The Bridge
Making research practical
November 2015 (updated to new format 2023)


St Peter's Anglican Grammar

Quality learning and teaching in primary science and technology

Abstract

Quality teaching and learning in primary science and technology is more likely to be effective when applied by a teacher with sound pedagogical and content knowledge in this subject. Research highlights inquiry-based learning as an effective pedagogical framework that underpins a number of useful teaching models and approaches explored here. Other strategies and characteristics associated with quality science and technology teaching and learning are also discussed.

Critical points

The relationship between science and technology is complex. Combining the two fields in a single learning area brings both challenges and opportunities. Aspects of connectedness allow teachers to exploit the intertwining nature of science and technology.

Some primary science and technology teachers have reservations about whether they have adequate subject knowledge and the pedagogical skills and pedagogical content knowledge (PCK) to teach primary science and technology effectively.

Inquiry-based learning, which focuses on strategic questioning, critical thinking and problem solving, is considered a positive approach to learning in this subject. Inquiry involves observing, questioning, researching designing, planning, analysing, explaining and communicating.

Research on primary science and technology capability suggests that there is a need to promote whole-school approaches and collaborative staffing environments in order to enhance the teaching and learning of science and technology.

Implications for educators

The development of individual teachers' science and technology PCK is essential for effective science and technology teaching and learning.

Teaching and learning in science and technology should include hands-on experiences, support problem solving and offer authentic opportunities that show the relevance of the subject to students' everyday lives.

Collaborative and supportive school environments help foster the development of individual and group PCK. Leadership and resourcing are also important elements in enabling the effective teaching of science and technology.

A number of teaching models focusing on inquiry-based learning are available for use. Professional learning to support the implementation of these models is recommended and widely available.

Introduction

For decades there have been calls in Australia for reform in science and technology education (Aubusson, 2011; Tytler, 2007). Reports on its status have identified a range of concerns regarding student learning, teaching quality, teacher confidence and school capability. It has consistently been argued that, in order to improve the performance of the nation in STEM (science, technology, engineering and mathematics), education in science and technology should be encouraged from the earliest years of schooling (ATSE, 2002; Fitzgerald, 2013; Harlen & Qualter, 2014).

As a result, STEM has become a priority in education at both the federal and state levels in Australia. This is a positive focus and has resulted in policy and curricula change. However, that alone may not be sufficient to address declines in student performance in science and technology as evidenced by Australia's declining results in international studies such as TIMSS (Trends in International Mathematics and Science Studies).

It is therefore important to have an understanding of what characterises quality teaching and learning in primary science and technology, as well as the barriers that restrict teachers from engaging in effective practice.

Barker College

Challenges for teachers

Science and technology: different but connected

The connection between science and technology is complex. Understanding the interrelationship of these fields, and subsequently how to teach them, can be muddied by a lack of consensus about how they can fit together within the teaching context. For example, technology and science can be viewed as separate endeavours or as intertwined. Science can also be viewed as preceding technology, and vice versa.

Despite this lack of clarity, science and technology are pedagogically and intellectually connected endeavours. Both enable hands-on learning, support problem solving and offer authentic learning opportunities whereby students are able to see the links between science and technology learning and relevant aspects of their everyday lives. This connectedness can provide educators with a foundation for teaching science and technology in an integrated manner.

What teachers need to know

It has long been acknowledged that many primary school teachers feel they lack confidence and expertise in teaching science and technology. This has been identified as one of the contributing factors to low student performance in, and attitudes towards, science and technology (AAS, 2012; Jones & Moreland, 2004; Pell & Jarvis, 2003; Rohaan, Taconis & Jochems, 2010). One influence of teacher confidence and expertise is PCK. PCK captures the idea that successful teachers have good content knowledge and possess a repertoire of pedagogical strategies that they draw on to teach that content. Teachers with strong PCK tend to teach science and technology effectively.

Research suggests that collaborative teaching environments are helpful in supporting teachers to improve their individual and team PCK. When teachers collaborate, there is potential for collective PCK to develop, and to compensate for relatively low individual PCK. This provides a supportive environment for individuals to build capacity.

School support and teacher capability matter

Reports (for example, ATSE, 2002) on primary school science and technology education capability suggest that in some schools, there is a need to ensure greater support for teachers at the level of infrastructure and management. Factors cited by teachers as supporting them in teaching science and technology more effectively include:

- additional professional learning opportunities
- an emphasis on science and technology in school programming and assessment
- more time for science and technology planning and preparation
- well organised and sufficient resources for planned and potential activities.

How can we improve the teaching of science and technology?

Although the barriers discussed above can be challenging, they do suggest strategies and approaches that educators can take to improve their teaching of science and technology.

Enhance teacher knowledge

Enhancing science and technology teacher knowledge is important. Quality science and technology teaching requires:

- knowledge of the curriculum and pedagogy
- knowledge of how students learn science and technology
- knowledge of assessment concepts
- understanding of context and authentic learning activities
- positive attitudes and beliefs, and the confidence to teach science and technology.

Use a range of successful teaching models and approaches

Research highlights student inquiry as being an effective pedagogical framework for the teaching of science and technology. There are a number of models that are broadly consistent with this focus, and five of these are briefly outlined below.

The 5Es Instructional Model

The 5Es model is a widely applied research-based learning cycle based on five phases: Engage, Explore, Explain, Elaborate and Evaluate (Bybee, 1997, 2014). The 5Es model of inquiry-based learning recognises that students need time and opportunities to develop concepts and abilities.

The Generative Learning Model

The fundamental premise of generative learning is that perceptions and meanings consistent with students' prior learning are generated by students in the learning environment (Osborne & Wittrock, 1985). This means that teaching needs to encourage learners to generate firm links between constructed meanings and their existing knowledge.

The Learners' Questions Model

Effective science and technology teaching involves providing learning conditions that encourage children to ask and investigate questions (Faire & Cosgrove, 1988). Learners' Questions outlines a series of connected steps within which the teachers' role is as a resource provider, a motivator, a challenger, a developer of learners' ideas and a communicator of different ideas. In this approach, the teacher learns with the students.

Hunter Valley Grammar School

Science in Schools (SIS) Model

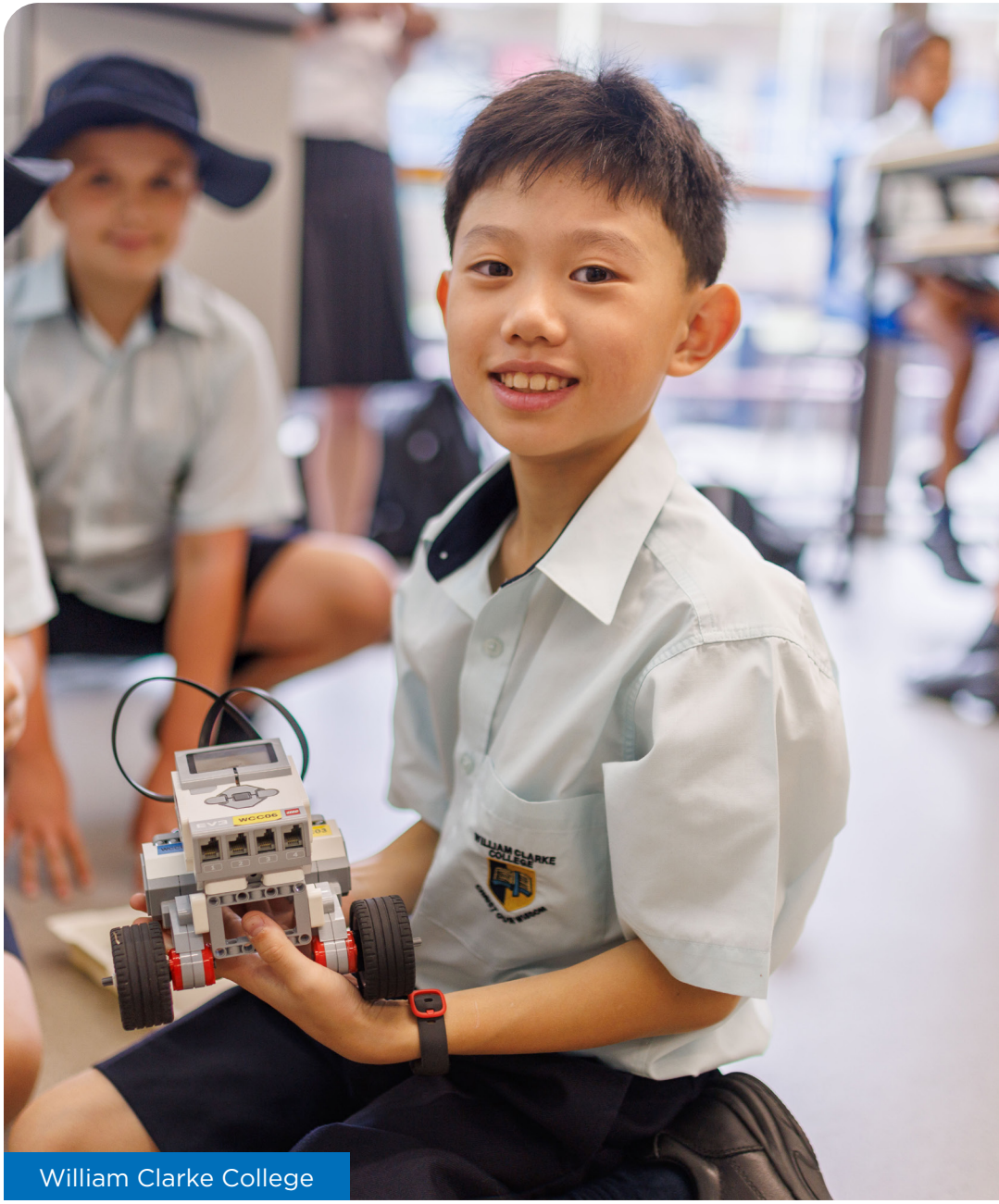
The SIS model outlines eight components of effective science teaching and learning (Tytler, 2001, 2009). This model builds on those outlined above and adds context, relevance and relationships in order to reflect the characteristics of effective teaching practice.

Representational Intensive Pedagogy

There is growing evidence that encouraging students to demonstrate their understanding using various modes of representation assists with conceptual development (AAS, 2012; Aubusson, Treagust, & Harrison, 2009; Prain, Tytler, & Peterson, 2009; Tytler, 2010). In this model, teachers scaffold learning by using multiple modes of representation, and students learn when they are encouraged to create and defend their own representations of ideas.

These five models should not necessarily be combined nor any of them be used exclusively, as they vary in the extent to which they promote open and closed inquiry, design and production. It is therefore recommended that educators use a variety of models based on their knowledge of student learning and understanding.

For further elaboration of these models, please refer to the Literature review: Quality learning and teaching in primary science and technology available through the AIS website.



William Clarke College

Characteristics of quality science and technology teaching and learning

The literature review highlights a number of elements that characterise quality teaching and learning in science and technology:

- Emphasis on student inquiry
- Use of 'starter' activities that arouse and engage students in investigations
- Identification of real needs or problems and investigations of ways of resolving these problems;
- Promotion of student questioning
- Exploration of ideas, development of designs, creation of products
- The sharing and subjecting of designs and ideas to scrutiny through evidence-based discussions and in trial by experiment
- Opportunities to fail and try again
- Support of ways to search for information and find out what is already known
- Engagement in authentic activities and connection to students' life experiences
- Display and presentation of products of learning and design
- Use of formative assessment to diagnose needs and inform iterative changes to planned learning sequences
- Students creating and analysing their own representations and analysing standard technological and scientific representations
- Exploitation of teachable moments for the explicit teaching of science and technology principles, skills and processes
- Employment of summative assessment to gather evidence of learning achievements
- Use of a variety of strategies to communicate ideas with a range of audiences
- Use of digital technologies to enhance learning
- Opportunities to connect learning experiences with local communities

These elements are most effective in science and technology when:

- they are applied by teachers with sound science and technology PCK
- they are supported by effective school leadership
- collaboration and professional learning is promoted
- a whole-school approach to improvement is taken.

Coupled with teachers' professional judgement the above recommendations provide teachers and schools with suggestions for improving classroom practice and student learning in science and technology.

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