International Journal of Teaching and Learning in Higher Education 2006, Volume 18, Number 2, 65-74
http://www.isetl.org/ijtlhe/ ISSN 1812-9129

Analyzing Differences Between Second and Third-Year Cohorts in the Same Science Education Course

Peter Hudson
Queensland University of Technology

Tertiary institutions need to gather evidence in order to determine the appropriateness of course design for particular year levels. Using a 35-item survey, responses from 127 second-year preservice teachers were compared with 164 third-year preservice teachers from the same university within the same year entering the same science education course. The survey, which was linked to the course outcomes and multiple indicators, measured the preservice teachers' perceptions of their prior knowledge before involvement in a primary science education course. Examining the differences between the two cohorts (i.e., n=127 and n=164), results indicated statistically significant t-test scores for each of the four constructs (i.e., Theory [t=6.07], Children's Development [t=7.85], Planning [t=10.31], Implementation [t=11.10]; p<.001) in favor of the third-year cohort. It is argued that each and every cohort of preservice teachers will have different levels of prior knowledge for learning how to teach primary science, hence, a needs analysis can provide evidence for targeting specific and collective needs of course participants. Further research is required for articulating a theoretical rationale for targeting particular cohorts in primary science education.

Prior Knowledge and Reform Agendas

The American Association for the Advancement of Science (AAAS) claims that a scientifically literate public can enhance a country's technological market place position (Bischoff, Hatch, & Watford, 1999). Indeed, scientific literacy has implications for economic gain and for empowering citizens (Jenkins, 1990). Attaining scientific literacy needs to be central to science education (Bybee, 1997). Hence, researchers must continually explore avenues for successful implementation of primary science education reform.

Regardless of reform efforts and professional development programs in science education, too many Australian teachers do not teach the mandatory science syllabus (Goodrum, Hackling, & Rennie, 2001), and so the focus for science education reform needs to be at the formative stages of learning to teach (McIntyre & Byrd, 1996; Roth, McGinn, & Bowen, 1998). Indeed, preservice teachers entering the profession may not receive opportunities for further developing practices once employed as teachers in schools (Hiatt-Michael, 2001). Tertiary science education courses ultimately aim at advancing science education in schools, particularly as these courses draw upon current literature towards achieving science education reform.

Constructivism, which is prominent in current literature for science education reform, is predicated on the belief that knowledge is constructed by learners as a result of their interactions with the natural world in a sociocultural context and mediated by their prior knowledge (Henriques, 1997). Constructivism highlights "the importance of prior knowledge or conceptualizations for new learning" (Matthews, 1994, p. 144), which may also be employed by educators for conceptualizing primary (elementary) science teaching practices for preservice teachers. Identifying students' prior knowledge and misconceptions can assist science teachers to challenge such misconceptions (Shuell, 1987). Effective primary teachers utilize primary students' prior knowledge as focal points for facilitating discussion and challenging conceptual understandings (Barnes & Foley, 1999) and effective staff development is guided by teachers' prior knowledge "as part of the staff development process" (Loucks-Horsley et al., 1990). Science educators must also determine preservice teachers' prior knowledge to more effectively design science education courses. Some universities are planning to model inquiry-based instructional approaches to promote conceptual change in preservice teachers' science knowledge (Henriques, 2001), which needs to include understanding preservice teachers' prior knowledge.

Preservice Teachers' Prior Knowledge for Developing Science Teaching

Assessment of prior knowledge requires defining specific conceptual parameters in order to target learning. For example, educators assessing the prior knowledge of preservice teachers involved in a science education course need to employ assessments in relation to the course objectives. Hence, this study aims to investigate preservice teachers' prior knowledge in relation to the following key objectives (constructs) for a science pedagogy course at one university, that is:

1. The 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.

More specifically, and in association with these key objectives and the literature suggesting particular science education reform practices (e.g., Fleer & Hardy, 2001), preservice teachers need to understand current science teaching theories, teaching approaches and models that underpin a science curriculum (e.g., Board of Studies, 1999; Queensland School Curriculum Council, 1999). Constructivism is a current theory advocated for primary science teaching as it promotes hands-on learning with consideration of prior knowledge and students' misconceptions (Skamp, 2004). Implementing reform measures also requires knowledge of approaches and models for teaching primary science (Fleer & Hardy, 2001). For example, Gunstone and White's (1981) reworked predict-observe-explain (POE) model provides a simple three-step process for facilitating a science lesson and Bybee's Five Es model (1997) sequences purposeful phases for learning science (i.e., engage, explore, explain, elaborate and evaluate). Such knowledge allows preservice teachers to develop and articulate viewpoints about theories, approaches, and models for teaching science.

Developing teaching practices includes understanding children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes. The National Science Foundation (1998), AAAS (1993), and educators (e.g., Dana, Campbell, & Lunetta, 1997; Henriques, 2001) propose that science teachers facilitate inquiry-based learning environments with effective teaching and assessment strategies to support student development in science education. Indeed, providing inclusive, equal opportunity education requires preservice teachers to understand primary students' development of science concepts, manipulative skills, attitudes, and scientific reasoning (Abruscato, 2004; Fleer & Hardy, 2001; Skamp, 2004).

Preservice primary 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 a program's parameters and provides justification for teaching proposed science education content. Scope and sequences, unit overviews, and integrated science overviews (using matrixes or concept maps) ensure that planning is proactive and projective with consideration of student needs and system requirements (e.g., school policies, syllabus aims and content). Key to effective planning is the employment of outcomes-based education, which enables stronger links between student achievement with more verifiable assessments (e.g., AAAS, 1993; Board of Studies, 1999; Queensland School Curriculum Council, 1999).

Implementing effective science teaching practices relies on effective planning and includes successful management of the learning environment (Fleer & Hardy, 2001). Implementing a science education program requires consideration of teaching strategies, hands-on lessons (Appleton & Doig, 1999; Corcoran & Andrew, 1988), classroom management (Feiman-Nemser & Parker, 1992), questioning skills (Fleer & Hardy, 2001), and assessment and evaluation procedures (Corcoran & Andrew, 1988; Jarvis et al., 2001; Hudson, 2005). Science content knowledge is also essential in the planning process (Appleton & Kindt, 1999; Lenton & Turner, 1999), and is an area requiring development in preservice teachers (Hudson, Skamp, & Brooks, 2005). Most importantly, preservice teachers need to critically reflect on becoming effective teachers of primary science in order to develop their pedagogical practices (e.g., Jarvis et al., 2001; Schön, 1987).

Examining preservice teachers' perceptions of their prior knowledge of primary science teaching may lead educators to devise more appropriate science education coursework. Specific assessments are needed to identify strengths and weaknesses in relation to the microteaching components of a course and the perceptions preservice teachers have of their prior knowledge for teaching primary science. These perceptions may also be different for different year levels of preservice teachers. Such identification for particular year levels in a preservice teacher education degree may assist in developing effective educational practices. Hence, this study aimed to examine and compare second and third-year preservice teachers' perceptions of their prior knowledge for the development of their primary science teaching.

Research Design and Method

A survey instrument (Appendix A) was used to gather data on 127 second-year preservice teachers and 164 third-year preservice teachers' perceptions of their prior knowledge for the development of their science teaching at the beginning of the same science pedagogy course during the same calendar year. Each cohort had completed the same number of science methodology units. In addition, all these preservice teachers were involved in the same Bachelor of Education degree at one Australian university. The 35 survey items contained a five-part Likert scale (Appendix 1), namely, "strongly disagree", "disagree", "uncertain", "agree", and "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 these preservice teachers' perceptions of their prior knowledge towards becoming primary science teachers. The items on the survey represented relevant indicators of four course outcomes (constructs). That is, 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 analyze 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 primary 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 and included frequencies of each survey item under each associated construct, mean scores (*M*), and standard deviations (*SD*, see Hittleman & Simon, 2002). The *M* and *SD* were used to calculate independent *t*-tests that compared the two cohorts (*n*=127 & *n*=164) on each of the four hypothesized constructs (i.e., Theory, Children's Development, Planning, Implementation). Fine-grained analysis using *M*, *SD*, and percentages of individual survey items associated with each construct aimed to provide further insight into these constructs. Calculating *z*-scores, which is the number of *SD*s from the *M*, presented statistical relationships between the second and third-year preservice teachers' perceptions of their prior knowledge on each of these items. A negative z-score is below the mean while a positive z-score is above the mean (Kline, 1998).

Results and Discussion

The following demographics (Table 1) provides key descriptors of the second-year preservice teacher sample (*n*=127; 90 female, 37 male) and the third-year preservice teacher sample (*n*=164; 125 female, 39 male) taken from the preservice teachers' responses on the first section of this survey (Appendix 1). These preservice teachers' ages and high school involvement in science education were not overly dissimilar for both the second and third-year cohorts (Table 1), even though it was expected that more second-year preservice teachers would be under the age of 22. The main differences between these second-year (SY) and third-year (TY) preservice teachers included the involvement of more than one practicum (SY=2%; TY=87%) and, possibly as a result of more practicum experiences, an increase in teaching more than one primary science lesson (SY=5%, TY=69%). Nevertheless, this only represented an increase of 7% for third-year preservice teachers who believed that science teaching was a strength compared with the second-year cohort (SY=24%, TY=31%; Table 1). Further qualitative data and analysis would be required to understand preservice teachers' definition of "strength" in science teaching.

TABLE 1
Demographics of Second and Third-Year Preservice Teacher

Descriptor	SY[1] (*n*=127)	TY[2] (*n*=164)
< 22 years of age	60	47
22-29 years of age	26	34
>30 years of age	14	19
Completed a science subject at high school	70	68
Had not completed a practicum	48	1
Completed one practicum	50	12
Completed more than one practicum	2	87
Had not taught a science lesson	90	21
Taught one science lesson	5	10
Taught more than one science lesson	5	69
Considered science as a strength	24[3]	31[3]

Note. All values are percentages.
[1] SY=Second-year preservice teachers
[2] TY=Third-year preservice teachers
[3] Percentage of preservice teachers who "agreed" or "strongly agreed" that science teaching was a strength.
`

TABLE 2
Descriptive Statistic and t-tests for the Four Constructs for Second and Third-Year Preservice Teachers' Responses

Construct	SY (n=127)		TY (n=164)		Mean score differences	t-test (df=126)
	M	*SD*	*M*	*SD*		
Theory	2.76	0.73	3.44	0.97	0.68	6.07**
Children's Development	2.86	0.79	3.67	0.91	0.81	7.85**
Planning	2.91	0.74	3.78	0.51	0.87	10.31**
Implementation	2.96	0.70	3.76	0.42	0.80	11.10**

** p<.001

Descriptive Statistics and t-tests for the Four Constructs

Analyzing t-tests between the two cohorts (n=127 and n=164) indicated educational and statistical significance for each of the four constructs (i.e., Theory [t=6.07], Children's Development [t=7.85], Planning [t=10.31], Implementation [t=11.10]; p<.001, Table 2). Mean scale scores were higher for the TY cohort; however both groups agreed or strongly agreed they had more prior knowledge of *Planning* and *Implementation* than *Theory* and *Children's Development* for primary science teaching.

For a fine-grained analysis of each item associated with these constructs, descriptive statistics and z-scores of each of the four constructs will be presented and discussed in the following.

Understanding the Theory for Developing a Science Curriculum (Construct – Theory)

The z-scores for the first construct, prior knowledge for understanding the theoretical underpinnings used for developing a science curriculum (Theory), ranged between –4.78 to –6.52. These z-scores were statistically significant (p<.001) and indicated the third-year cohort perceived themselves to have significantly more prior knowledge for developing a primary science curriculum on each of these items than the second-year cohort (Table 3). The percentages of second and third-year preservice teachers, who responded agree or strongly agree for each relevant indicator, are shown in Table 3.

Other than "teaching approaches" (Item 18), all indicators for SY were 25% or less, whereas TY ranged between 34-67% for items associated with *Theory* (Table 3). As TY had approximately the same number of science methodology courses as SY, the results further revealed that other factors may be involved with the acquisition of preservice teachers' prior knowledge. It is possible that coursework other than science education (i.e., other Bachelor of Education units) and an increase in practicum experience may have contributed to third-year preservice teachers' increased perception of their prior knowledge for understanding the theory for developing a science curriculum.

TABLE 3
Descriptive Statistics and z-scores of Preservice Teachers' Perceptions of their Prior Knowledge for the Construct "Theory"

Item	Indicator	SY (n=127)			TY (n=164)			z-scores
		M	*SD*	%	*M*	*SD*	%	
1	Syllabus	2.63	1.02	20	3.41	0.94	60	-5.41**
3	Rationale	2.71	0.95	21	3.35	0.82	49	-5.07**
9	Theory	2.54	0.84	11	3.12	0.78	34	-4.78**
15	Constructivist	2.81	0.85	18	3.56	0.71	54	-6.52**
18	Teaching approaches	2.98	0.89	31	3.60	0.70	65	-4.95**
23	Viewpoints	2.78	0.91	19	3.40	0.70	49	-5.01**
32	Talking about science	2.85	0.90	25	3.63	0.73	67	-5.49**

Note. For all means, 1 = strongly disagree to 5 = strongly agree.
** p<.001

TABLE 4
Descriptive Statistics and z-scores of Preservice Teachers' Perceptions of their Prior Knowledge for the Construct "Children's Development"

		SY (*n*=127)			TY (*n*=164)			*z*-scores
Item	Indicator	*M*	*SD*	%	*M*	*SD*	%	
2	Scientific reasoning	2.80	0.98	28	3.37	0.84	53	-4.83**
6	Attitudes	3.07	0.93	35	3.88	3.22	66	-5.06**
28	Manipulative skills	2.74	0.87	17	3.39	0.71	48	-5.76**
30	Science concepts	2.81	0.97	23	3.57	0.73	64	-5.93**

Note. For all means, 1 = strongly disagree to 5 = strongly agree.
** *p*<.001

Understanding of the Development of Children's Concepts, Abilities, Skills, and Attitudes (Construct – Children's Development)

The next construct examined the preservice teachers' perceptions of their prior knowledge for understanding the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes (Children's Development). Second and third-year preservice teachers' responses indicated significant differences in the mean scores, which were reflected in the z-scores (range: -4.83 to –5.93, *p*<.001) with a smaller variation in the *SD* for the third-year preservice teachers (Table 4). Despite a significant effect size for this construct (Table 2) and significant z-scores for each of the associated indicators (Table 4), descriptive statistics revealed that more than 30% from both groups of preservice teachers "strongly disagreed", "disagreed" or were "uncertain" they understood the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes at the beginning of this course. Nevertheless, the percentage difference between SY and TY indicated significant increases in the perceptions of their prior knowledge for the third-year cohort (i.e., a difference of: 25%, 31%, 31%, 41% across each of the items 2, 6, 28, and 30 respectively; Table 4).

Understanding Effective Planning for Science Teaching and Learning (Construct – Planning)

The next construct examined preservice teachers' prior knowledge of their understandings for effective planning for science teaching and learning. Responses indicated significant increases in the mean scores with smaller variation in the *SD* for the third-year cohort and significant z-scores (range: -5.19 to –7.72, *p*<.001) for each indicator (Table 5). It was expected that percentages on each of the items would be reasonably low for both cohorts, hence, it was surprising that 85% or more third-year preservice teachers agreed or strongly agreed that they could devise clear lesson plans for teaching science (Item 5), use an outcomes-based approach for planning, implementing and assessing primary science teaching (Item 10), integrate primary science education with other key learning areas (Item 14), and select appropriate activities and resources for teaching primary science (Item 19) compared with 35% or lower for the second-year cohort on these same items (i.e., 33%, 30%, 35%, 19%, respectively). Analysis of percentages also showed further differences in each cohort's perceptions of their prior knowledge of providing primary science lessons that cater for all students regardless of ability, that is, inclusivity (Item 26: SY=18%, TY=73%) and developing concept maps for planning a primary science unit of work (Item 35: SY=23%, TY=72%). However, less than 50% for each cohort did not agree or strongly agree that they could articulate the affective domains for teaching and learning primary science (Item 12) before commencing the science education course. Further investigation would be required to determine other factors that may have influenced the third-year preservice teachers' perceptions of their prior knowledge on items associated with significant percentage differences. Indeed, qualitative data in the form of random interviews may provide further elaboration and insight on these higher percentage items.

Implementing Effective Science Teaching Practices (Construct – Implementation)

Finally, the last construct involved an examination of preservice teachers' prior knowledge for their understandings of implementing effective science teaching practices, including successful management of the learning environment. Responses indicated significant increases in the mean scores with smaller variation in the *SD* for the third-year cohort and significant z-scores (range: -4.32 to –5.68, *p*<.001) for each relevant indicator (Table 6). In particular, these third-year preservice teachers perceived they had more prior knowledge for all the indicators with some items registering a difference of 50% or more (i.e., Item 13=56% difference, Item 22=52%, Item 25=50%, Item 29=52%; Table 6). Perceived increase in prior knowledge of classroom management, assessments, questioning skills, and hands-on activities may be due to increased practicum experience and completion of other Bachelor of Education units that may deal with these issues.

The third-year preservice teachers also perceived more prior knowledge for science content knowledge (Item 31: SY=19%, TY=56%; Table 5) even though 24% of second years and 31% of third years agreed or strongly agreed science was one of their strongest subjects (Table 1). Most importantly, 59% of these third-year preservice teachers believed they could teach primary science confidently (Item 33) compared with only 12% of the second-year

TABLE 5
Descriptive Statistics and z-scores of Preservice Teachers' Perceptions of their Prior Knowledge for the Construct "Planning"

		SY (*n*=127)			TY (*n*=164)			*z*-scores
Item	Indicator	*M*	*SD*	%	*M*	*SD*	%	
5	Lesson plans	2.98	0.96	33	3.97	0.52	88	-7.72**
7	Scope and sequence	2.81	0.91	24	3.41	0.72	49	-5.27**
8	Program	2.73	0.96	22	3.37	0.73	48	-5.19**
10	Outcomes	2.90	1.00	30	3.94	0.59	85	-7.28**
12	Affective domain	2.71	0.93	18	3.35	0.72	46	-5.30**
14	Integrate	3.11	0.95	35	4.33	0.49	88	-7.81**
17	Independent/collaborative	3.19	0.82	37	3.72	0.81	72	-6.84**
19	Appropriate activities	2.98	0.89	31	3.84	0.54	85	-6.09**
26	Inclusivity	2.82	0.83	18	3.77	0.61	73	-7.70**
35	Concept map	2.83	0.89	23	3.70	0.83	72	-7.40**

Note. For all means, 1 = strongly disagree to 5 = strongly agree.
** *p*<.001

TABLE 6
Descriptive Statistics and z-scores of Preservice Teachers' Perceptions of their Prior Knowledge for the Construct "Implementation"

		SY (*n*=127)			TY (*n*=164)			*z*-scores
Item	Indicator	*M*	*SD*	%	*M*	*SD*	%	
4	Problem-based learning	3.02	0.97	35	3.74	0.58	69	-6.00**
11	Strategies	2.81	0.92	24	3.68	0.59	69	-6.78**
13	Classroom management	3.10	0.89	34	4.01	0.50	90	-7.24**
16	Learning environment	3.08	0.87	35	3.83	0.55	77	-7.00**
20	Ethical issues	2.86	0.89	23	3.58	0.68	60	-6.24**
21	Unit of work	2.76	0.96	21	3.70	0.73	70	-7.00**
22	Assessments	2.87	0.92	27	3.82	0.60	79	-7.34**
24	Critical reflection	3.05	0.82	28	3.80	0.67	77	-6.52**
25	Questioning skills	2.96	0.89	26	3.78	0.62	76	-6.81**
27	Evaluate	3.07	0.88	32	3.80	0.66	77	-6.42**
29	Hands-on lessons	3.16	0.94	38	4.04	0.48	90	-8.29**
31	Content knowledge	2.80	0.92	19	3.49	0.77	56	-3.06**
33	Teaching confidently	2.63	0.90	12	3.50	0.83	59	-4.77**
34	Positive attitudes	3.23	0.92	39	3.94	0.57	85	-8.06**

Note. For all means, 1 = strongly disagree to 5 = strongly agree.
** *p*<.001

cohort, and there was a significant difference in positive attitudes towards science teaching for the third years (Item 34: SY=39%, TY=85%). Questions that can be further investigated include: what is the relationship between participants' perceptions of science as a strength and their science content knowledge?, how does preservice teachers' understanding of teaching approaches assist in talking about science education?, and what coursework other than science education assists in developing the preservice teachers' prior knowledge of classroom management or hands-on experiences for science education? Although the third-year cohort had approximately the same number of science methodology coursework in the Bachelor of Education as the second-years, 90% of third-year preservice teachers perceived they had prior knowledge of classroom management and hands-on experiences for primary science teaching compared with only 34% (classroom management) and 38% (hands-on experiences) for second years.

Further Discussion and Conclusion

This study argues that each and every cohort of preservice teachers will indicate different levels of prior knowledge for teaching primary science. Statistically significant *t*-tests and *z*-scores indicated third-year preservice teachers perceived they had more prior knowledge for teaching primary science than their second-year counterparts even though they had completed the same number of science methodology coursework. The greatest mean score differences were linked to *Planning* and *Implementation* for each cohort. This implies that both cohorts perceived they had more understanding of planning and implementing primary science teaching practices than their theoretical knowledge for science curriculum development and their understanding of children's development for teaching science education. They may have incorporated information and ideas from other key learning curriculum courses for their understanding of planning and implementing primary science teaching practices. If each of these constructs is considered important for developing primary science teaching practices and addressing reform agendas (e.g., Fleer & Hardy, 2001) then educators may need to target *Theory* and *Children's Development* more comprehensively.

Tertiary education courses need to take into account preservice teachers' prior knowledge in order to target the learner's needs. Examination of preservice teachers' perceptions of their prior knowledge for science education can provide insights for designing educational programs and teaching practices specific to the learner's needs. For example, if more than 80% TY indicated prior knowledge for particular science teaching practices (e.g., certain items within the construct *Planning*), then this cohort may not need as intensive lesson plan preparation and knowledge about outcomes, integration, and designing appropriate activities as much as other indicators associated with *Planning* (see Table 5). Conversely, more education may be required for these third years for understanding scope and sequences, developing science programs, and understanding the affective domain for teaching (Table 5). Hence, educators may more effectively devise preservice teacher education programs for addressing science education reform by initially understanding the cohort's perceptions of their prior knowledge. Further investigation of other courses undertaken by third-year preservice teachers to achieve this level of prior knowledge in science education may also aid tertiary educators for developing more effective science education programs.

There is a need for more coordination, integration and connection between courses offered within a Bachelor of Education degree. In this study, there was no rationale provided for targeting one year cohort over another. Investigation of science education courses at other universities also indicated no rationale for targeting a particular year cohort. As *z*-scores were statistically significant for each item on each construct with lower percentages for the second-year cohort, educators may need to consider the maximum effect of targeting a particular year (e.g., SY or TY). For example, facilitating a science education course to second-year preservice teachers would more than likely show significant increases at the conclusion of coursework compared to targeting third years. However, more research on second and third-year preservice teachers' pedagogical knowledge development as a result of a science education program would need to be conducted in order to determine which group would be more effectively targeted. This type of research may be used to gauge the maximum effect of coursework for particular cohorts, allowing curriculum designers to make better-informed decisions for advancing science education.

Educators in university settings expect teachers and preservice teachers to understand their students' prior knowledge of science concepts before teaching primary science (Abruscato, 2004; Appleton & Doig, 1999). This appears as an essential aspect of addressing primary students' needs and the possibility of employing specific teaching practices to enhance the learning of science education concepts (Fleer & Hardy, 2001). If a needs analysis is essential for primary science teachers' planning for science education then it is also essential for university educators' planning for preservice teacher education. Carefully devised prior knowledge surveys linked to course outcomes can allow university educators to understand the prior knowledge of a particular cohort. A needs analysis should be conducted at the beginning of every course to provide evidence for targeting specific and collective needs of course participants; hence no two courses should be the same if tertiary educators employ flexible practices to cater for participants' needs. Research possibilities can include: (1) comparing third-year and final-year cohorts in order to identify participant needs before entry into the teaching profession; and (2) collaborating with other universities to investigate similar course outcomes and determine practices that may lead to enhancing such outcomes.

References

Abruscato, J. (2004). *Teaching children science: A discovery approach.* New York: Allyn & Bacon.

Appleton, K., & Doig, E. (1999, July). *Primary school teachers' perceptions of activities that work.* Paper presented at the annual conference of the Australasian Science Education Research Association, Rotorua, New Zealand.

Appleton, K., & Kindt, I. (1999, March). *How do beginning elementary teachers cope with science: Development of pedagogical content knowledge in science.* Paper presented at the annual meeting of the National Association for Research in Science Education, Boston, MA.

American Association for the Advancement of Science. (1993*). Benchmarks for science literacy: Project 2061*. New York: Oxford University Press.

Australian National Science Standard Committee/ Australian Science Teachers' Association (ASTA). (2002). *National professional standards for highly accomplished teachers of science.* Canberra, Australia: ASTA.

Barnes, M. B., & Foley, K. R. (1999). Inquiring into three approaches to hands-on learning in elementary and secondary science methods courses. *Journal of Science Education, 4(*2), 1-8. Retrieved January 6, 2005, from http://unr.edu/hoempage/crowther/ejse/barnesfoley.html

Bischoff, P. J., Hatch, D. D., & Watford, L. J. (1999). The state of readiness of initial level preservice middle grades science and mathematics teachers and its implications on teacher education programs. *School Science and Mathematics, 99*(7), 394-399.

Board of Studies. (1999). *Science and technology K-6: Outcomes and indicators.* Sydney, NSW: New South Wales Department of Education and Training.

Burry-Stock, J. A., & Oxford, R. L. (1994). Expert science teaching educational evaluation model (ESTEEM): Measuring excellence in science teaching for professional development. *Journal of Personnel Evaluation in Education, 8*(3), 267-297.

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

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

Dana, T. M., Campbell, L. M., & Lunetta, V. N. (1997). Theoretical bases for reform of science teacher education. *The Elementary School Journal, 97*(4), 419-432.

Feiman-Nemser, S., & Parker, M. (1992). *Mentoring in context: A comparison of two U.S. programs for beginning teachers. NCRTL Special Report.* East Lansing, MI: National Center for Research on Teacher Learning.

Fleer, M., & Hardy, T. (2001). *Science for children.* Sydney, Australia: Prentice Hall.

Gonzales, F., & Sosa, A. (1993). How do we keep teachers in our classrooms? The TNT response. *Idra Newsletter*, 1, 6-9.

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

Gunstone, R. F., & White, R. T. (1981). Understanding of gravity. *Science Education, 65*(3), 291-299.

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 April 27, 2004, from http://www.educ.uvic.ca/depts/snsc/temporary/cnstrct.htm.

Henriques, L., et al. (2001, January). *Creating an integrated elementary teacher education program: The response of nine California state university campuses.* In Proceedings of the Annual International Conference of the Association for the Education of Teachers in Science. Costa Mesa, CA.

Hiatt-Michael, D. (2001). *Preparing teachers to work with parents.* Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education, American Association of Colleges for Teacher Education. (ERIC Document Reproduction Service No. ED460123)

Hittleman, D. R., & Simon, A. J. (2002). *Interpreting educational research: An introduction for consumers of research* (3rd ed.). Upper Saddle River, NJ: Merrill.

Hudson, P. (2005, September). *Analysing preservice teachers' rubrics for assessing students' learning in primary science education.* Paper presented at the Australian Curriculum Studies Association (ACSA) conference, University of the Sunshine Coast, Queensland, Australia.

Hudson, P., Skamp, K., & Brooks, L. (2005). Development of an instrument: Mentoring for effective primary science teaching. *Science Education, 89*(4), 657-674.

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.

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

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

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

Loucks-Horsley, S., et al. (1990). *Project TEAM: A partnership supporting staff development in science and elementary science teacher preparation.* Retrieved January 6 2005, from http://www.google.com.au/search?q=cache:rosLXMHfiZ0J:coe.cedu.niu.edu/scied/rpm/Project_TEAM.rtf.

Matthews, M. R. (1994). *Science teaching: The role of history and philosophy of science*. New York: Routledge.
McIntyre, D. J., & Byrd, D. M. (Eds.). (1996). *Preparing tomorrow's teachers: The field experience. Teacher education yearbook IV*. Thousand Oaks, CA: Corwin Press.
National Science Foundation (1998). The challenge and promise of K-8 science education reform, in *Foundations*, Washington, D.C.: National Science Foundation.
Queensland School Curriculum Council. (1999). *Science: Years 1-10 syllabus*. Brisbane, QLD: QSA.
Roth, W-M., McGinn, M., & Bowen, G. M. (1998). How prepared are preservice teachers to teach scientific inquiry? Levels of performance in scientific representation practices. *Journal of Science Teacher Education*, *19*, 25-48.
Schön, D. (1987). *Educating the reflective practitioner*. San Francisco: Jossey Bass.
Shuell, T. J. (1987). Cognitive psychology and conceptual change: Implications for teaching science. *Science Education, 71*(2), 239-250.
Skamp, K. (Ed.). (2004). *Teaching primary science constructively*. Sydney, Australia: Harcourt Brace.
Watters, J. J., & Ginns, I. S. (2000). Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of Science Teacher Education, 11*(4), 301-321.

DR PETER HUDSON taught in primary schools for 25 years, including 10 years as a school principal, and now lectures in science education at Queensland University of Technology. His research interests include mentoring, science education, sustainable living, subject integration, leadership and community engagement. Email contact details: pb.hudson@qut.edu.au.

Appendix A
Primary Curriculum and Pedagogies: Science

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 one 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. use hands-on materials for teaching primary science. …………………….	SD	D	U	A	SA
30. discuss the development of children’s science concepts. …………………	SD	D	U	A	SA
31. teach primary science with competent content knowledge. ……………….	SD	D	U	A	SA
32. talk comfortably about teaching primary science. …………………………	SD	D	U	A	SA
33. teach primary science confidently. …………………………………………	SD	D	U	A	SA
34. demonstrate positive attitudes towards teaching primary science. ………..	SD	D	U	A	SA
35. use concept maps for planning a primary science unit of work. …………..	SD	D	U	A	SA