Reforming Education: The Pursuit of Learning through Authentic Inquiry in Mathematics, Science and Technology

James J Watters & Carmel M Diezmann
Queensland University of Technology, Brisbane, Australia

Challenge confronting educators

Across the world, governments are recognising the important role that science, mathematics and technology are playing to achieve healthy, safe and peaceful society. In Australia, the development of scientific, mathematical and technological literacy is a national priority for the education system. A number of major reports have implicated the quality of teaching, the relevance of the curriculum and teacher training as areas of major concern (Breakspere, 2003; Goodrum, Hackling & Rennie, 2001; Glenn, 2000; Miles, 2000; NSB, 1999). In essence, classroom teachers and policy makers are being encouraged to accommodate global perspectives, contemporary issues in the sciences and acknowledge the myriad of social-emotional problems confronting modern youth and provide more meaningful learning contexts.

However, the teaching situation in many classrooms is problematic. Contemporary learning theories acknowledge that learning has to occur in context where students engage actively in negotiating meaning around new experiences. Learning theorists argue that the most important source from which we gain understanding is first-hand experience in a social context. However, traditional schooling is dominated by models of teaching, which assume learning occurs through transmission of information. Students are forced to learn from secondary experience, in which information is selected, modified, packaged and presented to them by "expert" teachers. The adoption of these models are further reinforced by community attitudes that tend to see education in mathematics, science and technology as being training for specialised careers in technical fields, rather than part of the essential general preparation to be an informed citizen in the twenty-first century. Reforming classroom practices to achieve a better balance between first-hand and second-hand experience requires teachers to assume new supportive roles in the classroom and develop the appropriate pedagogical knowledge to support new forms of learning.

Examples of inquiry learning

In this paper we draw upon a number of studies in which students engage in original inquiry problems. It is argued that students build their understanding and investigative skills through active inquiry, connecting their previous knowledge with new ideas and evidence. We specifically report on examples from the early years of schooling and in middle school.

Mathematical investigations

Mathematical investigations have three key implications for teaching. First, they are extended problem explorations, which provide students with opportunities to engage in deep learning through the identification of a problem, collection of data, exploration of multiple strategies, communication of solutions, and reflection on the outcomes of the investigation. Second, due to their open-ended nature, teachers can capitalise on the use of investigations to provide opportunities for students with a range of mathematical abilities and interests. Additionally, teachers need to cater for the diversity of students by creating authentic opportunities for collaborative teamwork because individuals can contribute their specialised knowledge or skills to the task. For example, one student may undertake and record complex calculations within an investigation, whilst another student may complement the symbolic representations of these calculations with text and pictures. Third, investigations provide a context for students to apply their mathematical skills and to learn new skills. Hence teachers can determine whether students not only know how to do a procedure, such as addition, but can apply it. For example, in one investigation students erroneously calculated the number of sweets in a sealed container by adding the height of the container and its mass. Thus the teacher needed to realise that although the students could add, their result was meaningless in this context.

Scientific inquiry

Several approaches to inquiry based learning in science can be identified. These include structured, guided and open inquiry. In both structured and guided inquiry the teacher plays a significant role in both identifying and planning the problem. However, open inquiries foster opportunities for students to experience

uncertainties, ambiguities and the social nature of scientific work and knowledge. Here, the teacher plays a very different role. In this study, the constraints, affordances and concerns that guide the role of the teacher are addressed. The study highlighted the importance of three main issues. First, the formation of a community of learners was developed which facilitated the higher ability children and also contributed to enhanced performances of lower ability children. Second, an open-ended inquiry approach afforded opportunities for high ability children to grapple with more sophisticated ideas and processes. Third, classroom discourse was structured to encourage the development of "scientific talk" for the children.

Through these complex investigations students develop in context a range of key scientific and mathematical processes and skills such as problem finding, problem posing, constructing hypotheses, explaining, justifying, predicting, and representing, together with quantifying, coordinating, and organising data. Students become mathematically literate by generating and interpreting information that is represented in multiple forms such as diagrams, charts, tables, and graphs. They become scientifically literate by engaging in hypothesis testing and evaluation of evidence and they become technologically literate through the use of tools relevant to information or data gathering. These processes and associated understandings are essential for effective participation in a knowledge-based society. They become technologically literate through the use of calculators, the internet, and various word processing, spreadsheeting and presentation technologies.

Implications

The implications of this research impact directly on attempts to reform the teaching of science, mathematics and technology to acknowledge contemporary learning theory and to accommodate the burgeoning and changing knowledge base necessary for competence in the sciences. However, there are significant challenges. Curriculum innovations have historically failed to influence teaching and learning practices due, in part, to teachers' scarce opportunities to learn new content and improve their practice. Inquiry approaches to learning assume that teachers are well prepared to engage in inquiry themselves a position that is challengeable given the preservice educational courses most have experienced. Teachers on the whole have had limited experiences in scientific research or opportunities to generate knowledge themselves through inquiry.

References

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