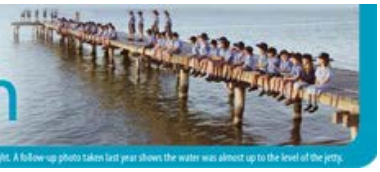
Australian & International Journal of Rural Education



IMPROVING MATHEMATICS AND SCIENCE EDUCATION IN RURAL AUSTRALIA: A PRACTICE REPORT

Robert Whannell and Stephen Tobias

School of Education, University of New England

ABSTRACT

There has been a steady decline in the number of secondary and tertiary students studying mathematics and science. Rural schools also report a shortage of qualified teachers in these disciplines. This paper describes the steps taken at the University of New England (UNE) to improve the provision of mathematics and science education (MS) in rural Australia. Initiatives such as the use of an online interactive digital classroom by rural NSW schools presenting MS contexts based on a SMART (sustainable, management, and accessible rural technologies) Farm will be presented. Research to improve teacher confidence and competence in these areas will be discussed along with the steps being taken to develop a Higher Education Research Facility (HERF) which will support research and engagement in the STEM domain.

Key words: Mathematics and science teachers, rural schools, online interactive digital classrooms

INTRODUCTION

The importance of science to Australia was described by Professor Ian Chubb, following his appointment as Chief Scientist in 2011, as *the value of good science to our nation and the world is colossal… Science has got us to where we are today – many of the good bits and sometimes the bad; and it holds the key to our future* (Chubb, 2011, p. 2). He identified a number of key foundations for the provision of a scientifically literate Australia, including the need for educators to inculcate *the coming generations with an enthusiasm for the wonder, beauty and endless potential of science* (p. 15) and the need to support science teachers throughout their careers.

This view of the importance of science and mathematics education to Australia's future contrasts strongly with the reality in our schools and universities where there has been a decline in popularity of these areas of study over many years. This paper describes initiatives at the University of New England (UNE) to address this challenge in rural Australia through the implementation of innovative practices in pre-service teacher education, including the creation of a Higher Education Research Facility (HERF). A primary focus of these practices and the HERF will be the development of research-based innovations in synchronous and asynchronous online delivery of science and mathematics education through partnerships with primary and secondary schools in rural and remote locations. The potential for this facility to radically change the approach taken to pre-service teacher education at the institution and in the development of

partnerships with isolated schools to engage in and improve the provision of Science, Technology, Engineering and Mathematics (STEM) education will be proposed.

CHALLENGES OF PRIMARY AND SECONDARY STEM EDUCATION

The number of students studying STEM related courses at the secondary and tertiary level of education has been in steady decline in recent years (Ainley, Kos, & Nicholas, 2008; Goodrum, Druhan, & Abbs, 2011). This is associated with a significantly lower level of interest and satisfaction by rural and remote students in the study of these subjects when compared with students in large towns and cities (Lyons & Quinn, 2012). The lack of interest in these fields of study is accompanied by lower levels of mathematical and scientific literacy in rural and remote students in Australian schools (Thomson, De Bortoli, Nicholas, Hillman, & Buckley, 2011).

Lyons and Quinn (2010), based on a national Australian survey of 3,759 year 10 students, identify three factors at the upper secondary level of education that contribute to the declining enrolments in senior school science: students have difficulty in picturing themselves as scientists; a perception of a decrease in the value of science relative to its difficulty, and a failure of school science to engage a wide range of students due to the nature of delivery. They also concluded that the challenges facing secondary STEM education are not likely to result from a decline in the level of interest in science among younger students, nor on negative experiences of science at the primary school level, with 92 per cent of the participants indicating that it was the early secondary school science experiences that influenced the decision on whether to study science at year 11 level. In a review of the literature, Tytler (2007) describes this lack of influence of primary school experiences of science on subsequent decisions to study science and identifies the primary to secondary school transition as a point where interest in studying science appears to decline sharply.

A second contributing factor to the state of STEM education in rural and remote areas is that many secondary schools are unable to obtain staff who are adequately qualified to teach these subjects (Harris, Baldwin, & Jensz, 2005; Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006; Marginson, Tytler, Freeman, & Roberts, 2013). International studies highlight the significance of this issue as impacting on teacher well-being (see for example Ingersoll, 1998; Steyn & du Plessis, 2007) and the quality of educational outcomes; for example, studies have shown that students taught by out-of-field mathematics teachers perform below students taught by qualified teachers (Attard, 2013; Thomson, Hillman, & Wernet, 2012).

The availability of teachers of chemistry and physics, which require a high level of mathematics proficiency, has been identified as a particular problem (Harris et al., 2005). This is exemplified in the enrolments in science curriculum units at UNE where few students study to be teachers of Physics. The issue of unqualified teachers in science is also greater in the lower years of secondary school, where heads of science departments in Australian schools report a much lower satisfaction with the science qualifications of staff in this area. The lowest satisfaction level (66.2%) was demonstrated at junior school science level (Harris et al., 2005). It will be remembered that Lyons and Quinn (2010) identified lower secondary school as being the point of decision making by students to continue their study of science.

The National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia (SiMERR) national survey of science, mathematics and ICT education (Lyons et al., 2006) established that teachers in non-metropolitan primary and secondary schools reported *a significantly higher unmet need for their students to have access to a broad range of learning experiences including opportunities to visit education sites, than did their metropolitan colleagues* (p. vii). This lack was particularly identified in relation to activities suitable for gifted and talented students who would be those most likely to engage in tertiary study in these areas.

The literature examined presents the situation for the education of rural school students of mathematics and science in a poor light, particularly in relation to the junior secondary years, and

presents substantial challenges for the future. The challenges also continue at the tertiary level of education, where the proportion of these students relative to their urban peers has been reducing and they are demonstrating lower retention rates (Bradley, Noonan, Nugent, & Scales, 2008).

THE UNIVERSITY OF NEW ENGLAND SCHOOL OF EDUCATION BACKGROUND

The UNE School of Education (SoE) currently has over 4,000 students, with 80 per cent of these students enrolled to study in the distance mode. In 2014, the core junior secondary school mathematics curriculum unit, EDME492, had 44 enrolments at the university census date. The core senior secondary school mathematics unit, EDME494, had 36 enrolments. These units are offered only once per year in trimester 1. The numbers enrolled in the core secondary science curriculum units were approximately 50. A number of students were enrolled across both the mathematics and science curriculum units.

The approach taken at UNE to pre-service teacher education is for students to study teaching units that address three different elements:

- compulsory teaching units, including professional experience in primary or secondary school;
- curriculum units that address how to teach within a discipline; and
- electives.

The academics who are engaged in the delivery of the STEM related curriculum units are allocated to one of three different teams, namely Mathematics, Science and IT. There has historically been very little cross disciplinary engagement between the STEM teaching teams and none of the academics who teach in the curriculum units are involved in the professional experience of the pre-service teachers in schools. This situation contributes to the disconnect between theory and practice for the pre-service teachers (Allen, 2009; Allen & Peach, 2007) and a separation between the SoE STEM academics and the school-based experience of students and their mentoring practicum teachers. Ramsey (2000), in a review of teacher education in Australia, described the importance of this relationship when he argued the need for *a high level of practical partnership between the supervising teachers and university lecturers* (p. 63).

An additional complication in relation to the research conducted is that the academics delivering the STEM curriculum units generally engage in research individually and in small curriculum based teams. The research targets independent projects with little facility to engage in cross disciplinary activity. This research is also organised on an ad hoc basis with secondary and primary schools. This theory-practice gap in teacher education has been previously identified (Grima-Farrell, Long, Bentley-Williams, & Laws, 2014). The capacity to develop the professional learning communities (Vanderlinde & Braak, 2010) involving pre-service teachers, SoE academics and practicing school teachers that would allow for this theory-practice gap to be bridged appears to be lacking.

THE CHANGING ROLE OF REGIONAL UNIVERSITIES IN RURAL STEM EDUCATION

The context described up to this point for STEM education in rural Australian schools presents challenges and associated opportunities for Schools of Education in all universities. The literature presented indicates the following conditions that need to be addressed to improve the quality of rural science and mathematics education:

- Declining interest and enrolments in science and mathematics;
- declining motivation to study these subjects in the junior high school years; and
- a lack of qualified staff.

A simple solution would appear to be the employment of well qualified and highly skilled individuals who are able to teach STEM subjects in a manner that would interest and engage a wide range of students. However, the current lack of availability of qualified science and mathematics teachers, combined with the relatively small numbers of pre-service teachers preparing to teach in these areas indicates that this is not a viable solution now, or in the foreseeable future. For this reason, alternative approaches involving changes in practice need to be adopted to provide a possible solution.

The traditional role for the School of Education at UNE has been, firstly, to prepare pre-service teachers to enter the teaching profession and, secondly, the conducting of educational research. There has been very little structured overlap between these roles. There has also been little focus on involvement in the preparation and delivery of resources and content to school students at the secondary level of education. Rural universities, such as UNE, include Schools of Education with experienced and qualified science and mathematics teachers and academics in other Schools who engage in research that is relevant to the particular context of the physical location of that university. This is exemplified at UNE by the UNE SMART Farm, located at Kirby, near the university campus, where the issues of farming sustainability are being addressed. The presence of these highly skilled educators and academics, and the availability of science and mathematics being used in regionally relevant contexts, provide the opportunity for institutions such as UNE to engage much more closely with the provision of educational services at both the content and delivery levels to schools in their catchment area. This engagement may improve the quality of mathematics and science education at this crucial point in a student's development and potentially result in an increase in the number of secondary students choosing mathematics and science programs at the tertiary level.

CURRENT UNE STEM EDUCATION PROJECTS

In an attempt to address some of the issues facing STEM education, Australia's Chief Scientist initiated a number of projects funded through the Office for Learning and Teaching (OLT) in 2013. Two of these multi-institution projects, funded to a total of $1.9m, were specifically targeted at rural and remote education and are being conducted by the Regional Universities Network (RUN) consortium, which includes UNE. These projects aim to provide rural and remote STEM students with access to engaging online content via a digital classroom and to develop the confidence and competence of pre-service teachers of science and mathematics.

The RUN Maths and Science Digital Classroom Project

The RUN Maths and Science Digital Classroom Project provides a learning management system (LMS) hosted in the Moodle environment, that provides each partner university with the capacity to provide engaging, interactive content that is based on the specific strengths of the institution. The LMS homepage is shown in Figure 1.

Figure 1: ***RUN Maths and Science Digital Classroom Project LMS Homepage***

The content of the LMS, written by academics from each university, embeds the syllabus needs of the students in their local settings with all teaching and learning materials provided. A focus on engaging, interactive learning activities has been made, with the provision for both synchronous and asynchronous interaction with university based researchers. Each learning context developed is different and is intended to focus on the particular research and teaching strength of each university. This provides an opportunity for future students to engage and identify with relevant local science and mathematics topics. Content developed by UNE has focussed on particular aspects of the UNE SMART Farm, including the remote management of livestock and sustainable grazing practices.

The digital classroom will be introduced to over 200 science and agriculture teachers from throughout regional and rural NSW at a teacher professional development workshop being conducted at UNE in late June 2014. Teachers will have the opportunity to tour the UNE SMART Farm and will be able to see the technology used to collect the data and the use which is made of the data, once analysed, at the farm to manage livestock grazing and ensure the sustainability of the farming processes. Following this, participants will engage in a computer workshop to examine the teaching and learning materials and discuss possible classroom implementation.

The RUN It's a Part of My Life Project

The RUN, It's a Part of My Life Project, seeks to improve the confidence and competence of pre-service mathematics and science teachers studying in regional universities. This three year project involves pre-service teachers (PST) in a six lesson practicum experience where lesson planning is supported by researchers and academics in mathematics, science and education at the institution. Following lesson delivery, PST's have the opportunity to engage with experienced school teaching staff and university academics in a reflective process to further develop their confidence and competence in the field. The research focus of the project is to identify strategies that are able to be incorporated into the curricula of pre-service teacher education programs that will specifically support the development of confidence and competence of the students. The findings will also be used by the institutions to develop strategies to improve these areas for practicing teachers of mathematics and science, particularly those teaching out-of-field.

THE HIGHER EDUCATION RESEARCH FACILITY

The Higher Education Research Facility (HERF) being established at UNE would leverage the institution's previous work focused on rural and remote STEM education by its National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australian (SiMERR) and its current involvement in the identified OLT projects. The facility will include a state of the art digital STEM classroom that will provide the opportunity to address the current issues in rural and remote STEM education at the primary and secondary school level. The classroom will include the latest in technology used in the teaching of science and mathematics and would be able to be used to deliver asynchronous and synchronous content to students and teachers in remote locations.

The digital STEM classroom will meet its obligations in research, teaching and learning, and service by:

- Supporting primary and secondary STEM education in rural and remote Australia via digital classroom by developing synchronous and asynchronous interactive content specifically targeting the UNE context;
- Providing specialist support and professional development to out-of-field STEM teachers in rural and remote schools in Australia;
- Conducting research on and identifying best practice for the remote delivery of pre-service teacher education practicum experience via the STEM classroom. The NSW DEC has indicated its support for this and will credit this experience.

In order to position the role of the STEM digital classroom, the following framework will be used to contextualize the role of the HERF within the functions of research, teaching and learning, and service that are relevant to the core business of the university and are shown in Figure 2.

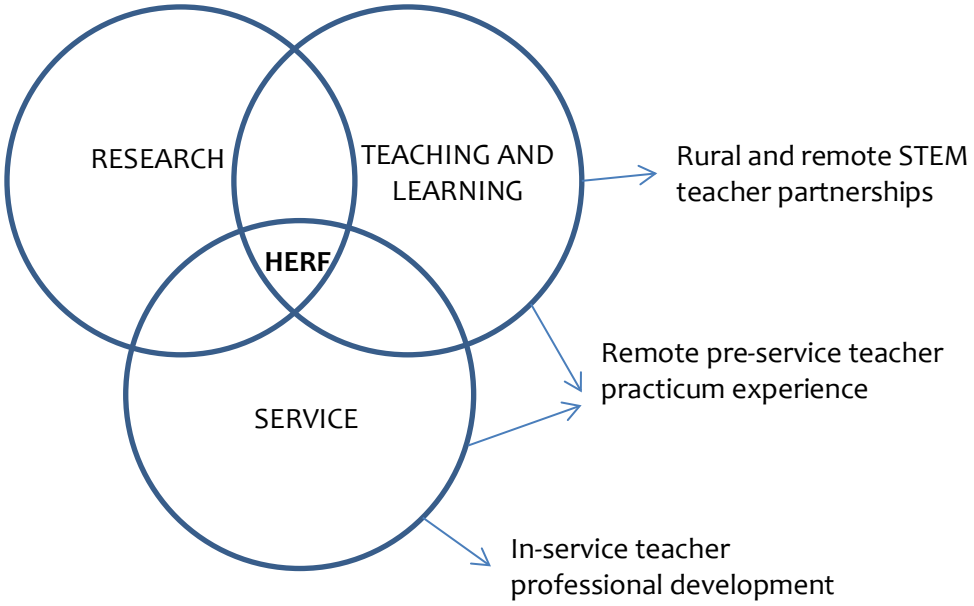


Figure 2 - *Relationship of STEM classroom within HERF to university functions*

This project has the capacity to have a substantial impact on the SoE at UNE, the NSW Department of Education and Communities and schools in rural and remote NSW. A successful implementation of the STEM digital classroom within this focus could see a substantial change in practice for the identified stakeholders, in that the UNE SoE will partner with rural and remote schools in the research-based delivery of current, high quality online education in the STEM disciplines. UNE, with the support of NSW DEC schools, will also pioneer the implementation of

virtual pre-service teacher practicum experience. This practicum experience will involve PST's located in the STEM digital classroom at UNE engaging in accredited virtual delivery of practicum lessons to rural and remote schools throughout NSW.

CONCLUSION

The challenges confronting STEM education in Australia, particularly in rural and remote schools, will not be solved in the short-term. The capacity for teacher education programs to meet the demand for highly qualified teacher education graduates in the STEM field has been questioned for a substantial period of time (Marginson et al., 2013; Thomas, 2000) and this appears unlikely to change in the near future. This situation places an onus on Schools of Education in rural universities to look for innovative strategies to provide in-school expertise in relation to research and content development and delivery for STEM subjects.

This paper has described the evolution of thinking at UNE in relation to how the problems facing STEM education in rural Australia may be addressed. A primary motivation in this process has been the recognition that the institution must engage more directly with teachers, students and the learning activity in schools. The implementation of the Higher Education Research Facility (HERF), incorporating the digital online STEM classroom and a virtual space for content storage, presents the opportunity for the institution to engage with schools throughout rural Australia in a research driven change in approach to STEM education. This approach will involve the institution and partner schools using digital technology to bring interesting, engaging and contextually relevant science and mathematics to rural students.

The opportunity now presents itself over the coming years for rural science and mathematics education in Australia to enter a new phase of development, where technology will provide the medium by which new approaches to the delivery of content to rural schools can be achieved and where teachers in rural schools, many of whom may be teaching out-of-field, are able to access the support required to fully meet the needs of their students.

REFERENCES

Ainley, J., Kos, J., & Nicholas, M. (2008). *Participation in science, mathematics and technology in Australian education*. Canberra: Australian Council for Educational Research.

Allen, J. (2009). Valuing practice over theory: How beginning teachers re-orient their practice in the transition from the university to the workplace. *Teaching and Teacher Education, 25*(5), 647–654.

Allen, J. & Peach, D. (2007). Exploring connections between the in-field and on-campus components of a preservice teacher education program: A student perspective. *Asia-Pacific Journal of Cooperative Education, 8*(1), 23–36.

Attard, C. (2013). "If I had to pick any subject, it wouldn't be maths": Foundations for engagement with mathematics during the middle years. *Mathematics Education Research Journal, 25*(4), 569–587.

Bradley, D., Noonan, P., Nugent, H., & Scales, B. (2008). *Review of Australian Higher Education*. Canberra: DEEWR.

Chubb, I. (2011). *Professor Ian Chubb's Address to the National Press Club*. Retrieved 13 May 2014, from http://www.chiefscientist.gov.au/wp-content/uploads/Professor-Chubbs-Press-Club-Speech-21-June-2011-2.pdf

Goodrum, D., Druhan, A., & Abbs, J. (2011). *The status and quality of Year 11 and 12 science in Australian schools*. Canberra: AAS.

Grima-Farrell, C., Long, J., Bentley-Williams, R., & Laws, C. (2014). A school system and university approach to reducing the research to practice gap in teacher education: A collaborative special education immersion project. *The Australian Journal of Teacher Education, 39*(5), 88–98.

Harris, K., Baldwin, G., & Jensz, F. (2005). *Who's teaching science?: Meeting the demand for qualified science teachers in Australian secondary schools*. Melbourne: Centre for the Study of Higher Education, University of Melbourne.

Ingersoll, R. (1998). The problem of out-of-field teaching. *Phi Delta Kappan, 79*(10), 773–776.

Lyons, T., Cooksey, R., Panizzon, D., Parnell, A., & Pegg, J. (2006). *Science, ICT and mathematics education in rural and regional Australia the SiMERR national survey: A research report.* Armidale: SiMERR.

Lyons, T. & Quinn, F. (2010). *Choosing science. Understanding the declines in senior high school science enrolments*. Armidale, NSW: University of New England.

Lyons, T. & Quinn, F. (2012). Rural high school students' attitudes towards school science. *Australian & International Journal of Rural Education, 22*(2), 21–28.

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). *STEM: Country comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education. Final report*. Melbourne: Australian Council of Learned Academies.

Ramsey, G. (2000). *Quality matters. Revitalising teaching: Critical times, critical choices*. Sydney: New South Wales Department of Education and Training.

Steyn, G. & du Plessis, E. (2007). The implications of the out-of-field phenomenon for effective teaching, quality education and school management. *Africa Education Review, 4*(2), 144–158.

Thomas, J. (2000). *Mathematical sciences in Australia: Looking for a future*. Canberra: Federation of Australian Scientific and Technological Societies.

Thomson, S., De Bortoli, L., Nicholas, M., Hillman, K., & Buckley, S. (2011). *Challenges for Australian education: Results from PISA 2009*. Melbourne, Vic: ACER.

Thomson, S., Hillman, K., & Wernet, N. (2012). *Monitoring Australian Year 8 student achievement internationally: TIMSS 2011.* Camberwell: ACER.

Tytler, R. (2007). *Re-imagining Science education: Engaging students in science for Australia's future.* ACER Monograph 51. Camberwell VIC: ACER Press.

Vanderlinde, R. & Braak, J. (2010). The gap betwen educational research and practice: Views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal, 36*(2), 299–316.