under each associated construct (outcome), mean scores (*M*), and standard deviations (*SD*, see Hittleman & Simon, 2002). The *M* and *SD* were used to calculate z-scores by comparing groups in terms of the "number of standard deviations from the means" (Neuman, 2000, p. 320). Mean score differences were calculated between the pretest and posttest on each of the four hypothesised constructs (i.e., Theory, Children's Development, Planning, Implementation). Cronbach alpha scores greater than .70 are considered acceptable for internal reliability (Hair, Anderson, Tatham, & Black, 1995). Analysing individual items aimed to provide further insight into these constructs.

Description of science education course

All of these preservice teachers (*n*=59) completed a science pedagogy course of one-semester duration. The course structure involved a one-hour lecture, a one-hour tutorial, and a two-hour workshop each week. Lecture topics included: Constructivism; The social nature of learning; Conceptual change; Problem-based inquiry; Instructional designs; and Designing units of work. The focus of workshops was the implementation of elementary science lessons by preservice teachers working in pairs. It was intended that preservice teachers would benefit from the experience of teaching science to their peers. In tutorials, preservice teachers were assisted in the development of a detailed elementary science unit. The lesson presentation with related documentation and the science unit of work were assessable items in the course.

Activities within workshops and tutorials aimed to facilitate these preservice teachers' understandings across the four constructs (i.e., Theory, Children's Development, Planning, Implementation). For example, workshops were used to: model sound science lesson structures including an appropriate introduction, main body of a lesson, and a conclusion; demonstrate constructivist principles with prior knowledge, use of questioning, hands-on/minds-on activities while facilitating active student participation; present effective teaching strategies including preparation and appropriate classroom management; show clear understandings of necessary content knowledge; and demonstrate the use of teaching and learning technologies. Tutorials were used to facilitate discussions for devising an elementary science unit of work with examples on: articulating clear rationales for teaching proposed units of work; well-structured, one-page overviews of science units of work; linkages to key concepts and the state's science syllabus; constructing detailed science lesson plans; teaching and classroom management techniques; and assessment and evaluation rubrics.

Results and discussion

The following are key descriptors of the posttest sample (*n*=59; 41 female, 18 male) provided from the preservice teachers' responses on the first section of this survey (Appendix 1). Although 53% of these preservice teachers were less than 22 years of age and 29% were between 22 and 29 years of age, there were also 18% who were older than 30 years of age. Seventy-one percent of the preservice teachers completed science content courses in Grades 11 and 12 at high school. Fifty-one percent had completed one science and mathematics content course, and 49% had completed two or more courses. In addition, 70% completed one practicum (field experience) and 30% indicated they had completed more than one practicum. Eighty-three percent claimed they had taught at least one science lesson in their field experiences. Comparison between pretest and posttest responses indicated that there was only a 3% increase for preservice teachers wanting to learn about teaching elementary science in other educational systems (pretest=53%, posttest=56%) and a 7% increase in wanting to collaborate with university teacher education students from other countries (pretest=39%, posttest=46%). In addition, only 35% indicated that science may be considered a strength at the conclusion of this course (compared with 22% in the pretest).

However, there was an increase of 28% for those who believed they had the knowledge and skills in elementary science teaching to interact effectively with university teacher education students from other countries (pretest=13%, posttest=41%).

Mean score differences and descriptive statistics for the four constructs

Mean score differences between the pretest and posttest were considered statistically significant for each of the four constructs (i.e., Theory=1.04, Children's Development=0.86, Planning =1.06, Implementation=1.02; Table 1). Cronbach alpha scores were considered acceptable on each of the four constructs (i.e., .92, .89, .96, .97, respectively, Table 1).

Table 1

Descriptive Statistics and Cronbach Alpha Scores for the Four Constructs for Preservice Teachers' Pretest-Posttest Responses

	Pretest (*n*=59)		Posttest (*n*=59)			
Construct	*M*	*SD*	*M*	*SD*	Mean score difference	Cronbach alpha
Theory	2.74	0.80	3.78	0.30	1.04	.92
Children's Development	2.81	0.88	3.67	0.42	0.86	.89
Planning	2.78	0.84	3.84	0.34	1.06	.96
Implementation	2.85	0.78	3.87	0.29	1.02	.97

Understanding the theory for developing a science curriculum (Construct – Theory)

All z-scores for the first construct, understanding the theoretical underpinnings used for developing a science curriculum (Theory), were significant ($p<.001$) with a range between –4.93 to –6.19 for the z-scores (Table 2). This indicated that these preservice teachers generally agreed or strongly agreed that they believed they understood the theory used for developing an elementary science curriculum. The percentages of preservice teachers who responded agree and strongly agree for each relevant indicator in the pre and posttests are shown in Table 2. Of interest was the increase in the preservice teachers' perceptions for the indicator, articulate constructivist principles for teaching elementary science (Item 15: pretest=15%, posttest=90%). However, the posttest responses also indicated that less than half claimed they could describe and analyse the theoretical base for a science curriculum (Item 9), and only 68% believed they could articulate different viewpoints for teaching science (Item 23) at the end of the course.

Table 2
Descriptive Statistics and ANOVA of Preservice Teachers' Pretest-Posttest Responses for the Construct "Theory"

		Pretest (*n*=59)			Posttest (*n*=59)			z-scores**
Item	Indicator	*M*	*SD*	%*	*M*	*SD*	%*	
1	Syllabus	2.58	1.10	22	3.71	0.67	73	-5.04
3	Rationale	2.59	0.95	17	3.73	0.74	78	-5.25
9	Theory	2.49	0.82	9	3.39	0.62	46	-5.15
15	Constructivist	2.69	0.90	15	4.00	0.53	90	-6.19
18	Teaching approaches	2.86	0.97	31	3.81	0.54	75	-5.09
23	Viewpoints	2.68	1.03	22	3.73	0.55	68	-5.43
33	Talking about science	2.85	1.05	29	3.86	0.54	78	-4.93

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood the theory for developing a science curriculum.
** $p<.001$

Understanding of the development of children's concepts, abilities, skills, and attitudes (Construct – Children's Development)

The second construct examined was the preservice teachers' understanding of the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes (Children's Development). Pretest-posttest responses indicated significant increases in the mean scores reflected in the *z*-scores (range: -3.91 to –5.13, $p<.001$) with a smaller variation in the *SD* for the posttest (Table 3). Despite a significant effect size for this construct (Table 1) and significant *z*-scores for each of the associated indicators, descriptive statistics revealed that more than 25% of these preservice teachers neither agreed nor strongly agreed they understood the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes at the conclusion of this course (Table 3).

Table 3

Descriptive Statistics and ANOVA of Preservice Teachers' Pretest-Posttest Responses for the Construct "Children's Development"

Item	Indicator	Pretest			Posttest			z-scores**
		M	*SD*	%*	*M*	*SD*	%*	
2	Scientific reasoning	2.73	1.06	29	3.66	0.66	66	-5.13
6	Attitudes	3.03	1.03	34	3.71	0.59	71	-3.91
28	Manipulative skills	2.69	0.93	17	3.59	0.59	64	-4.70
30	Science concepts	2.80	1.06	27	3.73	0.52	73	-4.75

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes.
** $p<.001$

Understanding effective planning for science teaching and learning (Construct – Planning)

The third construct examined preservice teachers' understandings for effective planning for science teaching and learning. Pretest-posttest responses indicated significant increases in the mean scores with smaller variation in the *SD* for the posttest, and significant *z*-scores (range: -4.82 to –5.91, $p<.001$) for each indicator (Table 4). Posttest statistics indicated that over 90% of the preservice teachers agreed or strongly agreed that they could devise clear lesson plans for teaching science (Item 5) and select appropriate activities and resources for teaching elementary science (Item 19). Analysis of percentages also indicated further understanding of inclusive science education (Item 26: pretest=12%, posttest=78%) and developing concept maps for planning a primary science unit of work (Item 35: pretest=22%, posttest=84%). However, 36% did not agree or strongly agree for the indicator that they could articulate the affective domains for teaching and learning elementary science (Item 12) after completing the course.

Table 4

Descriptive Statistics and ANOVA of Preservice Teachers' Pretest-Posttest Responses for the Construct "Planning"

Item	Indicator	Pretest			Posttest			z-scores**
		M	*SD*	%*	*M*	*SD*	%*	
5	Lesson plans	2.93	1.03	32	4.02	0.44	92	-5.17
7	Scope and sequence	2.78	0.95	27	3.72	0.58	73	-4.82
8	Program	2.61	1.00	20	3.68	0.54	71	-5.17
10	Outcomes	2.85	1.05	30	3.88	0.49	81	-5.06
12	Affective domain	2.58	0.99	15	3.63	0.58	64	-5.00
14	Integrate	2.97	1.05	32	4.05	0.60	88	-4.93
17	Independent/collaborative	3.05	0.94	34	3.95	0.47	87	-5.09
19	Appropriate activities	3.00	1.00	30	4.02	0.48	90	-5.19
26	Inclusivity	2.68	0.82	12	3.86	0.60	78	-5.91
35	Concept map	2.80	0.94	22	3.95	0.57	84	-5.48

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood effective planning for science teaching and learning.
** $p<.001$

Implementing effective science teaching practices (Construct – Implementation)

Finally, the fourth construct involved an examination of preservice teachers' understandings of implementing effective science teaching practices, including successful management of the learning environment. Pretest-posttest responses indicated significant increases in the mean scores with reduced variation in the *SD* for the posttest, and significant z-scores (range: -4.32 to –5.68, $p<.001$) for each relevant indicator (Table 5). In particular, pretest-posttest percentages revealed greater understanding for the indicators: addressing ethical and attitudinal issues related for implementing an elementary science lesson (Item 20: pretest=19%, posttest=76%), and developing, justifying and applying appropriate elementary science teaching strategies (Item 11: pretest=25%, posttest=78%).

Table 5

Descriptive Statistics and ANOVA of Preservice Teachers' Pretest-Posttest Responses for the Construct "Implementation"

Item	Indicator	Pretest			Posttest			z-scores**
		M	*SD*	%*	*M*	*SD*	%*	
4	Problem-based learning	2.97	1.02	35	3.88	0.46	73	-4.93
11	Strategies	2.68	1.03	25	3.86	0.54	78	-5.46
13	Classroom management	2.98	0.94	32	3.88	0.56	85	-4.91
16	Learning Environment	3.02	1.01	41	3.98	0.54	88	-5.11
20	Ethical issues	2.80	0.83	19	3.81	0.51	76	-5.68
21	Unit of work	2.68	1.01	19	3.78	0.60	78	-5.48
22	Assessments	2.76	0.97	27	3.88	0.95	81	-5.55
24	Critical reflection	3.03	0.98	32	3.86	0.73	81	-4.32
25	Questioning skills	2.92	1.02	31	3.93	0.45	86	-5.27
27	Evaluate	2.93	0.94	29	3.93	0.58	87	-4.96
29	Teach in other states	2.59	0.99	17	3.75	0.58	71	-5.55
31	Hands-on lessons	3.17	1.10	44	4.14	0.51	93	-4.85
32	Content knowledge	2.80	1.00	22	3.76	0.65	74	-4.92
34	Teaching confidently	2.58	1.04	17	3.83	0.56	78	-5.63
36	Positive attitudes	3.29	1.04	46	4.10	0.52	91	-4.53
37	Teach in other countries	2.46	0.99	13	3.39	0.87	53	-5.04

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood the implementation of effective science teaching practices, including successful management of the learning environment.
** $p<.001$

Most importantly, 78% of these preservice teachers now believed they could teach elementary science confidently (Item 34) compared with 17% in the pretest and there was a significant increase in positive attitudes towards science teaching (Item 36: posttest=91%), particularly as 54% were initially either uncertain or disagreed they had positive attitudes towards science at the beginning of the course. These preservice teachers also perceived their science content knowledge to increase (Item 32: pretest=22%, posttest=74%). However, 26% neither agreed nor strongly agreed they had adequate content knowledge (Item 32) or possessed an understanding of problem-based learning (Item 4), despite a significant mean score difference for this construct (Table 1) and significant *z*-scores (Table 5).

Discussion

The development of a survey instrument from the course outcomes provided a means for gathering general and specific information. It is suggested that significant mean score differences and *z*-scores could be expected after preservice teacher involvement in a science pedagogical course. Not expected, were the variations in percentages for various indicators associated with each construct. Although the greatest mean score difference was linked to the third construct (Planning), the highest mean score was associated with the fourth construct (Implementation). This implies that these preservice teachers perceived they had increased their understanding of effective planning for science teaching and learning to a greater degree than the other constructs; however their scores for Planning had not reached their perceived understanding for implementing effective science teaching practices. These preservice teachers may have incorporated information from practicum or other curriculum courses for understanding the implementation of elementary science teaching practices, particularly as 70% had completed a practicum and all had completed at least one science and mathematics course.

Specific evaluations of preservice teachers' development of pedagogical knowledge for science education can provide insights for improving educational programs and teaching practices. For example, if less than 70% may be considered inadequate for teacher preparation on any indicator linked to the constructs in this paper (e.g., items 2, 9, 12, 23, 28, and 37) then further program development will be required to ensure more preservice teachers achieve these indicators at the suggested levels. However, the ultimate goal is to strive for 100% (i.e., agree or strongly agree) on each of the posttest survey items, particularly as preservice teachers who do not agree they have an understanding of the concepts required for developing pedagogical practices may be entering the profession less than adequately prepared for current teaching practices. In addition, prioritising such items may lead to understanding critical or crucial aspects of effective elementary science teaching practices. For example, is the knowledge of concept mapping (Item 35) or teaching in other countries (Item 37) of equivalent importance for teaching science as having competent content knowledge for implementing lessons (Item 32)? These issues will require further research in order to define what is essential and what is desirable for learning to teach elementary science education and, as a result, for teacher educators to design courses for implementing such practices.

Conclusion

Education needs to become more outcomes based in university settings. Evaluation of preservice teacher education courses is generally generic if conducted at a system level. Administering specific instruments designed to assess preservice teacher development as a result of engagement in a course can provide further direction for enhancing tertiary education programs. A pretest-posttest survey instrument (e.g., Appendix 1) that is linked to course outcomes and the literature may aid in assessing the pedagogical development of preservice elementary teachers and their standard of preparation for the teaching profession. Information from a pretest can provide an understanding of the preservice teachers' prior knowledge, which may be used to redesign coursework at the beginning of a course. A posttest can be used to address issues for future course development. Indeed, educating preservice teachers needs to be sequential by constructively building upon their prior knowledge and facilitating a course that addresses their needs. It is important that universities lead the way in effective teaching practices by modelling the links between outcomes and assessments to better inform tertiary education practices.

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Appendix 1

Primary Curriculum and Pedagogies: Science

SECTION 1: This section aims to find out some information about you in relation to your responses in Section 2. To preserve your anonymity, write your mother's maiden name on this survey. Please ***circle*** the answers that apply to you. Thank you for your participation.

Mother's maiden name:____

a) What is your sex?   Male   Female

b) What is your age?   <22 yrs   22 - 29 yrs   30 - 39 yrs   >40 yrs

c) What science courses did you complete in Years 11 and 12 at high school?

____

d) How many science curriculum/methodology courses have you completed at university so far?

0   1   2   3   4 or more

e) How many block practicums (field experiences have you now completed during your tertiary teacher education?

0   1   2   3   4   5 or more

f) How many primary science lessons have you taught so far?

0   1   2   3   4   5   6 or more

g) Would science be one of your strongest subjects?

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

h) I would like to learn about teaching primary science in other educational systems?

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

i) I would develop my primary science teaching by collaborating with university teacher education students from other countries?

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

j) I believe I have the knowledge and skills in primary science teaching to interact effectively with university teacher education students from other countries?

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

SECTION 2:
The following statements relate to your development towards becoming a teacher of primary science. Please indicate the degree to which you disagree or agree with each statement below by circling only <u>one</u> response to the right of each statement.

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

In developing my understanding of primary curriculum and pedagogies towards becoming a teacher of primary science, I believe I can:

1. articulate the key components of the primary science syllabus. ………….	SD	D	U	A	SA
2. discuss the development of children's scientific reasoning abilities. …….	SD	D	U	A	SA
3. provide a rationale based on theory for designing and implementing an effective science program.	SD	D	U	A	SA
4. provide a problem-based learning environment for teaching primary science.	SD	D	U	A	SA
5. devise clear lesson structures for teaching primary science. ……………….	SD	D	U	A	SA
6. discuss the development of children's attitudes for learning primary science.	SD	D	U	A	SA
7. develop a scope and sequence for teaching primary science. ……………..	SD	D	U	A	SA
8. articulate the components of an effective primary science program. ………	SD	D	U	A	SA
9. describe and analyse the theoretical base of science curriculum development.	SD	D	U	A	SA
10. use an outcomes-based approach for planning, implementing, and assessing primary science education.	SD	D	U	A	SA
11. implement appropriate primary science teaching strategies. ………………	SD	D	U	A	SA
12. articulate the affective domains for teaching and learning primary science.	SD	D	U	A	SA
13. model effective classroom management when teaching science. …………	SD	D	U	A	SA
14. integrate primary science education with other key learning areas. ….…..	SD	D	U	A	SA
15. articulate constructivist principles for teaching primary science. …………	SD	D	U	A	SA
16. manage the primary science learning environment effectively. …………..	SD	D	U	A	SA
17. demonstrate a social capability to participate and work both independently and collaboratively in science education.	SD	D	U	A	SA
18. compare existing approaches for teaching primary science. ……………….	SD	D	U	A	SA
19. select appropriate activities and resources for teaching primary science. …	SD	D	U	A	SA
20. address ethical and attitudinal issues related for implementing a primary science lesson.	SD	D	U	A	SA
21. design a primary science unit of work. ……………………………………	SD	D	U	A	SA
22. assess the students' learning of primary science. …………………………	SD	D	U	A	SA
23. articulate different viewpoints on teaching primary science. …………….	SD	D	U	A	SA
24. critically reflect on becoming a more effective teacher of primary science.	SD	D	U	A	SA
25. use effective questioning skills for teaching primary science. ……………	SD	D	U	A	SA

26. provide primary science lessons that cater for all students regardless of ability (i.e., inclusivity).					
	SD	D	U	A	SA
27. critically evaluate my primary science teaching. ………………………….	SD	D	U	A	SA
28. demonstrate an understanding of the development of children’s manipulative skills for investigating science.					
	SD	D	U	A	SA
29. teach primary science in other states or territories of Australia ……………	SD	D	U	A	SA
30. discuss the development of children’s science concepts. …………………	SD	D	U	A	SA
31. use hands-on materials for teaching primary science. …………………….	SD	D	U	A	SA
32. teach primary science with competent content knowledge. ……………….	SD	D	U	A	SA
33. talk comfortably about teaching primary science. …………………………	SD	D	U	A	SA
34. teach primary science confidently. …………………………………………	SD	D	U	A	SA
35. use concept maps for planning a primary science unit of work. …………..	SD	D	U	A	SA
36. demonstrate positive attitudes towards teaching primary science. ………..	SD	D	U	A	SA
37. teach primary science in other countries. ………………..………..………..	SD	D	U	A	SA