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Balancing the Equation: Reflecting on the Learners' Experience of an Elective Chemistry Course for Pre-service Primary Teachers.

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Abstract

The Bachelor of Education (B.Ed) in Primary Teaching was previously a three year degree programme in Irish colleges. The programme has been re-designed to create an attractive and exciting new four-year programme. The first entrants to the new four-year programme will graduate in 2016.

The design of the new four-year programme has facilitated the faculty of education to provide more specialist elective options for the pre-service teachers. The National Council for Curriculum and Assessment (NCCA) recommended that Science should be offered as an elective option for pre-service primary teachers in addition to two compulsory Science education modules.

Five elective science modules have been outlined and approved; Physics, Chemistry, Biology, Creativity in Science and Environmental Awareness and Care. The first of these electives was developed and delivered to pre-service primary teachers in the Autumn semester 2015. This elective was :Science is all around us 1: Chemistry.

Much research has been carried out investigating pre-service primary teachers' perceptions of science. Many of these students may have a negative perception of science because they may not have studied it at primary or second level education themselves or perhaps experienced science in a didactic manner. Science subjects are not an entry requirement for the Bachelor of Education in Primary Teaching.

Specialist courses such as this Chemistry course have potential to provide the participants with a specialism in teaching science, which would facilitate teachers in developing the confidence and expertise to develop their own science teaching and also contribute to the whole-school context.

The author recognises the need to reflect and learn from the participants' expereinces of this inaugural elective science programme. Some of the challenges faced include the inter-relationship between Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK) and the pre-service teachers' perceptions and self-efficacy of science. This challenge has prompted reflection on the complex relationship between SMK and PCK in this context in the endeavour to find the optimum balance.

The short paper provides detail of the Chemistry elective module: the learning outcomes, an outline of the course content and delivery as well as an insight into the students' experiences of the first science specialist elective.

1. Introduction

1.1 Overview primary teacher education and primary science in Ireland

The current primary curriculum in Ireland was introduced in 1999 [1].Until recently, concurrent Initial Teacher Education (ITE) programmes for primary teaching were three years in duration. Since 2011, concurrent ITE programmes are now four years[2]. Following a report from the National Council for Curriculum and Assessment (NCCA) in 2008 on *Science in the Primary School* [3], it was recommended that ITE programmes should provide in-depth science education courses (in addition to existing curriculum science courses). Another NCCA report (2008) on curriculum overload in Irish primary schools acknowledged the diversity of challenges that primary teachers face and recognised that the pressures faced by Irish primary teachers are not indifferent to their counterparts in UK, and Australia [4]. Primary teachers have a broad curriculum which lends many challenges for appropriate development of Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK) in varied curricular areas. Primary science in Ireland is part of the Social Environmental and Scientific Education (SESE) syllabus. The SESE syllabus consists of three subjects: Science, Geography and

History. The teaching of primary science involves the development of two types of understanding: conceptual understanding and procedural understanding.

1.2 Challenges of teaching primary science

Research in the UK [5, 6] and Ireland[7] has found that although some pre-service primary teachers are positive about teaching science, insufficient SMK is still a concern. Many are also apprehensive about teaching methodologies and classroom management issues in teaching science[7]. In addition to the complexity of balancing SMK and PCK, Cremin *et. al* (2015) outlined many synergistic features of teaching primary science: play and exploration, motivation and affect, dialogue and collaboration, problem-solving and agency, questioning and curiosity, reflection and reasoning, and teacher scaffolding and involvement[8]. In comparison to second-level science teachers, who are often specialists in one discipline, the majority of primary school teachers have limited knowledge in both SMK and in science PCK. Teachers with low SMK and low confidence employ various strategies for coping, some of which when regularly applied have a severely limiting effect on children's learning[9].Many beginning primary school teachers use classroom and teaching activities that work, as a source of PCK in science. They rely on repeating science activities that have worked in the past. Although they may still be unsure of the SMK, this is an improvement from avoidance of teaching science.

The original[10] definition of PCK has been critiqued. However the fundamentals of subject matter, knowledge of students and possible misconceptions, knowledge of curricula, and knowledge of general pedagogy are consistent[11]. Researchers [12] in mathematics education have extended the two categories outlined in Schulman's (1986) scheme (see Figure 1), specifying the place of specialised content knowledge, which is distinct from the common content knowledge.

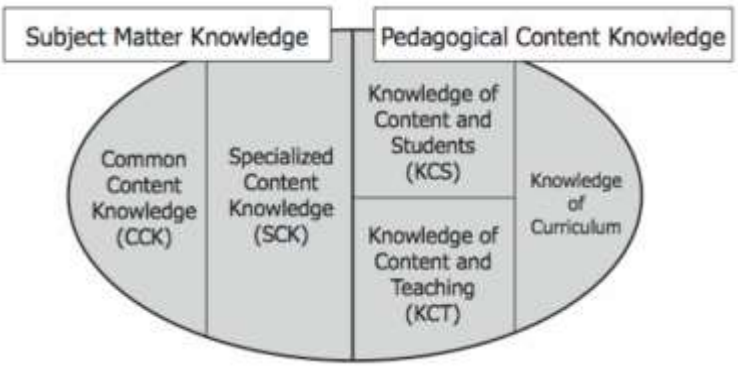

Figure 1. Shulman's (1985) Original Category Scheme mapped with Ball et al (2008) map of content knowledge [12]

2. Chemistry Elective Module

The overall aim of this module was to provide the pre-service primary teachers with the opportunity to develop the practical skills and competencies for teaching science by further developing the students' knowledge base in chemistry. Increasing teachers' own understanding is a key factor in improving the quality of teaching and learning in science [5]. Chemistry relates closely to the Materials strand on the primary science curriculum [1]. The learning outcomes of the module are outlined here. Students should:

- Develop a strong understanding of: the constitution of matter: elements and compounds; atomic theory of matter; classification of elements; states of matter; kinetic theory of matter; changes of state; physical and chemical changes; the concept of pH; chemistry of water; chemical bonding; properties of materials; solubility; separation techniques.
- Devise investigations of the properties and composition of various materials appropriate to the different levels in primary schools.
- Examine common misconceptions held by children in the area of materials, selecting and practicing appropriate analogies and intervention strategies to develop a greater understanding in these areas.
- Demonstrate a wide variety of teaching strategies to encourage creativity and higher order thinking in the primary science classroom.

- Apply the science knowledge they have learned to innovative interesting everyday topics for primary pupils.
- Integrate the topic on the Strand Units: Properties and Characteristics of Materials and Materials and Change with other aspects of the primary curriculum.

The topics for each week of the programme included: Kitchen Chemistry, Materials in the home, Water, Food Science, Gases in our world, Separating Substances, Chemistry and Exercise, Forensic Science, Exploring ICT and Primary Science Resources. The programme also included practical teaching experience. The students developed their content knowledge through individual, paired, group and whole class inquiry activities. The chemistry content knowledge was introduced in a spiral manner concurrent with the pedagogical knowledge.

3. Methodology

In total 19 students (9 males, 10 females) studied the Chemistry elective module. All students were in their third year of the B.Ed. programme. It is important to acknowledge that while this module was an elective programme, many of the 19 students had not chosen Chemistry as their first choice. Two evaluative questionnaires (Survey A and Survey B) were completed by the students on the final week of the programme. The author accepts the possibility of respondent bias in the feedback, given that the evaluations were completed before the module assessment. Survey A was administered by the lecturer. It was designed by the lecturers and approved for distribution by the research ethics committee in the college. It was composed of 14 short open-ended questions. This survey was completed by 13 students. Survey B was designed and administered by an external colleague from the Centre of Teaching and Learning within the college. This was an independent and confidential Student Evaluation of Teaching (SET). Survey B was composed of 11 closed Likert scale questions and one open ended question for additional comments. This survey was completed by 16 of the students. The students' responses were anonymous in both questionnaires.

4. Participants' perspectives of the Chemistry elective module

The students' responses to the Likert scale questions in Survey B are summarised in Table 1. The points on the Likert scale were Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A) and Strongly Agree (SA). Additional comments from the students in the open section of Survey B echoed the Likert responses; they really enjoyed the module (n=2), found it both challenging and interesting (n=2) and they felt an increased confidence in their future approach to teaching science (n=3). Three students felt that they had increased their understanding of chemistry but two students still expressed concern about their chemistry subject matter knowledge.

In the findings from Survey A, the students had expected the module to be more theory-laden. However, they were positive about the integration of theory and pedagogy; "*I didn't expect to actually enjoy it, but I found the combination of the chemistry and methodologies was beneficial to my teaching*". The students appreciated the time given for them to experience the concepts, activities and resources and the teaching experience with junior classes. The students felt that they had developed their content knowledge "*it gave me a greater understanding of concepts rather than just experiments"* and pedagogical knowledge "*I feel I know more about what it is and how I am teaching*". The students (n=13) were more confident about teaching primary science. The development of content knowledge, confidence in using a lesson framework and the opportunity to teach infant classes were key factors. Challenges that the students felt still exist included classroom management and the fear of not knowing all of the content knowledge.

Table 1. Summary of the students' response to the Likert statements. Data is presented as percentages (n=16)

	Statement	SD	D	U	A	SA
Students' experiences	I attend most / all required contact hours	0	25	6.3	25	**43.8**
	I do all I can to contribute to my learning	6.3	0	12.5	**56.3**	25.0
	I find this subject interesting	0	0	0	25	**75**
Structure & course materials of the module.	This is an effective module	0	0	0	43.8	**56.3**
	The objectives are clear	0	0	6.3	**50**	43.8
	Well organized and arranged	0	0	6.3	31.3	**50**
The lecturer	Is effective in teaching the module	0	0	6.3	25	**68.8**
	Communicates well in class and can explain difficult material	0	0	6.3	25	**68.8**
	Is well prepared	0	0	6.3	12.5	**81.3**
	Is interested and enthusiastic	0	0	0	6.3	**93.8**
	Is knowledgeable about the topics	0	0	0	6.3	**93.8**

5. Implication for future Science electives

The subjective feedback of the first participants in the inaugral science elective are generally positive. The challenges were similar to challenges faced by many in-sercice teachers relating to practical issues: lack of time, handling big classes, students working at different paces, handling materials, and classroom management [13]. It is important to learn from this first experiecne of developing and teaching an elective module. The aim of science pedagogy cannot be to enable teachers to know the answers to all the questions children may ask [5]. This would be impossible and inadvisable as children would not understand the answer. Harlen (1997) emphasised that teachers need pedagogical strategies for handling children's questions for appropriate investigative learning. It is important that while development of subject matter knowledge can contribute to pre-service teachers' confidence in teaching, it is important that this content knowledge is appropriately balanced with specific science pedagogical approaches. The challenge as teacher educators is to coalesce the students' needs and address thier concerns. Wiliam (2011) described five key principles to help making the teaching 'adaptive to student needs'[14]: Clarifying, sharing and understanding learning intentions and criteria for success, Engineering effective classroom discussions, activities and learning tasks that elicit evidence of learning, Providing feedback that moves learning forward, Activating learners as instructional resources for one another and Activating learners as the owners of their own learning. The inclusion and implementation of such principles in future science elective modules will help to improve the holistic learning for the student teachers.

Much of the positive feedback from this chemistry elective emphasizes the value and need for such specialist focus on science electives given the ongoing evidence of the diffilcties experienced and lack of confidence of gernalist teachers with primary science [15]. However, given the nature of an elective specialism, only ~5% of the student cohort will have the opportunity to take part. This in turn has implications for the need of science specialist professional development for in-service primary teachers.

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References

[1] DES, Primary School Curriculum - Science; Social, Environmental and Scientific Education. 1999, Department of Education and Science: Dublin.
[2] TeachingCouncilofIreland, Initial Teacher Education: Criteria and Guidelines for Programme Providers 2011, Teaching Council: Dublin.
[3] Varley, J., C. Murphy, and O. Veale, Science in Primary Schools- Phase 1. 2008, National Council for Curriculum and Assessment: Dublin.

[4] NCCA, Curriculum Overload in Primary Schools -An overview of national and international experiences. 2008, National Association for Curriculum and Assessment: Dublin.
[5] Harlen, W., Primary Teachers' Understanding in Science and its Impact in the Classroom. Research in Science Education, 1997. 17(3): p. 323-337.
[6] Murphy, C., P. Neil, and J. Beggs, Primary science teacher confidence revisited: ten years on.Educational Research, 2007. 49(4): p. 415-430.
[7] Murphy, C. and G. Smith, The impact of a curriculum course on pre-service primary teachers' science content knowledge and attitudes towards teaching science. Irish Educational Studies, 2012. 31(1): p. 77-95.
[8] Cremin, T., et al., Creative Little Scientists: exploring pedagogical synergies between inquiry-based and creative approaches in Early Years science. International Journal of Primary, Elementary and Early Years Education, 2015. 43(4): p. 404-419.
[9] Harlen, W. and C. Holroyd, Primary teachers' understanding of concepts of science: impact on confidence and teaching. International Journal of Science Educaion, 1997. 19(1): p. 93-105.
[10] Schulman, L., Those who understand: knowledge growth in teaching. Educational Researcher, 1986. 15(1): p. 4-14.
[11] Appleton, K., How Do Beginning Primary School Teachers Cope with Science? Toward an Understanding of Science Teaching Practice. Research in Science Education, 2003. 33: p. 1-25.
[12] Ball, D.L., M.H. Thames, and G. Phelps, Content Knowledge for Teahcing- What makes it special? Journal of Teacher Education, 2008. 59(5): p. 389-407.
[13] Whalan, S., B. McEwen, and N. Gericke, Enhancing primary science: an exploration of teachers' own ideas of solutions to challenges in inquiry- and context-based teaching. International Journal of Primary, Elementary and Early Years Education, 2015. 3(13): p. 1-12.
[14] William, D., Embedded Formative Assessment 2011, Bloomington, IN: Solution Tree.
[15] Appleton, K. and I. Kindt, Why teach primary science? Influences on beginning teachers' practices. International Journal of Science Education 2010. 21(2): p. 155-168.