iSCIENCE: A COMPUTER-SUPPORTED COLLABORATIVE INQUIRY LEARNING PROJECT FOR SCIENCE STUDENTS IN SECONDARY AND TERTIARY SCIENCE EDUCATION

Katherine L. Anderson[a], Shannon Kennedy-Clark[b], Louise Sutherland[c], Vilma Galstaun[d]

Presenting author: Kate Anderson (k.anderson@sydney.edu.au)
Faculty of Education and Social Work, University of Sydney, Sydney NSW 2006, Australia

KEYWORDS: pedagogy, wikis, inquiry learning, gifted and talented, pre-service teacher training

ABSTRACT

Pre-service teachers come to teacher education programs with a range of experiences and understandings about inquiry in Science. The iScience project aims to assist pre-service teachers develop their understanding of the issues and skills required to guide students through an open inquiry process. In addition, the project provides opportunities for pre-service teachers at the beginning of their teacher training to develop their skills in mentoring high school science students in an open-ended inquiry process. Wikis were used to support the interactions among the pre-service teachers and school students from several different geographical locations to enable collaboration on an open inquiry project. The impact of the project on the pre-service teachers' understanding of how to teach science by inquiry will be discussed.

Proceedings of the Australian Conference on Science and Mathematics Education, University of Melbourne, Sept 28th to Sept 30th, 2011, pages 49-53, ISBN Number 978-0-9871834-0-8.

INTRODUCTION

The purpose of this paper is to provide an outline of the current 2011 iScience project. This project requires pre-service science teachers to work with gifted and talented students in designing, carrying out and reporting on an Open Inquiry Based Project. There are four main aims of the project: helping students and teachers to come to a common understanding of inquiry; building new and innovative ideas; gaining technological proficiency in collaborative online software and building communication; and collaboration and reflection skills. The project is currently underway and this paper will provide a background to the project's development.

BACKGROUND

The advantages of using the inquiry process as a pedagogical tool in science teaching in improving student understanding and engagement in science has been widely discussed (Blanchard, Southerland, Osborne, Sampson, Annetta, & Granger, 2010). Recent reforms in science education around the world have focused on creating curricula that are heavily biased towards inquiry teaching methodologies (Bhattacharrya, Volk, & Lumpe, 2009). Melville, Favio, Bartley, and Jones (2008) discusses the issues that surround this shift in focus towards more student centered inquiry based pedagogies on science teacher education programs. There is a link between the experience that pre-service teachers have had with inquiry and their ability to confidently use inquiry based methodologies with students. The pre-service teachers with more firsthand experiences with inquiry, either from undergraduate science courses or work in the science field, has a direct relationship with their perceptions and capacity to teach inquiry. If pre-service teachers have no previous experience of inquiry it is very unlikely they will be able to effectively integrate inquiry into their teaching repertoire.

Lustick (2009) also suggests that talking about inquiry in pre-service teacher training courses is not enough to give them a good understanding of what inquiry actually is. Pre-service teachers need to experience inquiry first hand to really develop a sound comprehension of the skills and knowledge needed to teach content through inquiry.

The iScience project was established in 2007 as part of the ASISTM grant program to firstly give high school students an opportunity to develop their inquiry skills and secondly give pre-service teachers a firsthand experience of leading a small group of students through an open inquiry project. It was

designed as a collaboration between students, teachers at four independent high schools in Sydney and science educators at the Faculty of Education and Social Work at the University of Sydney. The project commences at the beginning of the pre-service teacher education programs for two cohorts; 1st year Master of Teaching (an 18 month graduate entry program) and 3rd year of the combined undergraduate Bachelor of Science/Bachelor of Education program. The pre-service teachers undergo three weeks of initial workshops where exemplars of different types of open- ended inquiry were demonstrated and teachers were shown how to facilitate high school students to generate researchable questions.

At the start of their teacher education program the pre-service teachers are asked to reflect on the Inquiry Framework seen in Table 1. This framework was developed by the authors for this project. This framework will be used as the basis of the iScience project and the development of the pre-service teachers' understanding of inquiry in science education.

Table 1: Framework for Inquiry

The Context: Observation / Problem / Scenario
Creating a Model
Developing a Question
Planning an Investigation
Conducting an Investigation
Collecting and Recording
Analysing Data
Reflection and Reassessment

The pre-service teachers were asked to develop an interactive activity or demonstration that could be used to engage the students in one of the following specific areas; water, global warming, materials, energy, health or transport. The pre-service teachers also attended workshops on wikis which gave them experience in how to set them up, how to use them and how to teach the school students how to collaborate via a wiki.

At the beginning of the program students from different high schools were allocated groups on the basis of their interest in particular focus areas of science. The pre-service teachers were assigned to work with a group, which collaboratively must decide on a specific topic to investigate and formulate experimental and research questions. Two students from each school were matched up with two students from a different school. Two pre-service teacher mentors were then assigned to each group. As a group a topic area was decided upon along with an appropriate research question which they will explore during the course of the project. The groups then met to plan and design an investigation that will address their research question. The students and pre-service teachers communicate online through a wiki. The group members update each other on what they have been investigating, questions they have and any research they have conducted. On two separate occasions the groups will meet face-to-face to conduct experiments.

The wikis are being used for the groups' ongoing online correspondence to discuss the project. The project culminates in a Science Fair held at one of the schools where the students present their projects and findings, which are judged and prizes are awarded in different categories.

INQUIRY LEARNING IN SCIENCE

Inquiry, as a term, is neither transparent nor clear-cut in a learning context as there has been much open-ended discussion about what inquiry learning is. A number of definitions that encompass

characteristics of inquiry have been put forward and these definitions are complementary in that they explain or develop existing definitions. Linn, Clark, and Slotta (2003) define inquiry as:

> engaging students in the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, revising views, researching conjectures, searching for information, constructing models, debating with peers, communicating to diverse audiences, and forming coherent arguments. (p. 518)

Howard, McGee, Shin, and Shia (2001) clarify that inquiry comprises of identifying questions or hypothesis to investigate, planning and designing investigations and then formulating and expressing conclusions. Poldoja, Leinonen, Valjataga, Ellonen, and Priha (2006) state that there are six collaborative inquiry steps, which include incorporate creating context, engaging in question driven inquiry, generating working theories, critical evaluation and advancement of knowledge, searching for new scientific knowledge and engaging in deepening inquiry. Inquiry-based learning is often represented by ill-defined and open-ended problems and is driven by a learner's questions and investigation skills (Edelson, Gordin, & Pea, 1999), and as Veermans, Lallimo, and Hakkarainen (2005) explain, inquiry learning requires more self-regulation than normal classroom learning.

Within the science classroom inquiry takes on further complexity as it is linked with the scientific method and the nature of science. (Anderson, 2002) has categorised inquiry in science education into three specific groups: Scientific Inquiry, Inquiry Learning and Inquiry Teaching. The practice of 'Scientific Inquiry' refers to, primarily the way in which scientists carry out the scientific method. This includes posing a question, developing an investigation around the question, analysing data to provide help explain the results of the investigation and using the results to answer the original question or pose new questions. It embraces the diverse ways in which scientists attempt to pose questions and find answers about various phenomena. This type of inquiry is linked to teachers understanding of the Nature of Science and the way in which scientists study and work.

The second way in which the term 'inquiry' can be categorised is in regards to "Inquiry Learning". This terminology can be linked to a constructivist view of learners building on their previous knowledge and constructing new knowledge by being actively engaged in the learning process (Anderson, 2002). Students are able to pose questions themselves and seek the answers to these questions without being given solutions by a third party. Much of the research done into how students learn and how the brain functions supports this type of learning as the way in which deep understanding is obtained (Bransford, Brown, Cocking, & Donovan, 2000).

Inquiry Teaching refers to the way in which teachers assist students to engage in the inquiry learning process. It involves the skills and methods that teachers chose to use when teaching students about areas of scientific content in an inquiry based learning approach. It requires the teacher to provide experiences that engage and inspire students to pose questions about particular events and then facilitate the process of students finding the answers to their questions based on collected evidence.

Inquiry teaching can be further categorized. Windschitl (2000) defines these inquiry activities by the degree of independence students have in asking and answering questions. A low level inquiry would be defined as confirmation or verification activities. These experiences are often referred to as the "recipe" or cookbook experiments where the teacher is responsible for the question, method and answers. Students verify known scientific principles by following a given procedure (Windschitl, 2000). The next level of inquiry, guided inquiry, is referred to as structured inquiry where the teacher presents a question and the students are given a procedure to find the answer. Guided inquiry requires the students to formulate a procedure to find answers to a question the teacher has posed. At the far end of the inquiry continuum are open inquiry activities where the students develop their own research question and method of investigation. Guided and open inquiry investigations are far more intellectually challenging for students than confirmation activities. They are also more challenging for teachers in terms of pedagogy and management (Windschitl, 2000). Facilitating the formulation of sound and verifiable student research questions is a highly skilled and metacognitively challenging process that is not simple for teachers.

Whilst the detail within the three forms of "inquiry" in education go some-way to clarifying the meaning of inquiry for teachers it is still quite vague on the details about how to actually teach inquiry to students in the classroom. Furthermore, how to teach teachers and pre-service teachers how to teach inquiry, when they may not had any experience of it, has not been dealt with in detail. The iScience

project and associated inquiry activities within the pre-service teacher program aims to help pre-service teachers develop their understanding and confidence in teaching open inquiry.

PROJECT DESIGN

PARTICIPANTS

Fifty six students from Year 8 from three Science classes from Moriah College, Bondi Junction, St Catherine's, Randwick and Kincoppal, Rosebay high schools. Students selected to participate in the project were from the top streamed science classes. Thirty six pre-service teachers from the 1st year of the Master of Teaching and from the 3rd year of the Bachelor of Education programs participated in the project. The pre-service teachers undertaking the Master of Teaching come from a range of backgrounds. Some have enrolled straight out of undergraduate science degrees others have come from working for many years in Science fields such as genetics or chemical engineering.

DATA COLLECTION AND ANALYSIS

The research study will use a mixed method approach to data collection and data analysis. At this stage only preliminary data have been collected.

PRELIMINARY RESULTS

Preliminary findings from course evaluations show that the iScience project is assisting the pre-service teachers in three key areas; knowledge of science content, understanding of the inquiry process and finally highlighting the difficulties of formulating appropriate language and questioning techniques to engage students in the teaching material:

> *I felt that my understanding of the science concepts involved was greatly enhanced by this project. My general science knowledge was improved in the process of researching the topic and exploring all possible facets of it in preparation for the mentoring experience.*

The results also indicated that the pre-service teachers are developing content knowledge. The majority of pre-service teachers spent a large proportion of their preparation time researching the science content, which was generally at only Stage 4 level, involved in their topic areas as displayed by this quote from Anne. They felt they needed to do this in the event that the students asked them questions they were unable to answer.

The pre-service teachers also found the project helpful in developing a better understanding of the difficulties in teaching using inquiry but also the advantages in using it to help students develop a deeper understanding of science content as one pre-service teacher reflects:

> *Initially, I was skeptical of the practicality of the Inquiry process in the classroom and how it would be beneficial to me as a teacher, however, by the end of the i-Science project, I could see the importance of students 'discovering' science for themselves in order to generate meaningful learning experiences.*

A major concern for many of the pre-service teachers was trying to match the language that they use to describe science concepts with the students' cognitive level of understanding as shown by one pre-service teacher's comment:

> *Prior to my involvement in this project, I tended to use terminology that students would never have encountered before, simply out of habit. I needed to consciously restrict myself when talking to the students and when I did need to mention a term they may not have been familiar with, I would elaborate on the definition to ensure students had a basic understanding of the concept.*

In addition to simplifying their language they commented on the difficulties they had trying to help the students develop researchable questions. The issue of dialogue between teacher and students during the inquiry process is emerging as one which needs further consideration in contemporary research. Pre- and post-test surveys have been collected from the pre-service teachers participating in the wiki workshop held in April 2011. The preliminary analysis indicates that pre-service teachers prior to the workshop saw wikis as a receptive tool that they could access to find information for their assignments. However, the pre-service teachers did not understand or have the skills to use wikis in educational contexts for collaboration. In the post-test survey, however, the educational benefits of using wikis for collaboration were evident. Teachers had a better understanding of the benefits and limitations of using Web 2.0 technologies in a classroom. For example, the pre-service teachers after

the workshop raised issues such as cyber-safety and the need to scaffold collaboration for it to be effective.

CONCLUSIONS

Overall, both the pre-service teachers and the high school students have the opportunity to develop a better understanding of inquiry learning and collaboration by participating in this project. We expect the pre-service teachers' understanding and confidence in undertaking open inquiry in their Science teaching will be enhanced by using wikis to collaborate on projects. The pre-service teachers will benefit from establishing links to schools and the project can be added to their e-portfolio. The students will benefit from participating in an authentic inquiry project that may contribute to a deepened understanding of science as a research career. However, several issues have arisen in these early stages of the project. As the school students are working in groups distributed over several schools, maintaining open channels of communication between the pre-service teachers, university educators, school teachers and high school students is proving to be difficult. We are addressing this issue by providing more explicit scaffolding for the groups in the use of their wikis to develop their projects, and by providing "just in time" technical assistance to the pre-service teacher mentors we are able to troubleshoot technical problems.

The preliminary findings and early feedback from the stakeholders involved in the project indicates that both the pre-service teachers and the students are motivated and engaged, and that the pre-service teachers are reporting that they have a better understanding of the pedagogy and practice of science inquiry.

REFERENCES

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.

Bhattacharyya, S., Volk, T., & Lumpe, A. (2009). The influence of an extensive inquiry-based field experience on pre-service elementary student teachers' science teaching beliefs. *Journal of Science Teacher Education, 20*(3), 199-218.

Blanchard, M. R., Southerland, S. A., Osborne, J. W., Sampson, V. D., Annetta, L. A., & Granger, E. M. (2010). Is inquiry possible in light of accountability? A quantitative comparison of the relative effectiveness of guided inquiry and verification laboratory instruction. *Science Education, 94*(4), 577-616.

Bransford, J., Brown, A., Cocking, R., & Donovan, S. (Eds.). (2000). *How people learn: brain, mind, experience and school*. Washington DC: National Academy Press.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *The Journal of the Learning Sciences, 8*(3/4), 391-450.

Howard, B. C., McGee, S., Shin, N., & Shia, R. (2001). The triarchic theory of intelligence and computer-based inquiry learning. *Educational technology, research and development, 49*(4), 49-69.

Linn, M. C., Clark, D., & Slotta, J. D. (2003). WISE design for knowledge integration. *Science Education, 87*, 517-538.

Lustick, D. (2009). The failure of inquiry: preparing science teachers with an authentic investigation. *Journal of Science Teacher Education, 20*(6), 583-604.

Melville, W., Fazio, X., Bartley, A., & Jones, D. (2008). *Experience and reflection: Preservice science teachers' capacity for teaching inquiry 19,*,(pp. 477-494), Springer: New York.

Poldoja, H., Leinonen, T., Valjataga, T., Ellonen, A., & Priha, M. (2006). Progressive inquiry learning object templates. *International Journal on E-Learning, 5*(1), 103-111.

Veermans, M., Lallimo, J., & Hakkarainen, K. (2005). Patterns of guidance in inquiry learning. *Journal of Interactive Learning Research, 16*(2), 179-194.

Windschitl, M. (2000). Pre-service science teachers and the independent inquiry experience.