Facilitating Meta-learning in Pre-service Teachers: Using Integration and Slowmation Animation

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Abstract

Meta-learning relates to one’s ability to have an awareness of one’s self as a learner, and being able to use this ability to become a more effective learner. It is important for pre-service teachers to develop this self-awareness about their own cognitive processes so that they can become more skilled in their approach to learning and therefor teaching. They become better equipped to make conscious changes in their approaches to learning and become more productive, independent learners (Winters, 2011). The purpose of this study was to use an inquiry-based learning experience so that primary pre-service teachers could explore their understandings of inquiry and begin to develop a meta-learning approach by integrating an innovative technology into a science methods workshop. Effectively, the aim was to create a learning experience for pre-service teachers that would enable them to participate in modelled inquiry experiences during their university classes, using curriculum and materials that were aligned with the requirements of the Australian Curriculum: Science, and had a focus on teacher content knowledge (knowledge of science subject matter (e.g. biology, physics), and knowledge of classroom inquiry). Inquiry-based learning and teaching is central to Australia’s national science curriculum – the Australian Curriculum: Science. Australian teachers are mandated to apply inquiry-based learning in their classrooms, but unfortunately very few classroom teachers have experienced a scientific inquiry, and even the most experienced teachers appear to have little knowledge of inquiry (Capps & Crawford, 2013). It is quite possible that most of Australia’s teachers learnt science through the traditional approaches. Loucks-Horsley et.al. (2003), argue that it is very difficult for a teacher to teach in ways in which they have not learned themselves. Thus, this paper explores the impact of an inquiry-based learning experience, as part of a teacher training program, in terms of self-awareness and meta-learning.

1. Introduction

The purpose of the study was to explore the understandings of primary school pre-service science teachers as they undertook an inquiry-based learning experience. Inquiry-based learning and teaching is central to Australia’s national science curriculum – the Australian Curriculum: Science (ACARA, 2013). One of the unique aspects of the Australian Curriculum: Science is the emphasis on practical work and inquiry-based
learning. The three strands that comprise the Australian Curriculum: Science (Science Understanding (SU), Science Inquiry Skills (SIS), and Science as a Human Endeavour (SHE)) are interrelated. No individual strand can be pursued as a discrete learning outcome. Both the SIS and SHE strands must be inextricably linked to the development of understanding. The aim of this paper is therefore to describe how an inquiry-based learning experience, integrated with an innovative technology, as part of a teacher training program, lead to transformative learning via excitement and inspiration, self-awareness and meta-learning. Just as it has been well documented that teachers need to identify and build on their students’ prior knowledge and ideas when teaching science, it is equally important for the pre-service teacher to identify and build upon their own ideas of not only science subject matter, but on their science pedagogical practices. Science subject matter knowledge alone is insufficient for teachers to teach well, they need the integration of pedagogical knowledge. The paper begins with an explanation of transformative learning, and then moves to a brief description of Slowmation Animation, the innovative technology used in the study.

1.1. Transfomative learning

Sterling (2010-11) writes of the assumption that learning is self-evidently a ‘good thing’ and that much learning discourse is directed towards “making learning effective, to learning to learn, learning methods and so on” (p. 18). There is scant discourse given to the notion of the purpose of learning. Through considering the process of learning, a qualitative shift in perception and meaning making, as performed by the learner, can result in a reframing of assumptions and thinking customs – transformative learning. Stirling builds upon the earlier works of Bateson (1972), Mezirow (2000), and Morrell and O’Connor (2002) in defining and exploring this concept of transformative learning. This work describes orders of learning and change:

- **First-order learning** is the most common form of learning. It relates very much to the world external to the learner. The material is content led, and often delivered through traditional transmissive pedagogies. This information transfer often leads to surface or shallow learning. Ideas already available to the masses are presented to the learner and regurgitated when required.

- **Second-order learning** occurs when there is a change in thinking or personal awareness. The learning has taken on an internal dimension whereby a critical examination of the self, in relation to the content matter occurs – a form of meta-learning. This learning is said to be deeper than the surface/shallow learning evident in first-order learning. Prior learnings are challenged and questioned and the purpose of an activity or the content is explored. Kelly and Cranton (2009) state that when a learner questions their assumptions and this then leads to a shift in how the learner sees themselves in relation to the world and content, then they have engaged in transformative learning. Through successive iterations, the deep learner undergoes a process of meta-learning and becomes aware of them-self in the learning process. A deeper conceptual and pedagogical learning is taking place. This may be viewed as an engagement in quality learning approach to learning – the focus is upon the learning process and not on the product.

Sterling (2012-11) describes any shift from first-order to second-order, as sometimes painful to the learner. Resistance may occur as existing understandings, beliefs and values are challenged. The learner is required to reconstruct meanings which may cause discomfort. However, a learner may also experience excitement and inspiration.

1.2. Slowmation Animation

Slowmation Animation is a simplified version of Claymation (the animation process used to make movies like Happy Feet) that uses many of the same learning processes – “researching information, planning and writing a story, storyboard, designing models, taking digital photographs, using visual literacies, using technology, evaluating and, most importantly, working collaboratively as a team” (Hoban, 2005, p. 27). Hoban’s study outlines a seven step procedure for making a Slowmation Animation movie: 1) Plan, research, teach, 2) Jigsaw, 3) Storyboarding and story writing, 4) Making and photographing, 5) Download and import, 6) Enhance and Edit, and 7) Show. Keast, Cooper, Berry and Loughran (2008) describe a three step process they use in conjunction with Slowmation Animation: (A) representation: recognising how the scientific concept can best be represented; (B) deconstruction: identification of the major elements of the process [chunking] through a storyboard; and (C) reconstruction: the re-chunking and synthesizing or model making and movie creation. Keast et al. go on to describe Slowmation Animation as a translation task “in which learners translate information from one form into another. In this case, Slowmation requires students to translate abstract scientific information into models to produce animated movies that demonstrate their understanding of the given concept, topic, or idea under consideration” (p. 3).

There is a dearth of research pertaining to the meta-learning resulting from the creation of a Slowmation
Animation. Most research reports the procedural nature of Slowmation Animation. Very few, if any investigate “the value of the teaching approach for student learning” (Hoban & Ferry, 2006, p.2), but instead they explore the pedagogical approach for teaching science concepts in higher education classes. The exceptions are papers which describe my research along with that of Keast and Cooper. Individually and collectively we have considered the creation of animations through the theoretical framework of conceptual change as well as the present account of transformational learning. This is responding to the call by Yore and Treagust (2006) who noted a need to investigate “the enhanced cognition that occurs during the transformation from one representation to another representation or one mode to another” (p. 208). Viewing Slowmation Animation as a translation task is essential when considering the meta-learning potential behind the creation of an animation.

2. Methodology

The inquiry-based learning experience met the requirement that when teaching the Australian Curriculum: Science, the three content strands are to be interrelated, and that the general capabilities are developed with a cross-curricula emphasis. The learning experience was mapped against the Australian Curriculum: Science (ACARA, 2013) content strands in the following way:

- Science Understanding: Biological sciences (Living things have structural features and adaptations that help them to survive in their environment (Year 5)); Physical Sciences (The way objects move depends on a variety of factors, including their size and shape (Foundation), A push or a pull affects how an object moves or changes shape (Year 2), Forces can be exerted by one object on another through direct contact or from a distance (Year 4))
- Science as a Human Endeavour: Nature and development of science (Science involves exploring and observing the world using the senses (Foundation), Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena (Year 5)); Use and influence of science (People use science in their daily lives, including when caring for their environment and living things (Year 1, 2), Science knowledge helps people to understand the effect of their actions (Year 3, 4), Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples’ lives (Year 5, 6))
- Science Inquiry Skills: (Questioning and predicting; Planning and conducting; Processing and analysing data and information; Evaluating; and Communicating).

2.1. Participants

265 pre-service teachers training to be primary teachers participated in the study. The participants were all enrolled in a core unit in the first semester of their first year of a 4 year university teacher training course. The vast majority had completed 2 years of post-compulsory high school six months earlier. The participants would not formally enter a school for a teaching practicum for a further 12 months, so all school and teaching experiences were from their own perspectives as a learner. The observational and video data was collected from 26 participants for closer analysis.

2.2. Intervention

The unit was an integrated science and mathematics content knowledge unit designed to familiarise pre-service teachers with core ideas of the science and mathematics disciplines. A 2 hour lecture and a 2 hour practical workshop were timetabled for each week. The learning experience was designed to occur over a 4 week time period. Initially the pre-service teachers participated in a workshop exploring fresh water invertebrates using digital microscopes, working in groups of 3 or 4. The learning outcomes were to produce an anatomical sketch of a single invertebrate (to develop scientific and microscopic drawing skills), to save a jpeg file of their invertebrate (a photo to assist with later identification), and to record a short 10 second movie of their invertebrate, in motion, in their water sample (to assist with a subsequent ICT workshop). In the subsequent lecture the pre-service teachers explored the development and use of a ‘Slowmation Animation’ (see Hoban, Loughran & Nielson, 2011) for science teaching and learning. In the 2 hour workshop, the pre-service teachers accessed the internet, their sketches, photo and 10 second movie, and used modelling clay and their own cameras or cell phones to create an animation that depicted their group’s understandings of invertebrate motion and associated forces. Each group then presented their animation to the class in a workshop, discussing their learnings and their creative intent. During all in-class sessions, the instructors modelled how to teach skills and content using an inquiry approach.
2.3. Data

The data was collected using a mixed method approach. A short identical pre-test and post-test instrument consisted of 10 multiple choice questions (investigating subject matter knowledge) and 3 open response items (exploring ideas of inquiry-based learning and teaching and the use of ICT’s in the classroom). Classroom observations and pre-service teacher comments that were collected by the instructors using a checklist as well as ad-hoc questioning and conversations during lectures and workshops. The scientific drawings and animations were collected along with a video recording of the animation presentations and discussions for later analysis.

3. Findings

So that the findings of the study could have no bearing on the assessment results assigned to each participant upon completion of the unit, data analysis was delayed until after unit results had been released to the participants. The analysis of the pre-tests revealed that 89% of overall cohort had little or no knowledge of motion and forces, and 54% of the overall cohort had little or no knowledge of freshwater invertebrates and ecosystems. Only 5% of the participants displayed knowledge relating to the structural features and adaptations of organisms that help them to survive in their environment (Year 5 content of the curriculum). Post-test results showed an overall improvement for all participants. This was to be expected as many participants would have invested greater time and thought more deeply about or investigated the concepts (test-retest effect). A number of four-point rubrics were developed to analyse the open-response questions, the artefacts and the presentations/discussions (0 = naive, 1 = emergent, 2 = informed, 3 = developed). At the time of the pre-test, there was a range between 0 and 2 of understandings of inquiry-based instruction and of 1 and 3 of understandings of ICT instruction. The mean score was 0.9 for inquiry, and 1.3 for ICT’s. By the time of the post-test, both ranges had shifted, and mean scores rose to 2.1 for inquiry, and 2.5 for ICT’s. The item that contributed most to the improved post-test score for inquiry was “Do you think inquiry-based instruction is worthwhile in the classroom? Unlike the pre-test, most responses included a form of definition of inquiry that went beyond ‘cook-book labs’ to include questioning and problem posing. Likewise, ICT responses indicated learning had moved beyond the use of word processes to the use of technologies that could be used to represent learning.

The pre-service teachers had, as Songer (2007) described, begun to consider the difference between ICT ‘for doing science’ and ICT ‘for learning science’. This latter finding was somewhat unexpected, as the information participants received in the lecture and workshop about Slowmation Animation was heavily biased towards the process of creating the animation, and not on aimed at the associated learning. Participant content knowledge learning associated with integrating inquiry-based instruction and ICT’s was further exemplified from the analysis of the artefacts, presentations and discussions. It became evident that there exists inter-domain knowledge between 1) the science concept knowledge and the ICT knowledge, 2) the inquiry-based instruction and the ICT knowledge, and 3) the inquiry-based instruction knowledge and the science concept knowledge (see Figure 1). The first inter-domain knowledge focuses on how ICT’s influence the science domains, the second focuses on how ICT affects inquiry-based instruction, and the third focuses on the enhancing and constraining influences of inquiry-based instruction on content knowledge development. The critical component is at the intersection of the 3 domain knowledges (Point 4 on Figure 1). This is the knowledge held by the pre-service teacher that communicates the individual knowledges and the three sets of inter-domain knowledge. It is a knowledge that, in this study developed from the interactions between the science content, the inquiry-based instruction, and the integration of the Slowmation Animation ICT. This is a knowledge that has resulted from maximising the potential of inquiry-based learning and the use of ICT to enhance science understandings.

Fig. 1. Inter-domain knowledge.
The inquiry-based learning experiences impacted greatly upon content knowledge as well as knowledge relating to inquiry-based pedagogy. Pre-service teachers made the conceptual shift from using ICT’s for learning science rather than for doing science. Through the integration of science content (biology and physics) with ICT’s (Slowmation Animation) via inquiry-based instruction, it is possible to model the learning of pre-service teachers by investigating inter-domain knowledge. The data was further investigated through the transformative learning framework outlined earlier in this paper. Figure 2 is the resultant model. The starting point, for all learning is with background knowledge, and testing this knowledge against representations of the science concept. In the case of animation, should the existing representation be accepted as was previously published (First-order Learning), the representation is copied and accepted (shown as ‘A’ in Figure 2), resulting in surface learning.

A second pathway (shown as ‘B’ in Figure 2), emerges once the learner engages with the science content. This is considered as deep learning - “I had this burning need for more information” (Preservice Teacher 1), and what Stirling (2010-11) calls Second-order Learning. Along this pathway, the learner mentally engages with their prior knowledge, the new information provided in published sources, and the information interpretation provided by group participants. The learner makes meaning of all this information, and then re-represents their new understandings in a Slowmation Animation. Pathway B is cyclical rather than linear as the representation is reworked several times with scientific accuracy a key consideration. An animation that has a reasonable level of scientific accuracy would be a useful resource for preservice teachers, and having the ICT skills to create such resources, could both be considered good outcomes for preservice teacher methods courses. However, I consider it equally important for the preservice teacher to be able to identify and build upon their science pedagogical practices. Hence, the preservice teachers are prompted to consider what they are experiencing and why – their meta-learning.

This consideration results in the third pathway (shown as ‘C’ in Figure 2) of the inquiry-based transformative learning model. This pathway occurs simultaneous to Pathway B. Preservice teachers experience significant ‘AhHa’ moments when they comprehend what it ‘means’ to understand a pedagogical strategy. This new
understanding is referred to as meta-learning. Again this is a cyclical process where the preservice teacher experiences learning in such a way that they are aware of the meaning of this learning. In the time it takes to create a Slowmation Animation, there are many opportunities for meta-learning to occur. These include the dynamics of group work, the art of questioning, the art of explanation and conceptual change.

The final pathway (shown as ‘D’ in Figure 2) results when Pathways B and C are combined. As the preservice teacher engages in meaning making (Pathway B) as well as meta-learning in relation to pedagogical practices (Pathway C), it is possible for a wider understanding to develop. This is what O’Sullivan (2002) described as Transformative Learning. The teaching and learning of science is seen differently and where the new learning is translated into other and new, more highly developed teaching opportunities.

It appears that transformative learning occurs when the meta-learning opportunity is of a high quality. Consider the task given to the primary preservice teachers described in this paper: To participate in an inquiry-based teaching and learning experience where physics principles were explored through a biological context - the motion of an aquatic invertebrate is represented and described in an animation. The primary preservice teachers, who travelled down Pathway D, did so as a result of awareness of the inquiry learning process from the learners’ and teachers’ perspectives (“I think it is the benefit of knowing inquiry. I can see that a teacher might use this thinking in lots of subjects with different activities”, Preservice Teacher 2). There was also an awareness of learning physics through a biological context as described in a class discussion: “We just sort of created knowledge. I don’t mean we invented theories, we just thought it up, the pushes and pulls ‘n stuff. And it made sense from what we knew anyway from school, but didn’t know we knew” (Preservice Teacher 3). By being able to experience meta-learning within diverse pedagogical contexts, the primary preservice teacher could experience transformation learning.

To facilitate transformative learning, the instructors must construct learning experiences through which the preservice teachers can explore epistemic change as a collaborative inquiry. Slowmation Animation when used in an inquiry-based learning context is a technique that offers what Stirling (2010-11) refers to as a two-level learning process: “the new ‘meaning making’ of the designers/teachers facilitates the new ‘meaning making’ of others” (p. 27).

4. Conclusions and implications

The results suggest that it is possible, and highly desirable, to develop university classes for pre-service teachers to experience inquiry-based instruction prior to having to teach inquiry-based lessons. The present study, then, contributes significantly to the literature on teacher training in science and technology contexts. It attempts to bridge the content knowledge of the pre-service teachers and their practical classroom actions. In particular, the study highlights the extremely limited physical sciences and biological knowledge most prospective primary teachers bring to their teacher preparation studies. Based on experiences in the present study, there is much more work to be done by researchers and teachers to provide inquiry-based learning experiences so that teachers of the future are better informed, via authentic experiences, to use such pedagogies. In relation to the research focus, the inquiry-based learning experiences impacted greatly upon content knowledge as well as knowledge relating to inquiry-based pedagogy. Pre-service teachers made a conceptual shift of using ICT’s for learning science rather than for doing science. Through the integration of science content (biology and physics) with ICT’s (Slowmation Animation) via inquiry-based instruction, it is possible to model the learnings of pre-service teachers by investigating inter-domain knowledge, but further work is needed in this area. It is also possible to introduce novice pre-service teachers to the notions of meta-learning, and to have them detect changes in their own cognitive processes. Based on experiences in the present study, there is much more work to be done by researchers and teachers to provide inquiry-based learning experiences so that teachers of the future are better informed, via authentic experiences, to use such pedagogies and to developing their self-awareness and meta-learning skills.

References


