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# Working scientifically: Positioning research into inquiry based practice for pre-service teachers.

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## ABSTRACT

Dominant discourses promote the notion of lifelong learning that fits snugly into the creation of on-going professional development for beginning and experienced teachers. In this paper I present a discourse/textual analysis highlighting the process of confidence building and critically reflect on whether this is enough for beginning teachers, opening the avenue for researching our own practices and establishing an on-going market for professional development. One of the aims of this research project was to establish a baseline for further research and professional development for beginning teachers, thus positioning the researcher in an on-going relationship with potential respondents.

Data presented focuses on the experiences of one cohort of pre-service primary teachers who elected to do an inquiry-based course to supplement their pedagogical knowledge for teaching science at the primary level. This cohort had limited knowledge of science concepts and processes but realised that they would be expected to teach science as a Key Learning Area in Queensland schools. During that time many students moved from being nervous to being motivated to teach science. Many of these pre-service teachers saw the teaching of science could be an inquiry-based process emphasising working scientifically, rather than regurgitating a standard body of facts or conclusions.

## INTRODUCTION

There has been growing concern regarding the quality and quantity of science being taught across Australia(Goodrum, Hackling, & Rennie, 2000). This concern has come from a perception of low scientific literacy levels within the general population. The answer to this low level of scientific literacy according to the Federal Government is to have appropriately trained teachers both confident and competent in their own scientific literacy (Committee for the Review of Teaching and Teacher Education, (CRTTE), 2003). Research has shown some worrisome trends in the teaching of science at both the primary and secondary school levels. Appleton and Asoko (1996) found that there was a reluctance on the part of many primary teachers to teach science. Coupled with this is an

approach whereby some teachers are subsuming science under SOSE or other subjects where rather than working scientifically and focusing on science concepts, students are developing core skills that relate to reading, writing or researching *about* science (Appleton, 2003). Appleton and Asoko (1996) suggest that primary teachers typically lack science content knowledge and subsequent pedagogical knowledge (PCK) that enables them to teach science effectively.

In 1999 a new science curricula was introduced in Queensland that specifically addresses the development of students' conceptual understandings in science (Queensland Schools Curriculum Council, 1999). Embedded within this document is a process emphasising 'working scientifically' designed primarily to achieve scientific literacy (Abd-El-Khalick & Lederman, 2000; Committee for the Review of Teaching and Teaching Education, (CRTTE), 2002). Driver, Squires, Rushworth and Wood-Robinson (1994) remind us that students actually develop ideas about natural phenomena before they are taught science at school. Therefore children come to the classroom with their own conceptions and ideas about how science works and what science is. Osbourne and Freyberg (1985) suggest however that while students have ideas about science these may not always be scientific views on science. Taking this to the level of pre-service teachers I would suggest that these students come to university with diverse and heterogenous repertoires of knowledges, beliefs and values that include contemporary and redundant perceptions relating to science. Some of the students enrolling at our university are school leavers and therefore we would surmise that much of their attitudes towards science reflect their recent school experiences. The other group of students enrolling for the Bachelor of Learning Management (BLM) pre-service teaching degree comprise mature age students with many starting second careers because of local redundancies or embarking on first careers after years of being at home with family responsibilities. This group brings life experience of other societal institutions as well as their memories of school experiences from sometimes twenty or more years.

Added to this is the focus on constructivism as a way of teaching and learning science. Closely aligned with constructivism is the inquiry process. In an inquiry classroom the teacher formatively assesses student learning (Black, 1993) asks questions, provides cues and functions as a co-learner. Together the teacher and students identify questions, design research methods or a fair test, investigate, negotiate findings and test predictions. Herron (1996) states that constructivism also requires that the teacher provide essential information such as the names of elements and details of life cycles for example, highlighting that students can not discover what took scientists decades to learn. What teachers do not do as part of the constructivist paradigm is to tell students what they can find out for themselves. What this means for our pre-service teachers is that they require both pedagogical knowledge but also some content knowledge associated with the topics and concepts they are required to teach as part of the syllabus. It then becomes our role as pre-service teacher educators to provide courses that build both confidence and competence in science teaching equipping the beginning teacher with the best tools on offer. As Appleton and Harrison (2000) found, low levels of confidence to teach science is one of the major factors contributing to teacher difficulties. In preparing BLM students for future teaching confidence building featured highly along with changing reductant

images associated with traditional notions of science as a body of 'known and proven' facts and textbook formulas.

**Context**

The context of this study was an intensive elective course that took place over a Spring/Summer semester. The course was designed to prepare pre-service teachers to teach primary science. The objective of the course was to improve understanding of physical science processes and ideas but as science knowledge is vast the lecturer chose to look at three concepts in greater detail. These concepts were floating and sinking (forces) mystery white powders and bright lights and batteries (electricity). This particular elective is one of two courses provided by a Science lecturer during the spring semester. He alternates an elective on the physical world with a course on the natural world that focuses more on biology. The course was delivered in an intensive face-to-face mode that meant that students attended two, three hour, workshops per week for five weeks. There were two pieces of assessment; the first consisted of a book review of a popular science book from the lecturer's recommended book list plus the answering of a curious science question again from the recommended list of the lecturer. The students needed to research the question, talk about it, carry out experiments if appropriate and then write a scientific explanation of the phenomenon. The second assessment piece concerned a concept cartoon. The students were to choose a key science concept and explore the understandings of 4-6 students in a primary classroom. This was to be linked to the Queensland syllabus and match the age and level of the primary student. The pre-service teachers were to do three things: firstly, determine the students' ideas about the chosen concept, secondly, ascertain any preconceptions and misconceptions and then thirdly, design a concept cartoon teaching intervention that clarified the chosen concept. During the fifth week of the intensive course the BLM students had to attend a pre-arranged primary school class and implement the second assessment piece prior to writing a reflective conclusion including recommendations of their teaching intervention.

**The study**

This paper is based on data from a larger study. The aim of the large study was to establish the kinds of perceptions and ideas about the nature of science and the teaching of science that BLM students brought with them into the compulsory and elective science courses on offer at CQU. Identifying these perceptions is important because it has shown that the way science is viewed often reflects the way in which it will be taught (Koch, 2002, p. 38). For example if a teacher views science as a particular body of knowledge that is based on 'the' truth, then that is the way that science will be communicated to the student. Alternatively if the teacher views science as a process of inquiry then that teacher is more likely to incorporate much more 'hands on' activities and investigations that students can physically do in the classroom and beyond. When science is seen as the investigation of the world that we live in, then students are likely to experience science as everyday phenomena.

With both the elective and compulsory courses two questionnaires were administered; in the elective course the first questionnaire was given out during the first workshop to attempt to capture the students' current attitudes. The questionnaires drew on an

established instrument known as VNOS (for full discussion of this instrument see Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; see also Lederman & O'Malley, 1990). As part of modelling a constructivist approach to science teaching this pre-course questionnaire was used to determine the students prior knowledge associated with science that could offer a way of getting to know the ideas that these students brought with them to this course. A second questionnaire was given out to the same people towards the end of the intensive course to capture any change of attitude and to assess any increase in content knowledge associated with some of the key concepts discussed during the course. I attended the classes held at the Rockhampton campus as a participant observer. Eight students from the Rockhampton campus were also interviewed after the course looking at explanations around floating and sinking. While the questionnaires covered a range of questions the data in this paper refers to three areas only and they are:

1) what did the student see as science
2) why was the student doing this elective
3) how can students be better prepared for teaching science

The methodological approach to this study combines an ethnographic and post-structural perspective and reflects the way that I view the world. In a broad sense the ethnographic emphasis highlights research around people with the purpose of exploring their attitudes and activities as a group. In this context I was researching a particular cultural entity — the science tutorial group. Ethnography involves collecting descriptive data that is later analysed and interpreted within a defined context and as Burns (1997, p. 298) declares

> a classroom never stands alone in isolation from larger cultural and social landscapes, such as local and national, political or economic processes and values. [Tutorial] activities take place against a background of premises, interests and values concerning what it means to be a student or teacher, and what constitutes worthwhile knowledge and learning.

What this means for my study of this particular intensive course was that there were a range of attitudes predicted around what a 'science teacher' did in the classroom and more importantly what a 'science teacher' needed to know. This is reflected in the emerging themes coming from the data. The following results are taken from a small section of the study that concerned the Rockhampton campus cohort only, where I reviewed qualitative responses to the three questions listed above.

**Participants**

The study included 150 students located in Mackay, Rockhampton, Gladstone and Bundaberg. For this paper I am focussing on one cohort of students from the Rockhampton campus. This particular class consisted of a mixture of first and second year students. There were 42 students enrolled for this course however not all of these students completed both questionnaires. Many of the BLM students were likely to be those school students who had avoided science when they were at school especially at the High School level. The lecturer predicted that their levels of science literacy were more likely to be low rather than high and that there would be some misconceptions around the concept of floating and sinking as balanced/unbalanced forces. The students enrolled in this elective course wanted to develop their working knowledge of teaching primary

science; when talking with this group during classroom activities I found that many of them had had less than good school science experiences but realised as future teachers that they would need to teach science at this level.

## RESULTS AND DISCUSSION

In this section I review three questions from the pre and post course questionnaires. The first question appeared in both questionnaires. This was to see if there was any change in the students' perceptions of what science was. The second question asked the students why they had chosen this elective. There were three main reasons: the first related to timetabling and choice; the second to content knowledge while the third reason was related to pedagogy. In asking the last question addressed in this paper, I wanted to know from the participating students as to how they thought the course could better prepare BLM students for teaching science.

### The first question: what do you see as science?

The first question — what do you see as science — was asked in both the pre and post course questionnaires. This was to attempt to identify and illustrate any change in students' perceptions regarding the nature of science. Key themes among the pre-course questionnaire responses included the following:

- Science was associated with how the world worked
- Science explained how the world worked
- Science was experiments and
- Understanding the world

In the post-course questionnaire the key themes followed more of a process rather than answers to how the worlds worked:

- Discovery
- Investigations
- Increasing knowledge around the world through experiments and
- Finding out about the world.

Responses from seven students indicted a change in their perception of what science was. This can be seen in the following responses:

> Knowledge, theories, reports, proven facts. Experiments etc, regarding the natural and living world (St 25 pre-course).
> Learning about the world we live in (St 25 post-course).

Some students such as St 10 were not sure what they saw science as in their pre-course questionnaire but had developed a more precise working definition by the second questionnaire:

> Not sure (St10 pre-course)
> The discovery process involved in finding out the 'why's' of a problem or concept (St 10 post-course).

Sixteen students did not vary their answers as seen in the following common responses:

> Reasonings for why things happen (St 4 pre-course)

> Providing reasonable answers for natural phenomena (St 4 post-course)
>
> Science is all around us; I see science as some of the obvious things around us but also the technical and not so obvious things in our world (St30 pre-course)
> Science is everywhere; I see science in many everyday experiences and others (St 30 post-course).

Many students were reluctant to offer any concrete examples, especially in the pre-course questionnaire. This may well be due to being put 'on the spot' to answer a questionnaire with limited preparation. The only exposure to the course prior to the questionnaire had been the course profile. This document outlines the course timetable and assignments but does not explain, in great detail, any science content that may be related to the course. There is the possibility that students were hesitant in their responses because they may have felt that the questionnaire was being used to indirectly test their knowledge about science.

There were however nine students who were much more precise or confident about their answers in their post questionnaire response. The basic underlying meaning did not change but they included more precise 'process' descriptors in their response such as the following:

> The explanation of how things work and why things are (St 2 pre-course)
> Discovering how things work (St2 post-course).

The difference between the kinds of answers provided in the pre-course questionnaire to those provided by the same respondent in their post-course questionnaire focused around the language used. In the post-course questionnaires many of the students provided more precise description that used words associated with 'working scientifically' (Queensland Schools Curriculum Council, 1999) such as investigation, testing processes, doing experiments. Comments from the pre-course questionnaires were more aligned with the idea that science explained things, provided an answer and resulted in a body of facts and that science for some was a way of understanding the world. While many attitudes remained similar, these attitudes corresponded to a view that perceived science as a way of understanding and explaining the world. Between the two questionnaires other students had moved their perception of science away from being a study of things or the world to that of science as investigating the world around us.

**The second question: why are you doing this course?**

When asked why the students were doing this course, there were three basic reasons: the first reason related to timetabling and choice. Seven students indicated that this elective was best option for them during the spring/summer semester:

> Because I don't want to do HPE (Health and Physical Education) or Drama and there are no other choices (St 33 pre-course).
> Did not like the others (options) (St 01 pre-course).

All BLM students are required to do courses during this semester however there is a small choice among courses. Unfortunately those students doing early childhood courses do not have the option of doing a science elective as well. There is a misguided assumption here that early childhood teachers would not be interested in teaching science to their little students. Many of the BLM students did not want to do HPE or Drama so by default ended up doing the science elective.

The second reason concerned improving their knowledge base around science concepts. This was by far the most common reason for choosing to this course. Sixteen students indicated that they wanted to increase their science knowledge. This referred to content rather than pedagogical knowledge. One student stated that he wanted:

> To learn about concepts that I missed during my school years, I need the experience (St 10 pre-course).

This student was a mature-age male student who had been working in a labouring job prior to doing the BLM degree. Another student, male and a recent school leaver stated:

> Science is an area I feel I'm weak in. If I am going to teach science I'll need to know what I'm teaching so I'm hoping that this subject will improve my science knowledge (St 26 pre-course).

The third reason was to learn how to make science lessons more enjoyable and for the students to become more effective teachers. This last reason hints at a common discourse of science as boring and can be related to past school experiences of 'high school science' where some of these students alluded to 'boring textbook stuff' or 'formulas that meant nothing'. In other words they did not want to teach science in a way that could either turn off students or to be seen as boring, uninteresting and just textbook rote learning. This reason also indicates the pedagogical approach that students wanted to improve rather than just content knowledge.

> I am interested in science and would like to learn more to successfully teach science (especially to make science more interesting to school children) (St 25 pre-course).

This student was a mature-age woman with young children whereas St 11 is female and a recent school leaver:

> So I will learn skills that make my science lessons engaging (St 11 pre-course).

There is the possibility here that this student may have been reflecting on her own experiences of 'school science' and did not want to be the kind of teacher who had uninteresting science lessons.

**The third question: how can we better prepare students for teaching science?**

This question appeared twice in the post-course questionnaire in two different forms. Initially the students were asked what they would like to see in science courses for primary teachers and a follow up question asked more directly about what the students thought could be done to better prepare them for science teaching. The key themes

emerging from both questions related to resources, content knowledge and pedagogy skills. There were two sub-themes regarding resources. While nine students suggested that more resources were needed the example put forward implied that a workbook similar to what had been offered during the course would be ideal. Students commented that they wanted the course to:

> Provide a useful resource of references to books, booklets, websites that will be useful when teaching (St 36)
>
> Show us how to find resources, booklets like the maroon one (workbook) with lots of simplified explanations and experiments to assist teachers; needs to cover simple concepts (St 11).

Comments such as these could be worrisome as they may indicate that the students want resources that give them very simple explanations or content knowledge of scientific concepts, implying that they weren't sure about their understanding of the concepts covered in the elective. The workbook had consisted of four unit plans complete with individual lessons that built on each other working towards the student developing their understanding of a concept in various steps. For example floating and sinking was implemented over three weeks in a series of seven lessons that worked towards floating as a balanced force. The second sub-theme concerned the provision of activities. Most students wanted more activities or experiments had could then be done in their classroom. Responses that illustrated this were as follows:

> More hands-on experiments – this is where I feel we learn the most because we are seeing and doing while experiencing it ourselves. This will be the same for children. There needs to be some conclusion for each experiment though to increase our understanding (St 02).
>
> Experiments to discover concepts – like we have done in class (St 21).

Many students like St 02 wanted a repertoire of activities to teach in the classroom. This is a two edged situation. On the one hand I would support BLM students to have as many activities/experiments as possible to choose from when they are implementing or planning a science module. If, however, the desire to have lots of activities was more about having the activities somehow provide or explain the 'answer' for both the beginning teacher and the primary students, then this would suggest that these BLM students have misunderstood constructivism. There could be an implication here that some of the students who are still unsure of their own competence levels could perhaps be relying on the activities to *do* the teaching rather than *support* the teaching of a particular science concept. Nine students expressed a desire for more pedagogical skills:

> Writing unit plans, looking directly at assessment and learning outcomes (St 36).
>
> Ideas of how to teach science for primary students and also how to explain scientific concepts to them (St 31).
>
> Give more information (from experiences or known knowledge) as to what is the best way or most effective way to teach science concepts to students (St 30).

While the focus is basically pedagogical, it could also be argued that there is an underlying discourse related to content knowledge. Three students were concerned about identifying student misconceptions in their own classes while fifteen students felt the course should be offering more content knowledge to plug their gaps. This was indicated through such statements as:

> Make sure that they have a solid base of scientific knowledge to help them prepare lesson and unit plans when they teach science (St 16).
> Give them more knowledge of scientific content the more confident we are the more likely we are to teach it (St35).

St 35 sees her confidence to teach science at the primary level being related to her level of content knowledge of science. There was still an underlying desire to have more content knowledge before feeling confident to teach science among some of the students on this elective course. Indeed some of them had enrolled hoping to supplement their science understandings as indicated by the responses to the second question outlined in this paper. I would argue that this is positive rather than negative as it highlights the way in which some students have identified their own knowledge gaps. As lifelong learners these students are demonstrating their personal learning management through expressing a desire to supplement their current science knowledge. I would also argue that presenting science as a process of working scientifically and co-learning with students is not enough to raise the confidence levels of many of the pre-service teachers on this course. The data presented in this section points to students wanting content knowledge, resources, more activities and pedagogy.

The overriding theme with these questions is the notion of pedagogical content knowledge. Unfortunately these students all wanted pedagogical content knowledge without actually going through the process of developing this through experience. The one thing that courses like this elective cannot do for students is develop their own experiences based on their level of content knowledge and teaching experience. The students wanted a mixture of activities that work (Appleton, 2003; Appleton & Harrison, 2000) and an in-depth knowledge of both appropriate scientific conceptions and student misconceptions. One of the aims of the course was to change the perception that teaching science was about knowing scientific facts and move these students towards understanding science as a process of guided discovery assisted by content knowledge. However I would argue that for some of the students, learning to work scientifically may not be enough to raise confidence levels to embark on science as co-learning with their students.

Anecdotal evidence gathered post-course during informal chats with many of the students, signalled their willingness to teach science at the primary level. Now while they are willing, there was also a desire to have/seek out more resources to enable them to achieve this; nearly every student indicated that providing more information, both with content and related pedagogy, would better prepare them for teaching primary science.

In essence the course had been successful in two things

1) changing a few redundant images and perceptions around the nature of science and
2) raising confidence levels of some students to approach science teaching

I argue that many of these students want more support before raised confidence and competence levels could become a reality for them. The students enrolling on this elective were the ones interested in doing science teaching to start with, albeit some by default. Most of the students really enjoyed the 'hands-on' approach of implementing activities that could be done in the regular classroom rather than a laboratory setting. Neither did these activities require expensive or enormous resources. Many students were excited by 'working scientifically' or an inquiry based process. There was hesitation with ascertaining misconceptions of primary students because of a perceived lack of knowledge around 'appropriate' science knowledge and understanding.

**CONCLUSION**

What this means for pre-service teacher educators is some creative thought around how to better equip university students to enter the classroom as early career teachers armed with the desired PCK. Is it just a matter of running extra 'content knowledge' courses, building higher levels of confidence, running continuing professional education programs and mentoring? It raises another debate – should schools employ specialist science teachers at both the primary and secondary level (following the Yr 1-10 curriculum) meaning that science teaching becomes a postgraduate course. Time is something that most BLM students lack; most are working part time and studying full time. Many students find their workloads are such that even the so-called brightest of students — however that is defined — can often only manage to do the bare minimum of reading required to gain a pass/credit in their assessment.

The original aim of the study was to look at ideas around the nature of science held by a specific cohort of students. I believe that there has been some attitude change among this group of students relating to understandings of the nature of science that has, in turn, raised some confidence levels in their willingness to teach primary science. Despite developing an understanding of science as tentative, changing, contextualised and political, I would suggest, however, that many of these students still felt that there were enormous gaps in their everyday understandings of specific science concepts. Having said that I also believe that many of these students were excited by the 'inquiry' based approach and the constructivist teaching and learning framework used to 'do' science in the classroom. There was anecdotal evidence of apprehension among the BLM students concerning their own limited knowledge of preconceptions and misconceptions held by primary students; again this can be linked to the BLM students' personal gaps in science understandings. As beginning teachers this particular cohort wanted access to resources and activities that they could use in their classes, however a reliance on activities that work (Appleton, 2003; Appleton & Harrison, 2000) could inhibit these teachers in developing their own PCK and deeper understandings of both specific science concepts and the current Queensland science syllabus.

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