Editorial

Some Contemporary Issues and Challenges in Tertiary Science Education

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There is now a substantial body of research on the teaching and learning of science, technology and mathematics. Not surprisingly, much of this research is concerned with education at the compulsory school level. There is, in contrast, less written about tertiary level science teaching and learning. This special issue seeks to highlight current research at the tertiary level. Here we interpret tertiary as being post-compulsory school and the research studies reported in this volume are concerned with two broad areas: the learning of tertiary science, and tertiary level science teacher programs.

Tan looks at pre-service secondary science teachers' conceptions of basic inorganic qualitative analysis (the reactions and procedures used to identify inorganic substances using wet-bench chemistry). Using an O-level based diagnostic test, Tan revealed a plethora of alternative conceptions which were found to be common to teachers and, perhaps not surprisingly, to their students. This work highlights the need for teacher trainers to have a good appreciation of pre-service teachers' basic science knowledge in order to work towards producing capable science teachers. The work reported by Jarvis et al. follows on from Tan's work and looks at ways of promoting conceptual change for pre-service primary science teachers to help address their problems in science understanding. The use of intensive, small-group problem-solving activities is reported to increase conceptual understanding and confidence, although some errors remain. The authors caution that increased confidence is not necessarily grounded in correct scientific understanding, and recommend a cyclical review process.

Taylor and Corrigan also look at ways of improving pre-service teachers' science understanding. They implemented a program of self-regulated learning which allowed the students a significant amount of flexibility and freedom in what science topic they investigated and how they did so. The participants were under-confident about science teaching before the program, and by the end of the program report increased confidence. Interestingly, Taylor and Corrigan found that the pre-service teachers identified specific components of the program and learning environment they believed contributed to their increased confidence in science teaching. But, like Jarvis et al., Taylor and Corrigan caution that it is difficult to establish whether competence as it relates to conceptual understanding, had been enhanced.

Much of the research of undergraduate science teaching and learning reported here seeks to identify problems with learning and ways of using modern theories of learning to address such problems. Dalgety and Coll used a mixed-methods approach comprising interviews and a previously validated survey instrument to measure undergraduate chemistry students' learning experiences. As one might expect the students enjoy tutorials and are not so keen on lectures, but, rather surprisingly, they were not particularly positive about their practical classes. This latter observation seems to relate to the content of the practical work, and what was perceived to be overemphasis on accuracy of measurements for some specific experiments.

The notion of preferred learning styles is also addressed by Pedrosa de Jesus et al., who look at the progress of a university department as it seeks to 'orchestrate' the interplay between the demands of an undergraduate chemistry program with preferred teaching and learning approaches. The work, based on Kolb's *Learning Styles Inventory*, suggests that the majority of students were 'accommodative' or 'divergent' and more focused on concrete experience, in contrast to scientists who are 'convergent' or 'assimilators,' and engage more in abstract conceptualization. These findings have pedagogical implications and the authors subsequently developed some new teaching approaches that sought devolution of student learning. The approaches include enhanced lectures in which, for example, students are able to pose questions and topics in advance. Student evaluation suggests that these students found the new approaches appealing.

Chang likewise looks at preferred learning styles for undergraduate physics students. In her case, two cohorts of students were exposed to two different teaching approaches: one based on a didactic, traditional teaching approach, the other informed by constructivism. This latter approach was more interactive and incorporated constructivist-based pedagogies that were more learner-centered. In contrast, the traditional approach consisted of didactic presentation of content, rote memorization, and test and drill type tasks such as repeated solving of algorithms. As has been observed in some previous studies, the students did not necessarily embrace new teaching approaches wholeheartedly, and Chang points out that both cohorts of students resorted to superficial learning approaches when faced with summative end-of-course examinations. The conclusion here is that more learner-centered approaches have potential at the tertiary level, but will need careful management to be accepted by students, and indeed staff.

Tsaparlis and Gorezi present a similar theme, this time related to undergraduate physics practical classes. They derived a teaching approach for practical classes that attempts to move away from instructor-centered, 'cookbook' styles towards group work and interactive student-centered, inquiry-based teaching approaches for practical work. As seen in Chang's work, the students were not automatically enamored of such approaches, and found some features of group work off-putting, namely, uneven work contributions from group members.

Head et al. present an in-depth study and analysis of a problematic activity for undergraduate chemistry students: representation of molecular structure. Chemists and other scientists use pictorial representations to illustrate atom arrangement, and features of molecular structure. Other work suggests that students find it difficult to respond to visual clues in the same way as experts. Drawing on rich qualitative data, Head et al. identify four skills necessary to understand structural representations for the molecule that was the focus of their study (cyclohexane): an appreciation that the hexagon skeletal and chair skeletal styles of representation depict two different perspectives of a given molecule; an understanding of the depth cue conventions of each style of representation; an ability to mentally rotate a structure and re-represent it in the same style; and, an ability to take a molecular structure drawn in one representation style and redraw it in another style.

All of the above work on students' learning and teaching approaches is essentially derived from constructivism and involves what might be seen as 'normal' learning contexts: namely, lecture halls or classrooms, tutorials and laboratory classes. The final paper in this special issue reports on science and technology learning using an integrated approach in which these on-campus pedagogies are integrated with substantial components of relevant work experience. Eames and Bell use a sociocultural theoretical basis to investigate what and how students learn in work-integrated or 'cooperative education' programs (not to be confused with cooperative group learning as discussed by Chang, and Tsaparlis & Gorezi). As Eames and Bell point out, the practice of cooperative education is widespread and has a long history. Much research has been done, but this research has traditionally been dominated by studies that look at vocational issues, such as whether or not graduates gain work more easily or advance in their careers more rapidly. The major contribution of Eames and Bell is to inform the educational features of cooperative education: as they note, research and the practice of cooperative education often lacks any theoretical basis. This work identifies some important features of cooperative education that differ from campus-based learning. For example, learning in the workplace is highly situated, and the social context is an important feature of work-integrated learning. An interesting finding is that the work-based and campus-based learning complement each other and the authors point out that this integrated approach is potentially a potent tool for the enculturation of initiates into the scientific community.