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Remote Access Laboratories enhancing STEM education

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Science, Technology, Engineering, and Mathematics (STEM) workers are important contributors to the innovation on which modern life depends. Hence it is important that education develops STEM capability but too few teachers, especially in primary schools, are well prepared for teaching STEM. Remote Access Laboratories (RAL) have potential to offer STEM experiences in schools and to influence pre-service teachers' capabilities to teach STEM subjects effectively. This mixed methods research is investigating how engagement with RAL influences pre-service teachers' self-efficacy for teaching STEM.

Keywords: Self-efficacy, STEM, Remote Access Laboratories

The STEM education crisis

There is a gap between the rhetoric and reality surrounding education for Science, Technology, Engineering and Mathematics (STEM) in Australian schools. In the rhetoric of public discourse, researchers and policy makers have highlighted the significance of STEM learning (Office of the Chief Scientist, 2013). STEM is important for society because it contributes to new knowledge and sustainable technologies, which benefit national prosperity and social welfare. STEM education is important not only for those who pursue STEM careers but also for everyone who is a 21st century citizen. STEM education will enhance Australia's competitiveness in the global digital economy and underpin Australian citizens' digital literacy skills and digital confidence (Department of Broadband Communications and the Digital Economy, 2013). Therefore STEM education is essential to stimulate creativity, productivity and economic growth for Australia. Schools should offer motivating and engaging STEM lessons to encourage students to continue STEM learning throughout their education.

However, in reality, few students complete STEM degrees and few come from schools with STEM subjects. Fewer tertiary students choose to study STEM as a career path because there is a high dropout rate from STEM learning in secondary school. One reason for low STEM interest in secondary school is that little time is spent on STEM in primary schools (Office of the Chief Scientist, 2013). The shortfall of STEM graduates entering the workforce is attributed to early withdrawal from STEM subjects during primary and secondary school years. Therefore, it is important to engage and motivate students to learn STEM when they are young.

Primary school teachers are not well prepared to teach STEM as required by the newly developed Australian Curriculum. There is evidence that "primary school teachers are not adequately trained to teach science" (Van Aalderen-Smeets, Walma van der Molen, & Asma, 2012, p. 159). Moreover, there are insufficient training and professional learning programs in STEM subjects, especially for primary school teachers who are required to teach STEM curriculum without specific discipline training (Freeman, 2013). It is important to provide professional learning programs for primary school teachers that are in line with the *Australian Professional Standards for Teachers* (AITSL, 2011) and the *Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA, 2008). Professional learning related to STEM is needed for primary school teachers to build up their confidence and capacity to teach STEM in motivating and engaging ways.

STEM teacher shortages have been identified as a key contributor to the crisis in STEM education in Australia (Freeman, 2013). In order to fill STEM teaching positions, primary and secondary schools apply the following strategies: requiring teachers to teach outside their expertise; recruiting less-qualified or unqualified replacement teachers; reducing the curriculum offered; reducing the length of classroom time for STEM (Marginson, Tytler, Freeman, & Roberts, 2013). The consequences of employing such strategies are serious. Requiring teachers to work outside their expertise would increase teachers' anxiety (Bandura, 1997), thereby causing student anxiety and low performance in STEM (Ping, Bradley, Gunderson, Ramirez, Beilock, & Levine, 2011). Teachers who are not qualified to teach STEM are not capable of delivering motivating and engaging lessons to engage students in learning STEM. Employing less-qualified or unqualified teachers breaches the *Australian Standards*

for Professional Teachers (AITSL, 2011) and removing STEM from the curriculum or reducing teaching time for STEM breaches the learning requirements of the *Australian Curriculum* (ACARA, 2013). Therefore, it is important to recruit qualified teachers to teach STEM in schools.

Laboratory experimentation that allows students to explore and apply science through hands-on experience is considered central to science education (Lowe, Newcombe, & Stumpers, 2012). However, physical equipment for science and technology is expensive to purchase and maintain for individual schools (Lowe et al., 2012). Logistical constraints, particularly funding difficulties, place huge limitations on schools' capacities to maintain students' interest and engagement in learning science-related subjects (Lowe et al., 2012).

In order to engage more students to learn STEM, they need to access STEM experiences more often and more effectively. Hence, schools need to provide equipment for students to learn STEM and teachers need to be prepared to teach STEM. Access to equipment and professional development will ensure that teachers can provide motivating and engaging lessons for students to learn STEM.

Remote Access Laboratories (RAL)

Remote Access Laboratories (RAL) can be part of the solution to bridge the gap to make STEM experiments accessible to students. RAL provides a virtual space which is beneficial to share knowledge and resources for STEM subject learning (Lowe et al., 2012). RAL enables schools to share access to high quality facilities and resources to offset costs (Lindsay, Murray, & Stumpers, 2011). Thus RAL provides more opportunities for children to learn STEM and maintain their interest over the long term.

The Remote Access Laboratories for Fun, Innovation and Education (RALfie) project at the University of Southern Queensland (USQ) will provide the RAL to be used in this research. The activities can be face-to-face or virtual and the equipment includes cameras, sensors, Legos and robots. The RALfie box interface has been designed to enable experiments to be installed and connected to the Internet so that schools and share them, thereby avoiding the cost of unnecessary duplication.

Robot RAL-ly is a RALfie activity in which children in Japan designed a track that was constructed and connected by their peers in Australia. The Japanese students then navigated the track, which was located in Australia with remotely controlled robots using the RAL system. The setup included multiple camera feeds, which enabled the students to observe the robots and the track (Maxwell et al., 2013). The distributable characteristic of RALfie supports flexible and accessible use of RAL for educational cooperation.

Teacher Preparation

In order to improve STEM teaching in primary schools, there are some initiatives which focus on "allocating more time" to STEM education (Van Aalderen‐Smeets et al., 2012, p. 159). However, merely adding more time to STEM teaching does not solve the problem for unqualified or less qualified STEM teachers in primary schools. In order to improve STEM teaching in primary schools, teachers need professional learning about how to teach STEM in an engaging way. When teachers are confident about their professional knowledge, they are more likely to increase their self-efficacy to teach effectively (Beilock, Gunderson, Ramirez, & Levine, 2010).

Self-efficacy is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Self-efficacy strongly influences how people make choices, how much effort they exert and how long they persist in the face of adversity. Self-efficacy beliefs are derived from four principal sources of information, namely *enactive mastery experience*, *vicarious experience*, *verbal persuasion*, and *physiological and emotional status* (Bandura, 1997). Successful or *mastery experiences* have the most robust influence on people's personal efficacy, whereas failures undermine it. *Vicarious experiences* also contribute significantly to self-efficacy. When people perceive others who are similar, such as classmates, colleagues and competitors, succeed it serves as a positive model for their efficacy appraisals (Bandura, 1997). *Verbal persuasion* provides a further means of strengthening people's efficacy. People who are persuaded that they have the ability to achieve a given task are more likely to exert greater effort and sustain it (Bandura, 1997). *Physiological and emotional state* is indicated by somatic information, which is relevant to physical accomplishments, health functioning and coping with stressors.

Investigating the issues

This study is investigating pre-service primary teachers' self-efficacy to teach STEM content. RAL is a vehicle

to impact and influence pre-service teachers' confidence and capacity to teach STEM. This study will expand the understanding of the relationship between teachers' self-efficacy and their capacity for teaching STEM.

RALfie activities cover programming, connectivity and designing skills, which are in line with the Australian Curriculum. RALfie activities will enhance students' abilities, including communicative skills, collaborative skills, problem solving skills and creativity which are in line with the requirements of the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2010). Participants in this study are primary pre-service teachers who are enrolled in an undergraduate program at USQ.

Based on Bandura' theory (1997) the *Science Teaching Efficacy Belief Instrument* (STEBI) has been developed and validated and has become one of the most widely used instruments targeting teachers' self-efficacy for teaching science (Albion & Spence, 2013). STEBI-A is used for in-service teachers (Riggs & Enochs, 1990), whereas STEBI-B has been adapted and developed for pre-service teachers (Enochs & Riggs, 1990). The original STEBI has been modified as the basis for similar instruments. It is a valid and reliable instrument, which has been justified and used in different numerous research studies. For this study the STEBI-B has been modified for the measurement of pre-service teachers' self-efficacy to teach technology. The modified instrument is the Technology Teaching Efficacy Belief Instrument (T-TEBI) and is used for participants enrolled in technology courses. Some wording has been adjusted to suit the Australian context.

Because self-efficacy is a specific construct, it will be linked directly and specifically to RAL skills. The RALfie project includes a variety of RAL activities. The common and basic learning requirements for pre-service teachers are to be able to construct an experiment, connect the experiment to a server to test networks, program the interface, transmit data and remote control the experiment. These are in line with the requirements of the *Australian Curriculum: Technologies* for Year 5 to Year 6 (ACARA: Australian Curriculum Assessment and Reporting Authority, 2013). These RAL skills will be used to develop specific RAL self-efficacy questions, which will follow the pattern of the T-TEBI and STEBI-B but be analysed separately. The T-TEBI and RAL related self-efficacy questions will be administered in pre- and post- surveys to enable tracking of the changes in pre-service teachers' self-efficacy for STEM teaching and for using RAL.

The study will use mixed methods. Interviews, observations, reflections, lesson plans, and online group discussions will be used to collect qualitative data. Semi-structured interviews will take place at the end of semesters using questions based on self-efficacy theory (Bandura, 1997). Observations of pre-service teachers working with RALfie will focus on behaviours that might indicate presence or absence of self-efficacy. Thematic analysis will be adopted to analyze qualitative data.

The study is in its early stages with pilots being undertaken in 2014 to test techniques to be used for data collection and analysis. The major data collection is scheduled for early 2015. Preliminary findings from the pilots will be presented at the conference.

Conclusion

In rhetoric, STEM is very important for society and STEM education is of great significant for the innovation and sustainability in the digital future. However, in reality there are several STEM crises which impede the success of STEM education. Remote Access Laboratories can be part of the solution to make STEM experiences accessible to both teachers and students to fulfill the requirements of the newly developed Australian Curriculum. RAL will be used as a vehicle to enhance pre-service teachers' self-efficacy to teach STEM. Therefore, teachers can have a broader understanding of the Australian Curriculum and to be better prepared to teach STEM in the 21st century.

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References

ACARA: Australian Curriculum Assessment and Reporting Authority. (2013). *Australian curriculum: Technologies*. Sydney. Retrieved from http://www.australiancurriculum.edu.au/technologies/

AITSL: Australian Institute for Teaching and School Leadership. (2011). *Australian professional standards for teachers*. Retrieved from http://www.aitsl.edu.au/australian-professional-standards-for-teachers

Albion, P. R., & Spence, K. G. (2013). Primary Connections in a provincial Queensland school system: Relationships to science teaching self-efficacy and practices. *International Journal of Environmental & Science Education, 8*(3) 510-520.

Australian Curriculum Assessment and Reporting Authority. (2010). *The Australian Curriculum*. Retrieved from http://www.australiancurriculum.edu.au/technologies/digital-technologies/Curriculum/F-10

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: WH Freeman.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Reply to Plante et al.: Girls' math achievement is related to their female teachers' math anxiety. *Proceedings of the National Academy of Sciences, 107*(20), E80-E80.

Department of Broadband Communications and the Digital Economy. (2013). *Advancing Australia as a digital economy: An update to the national digital economy strategy*. Retrieved from http://www.dbcde.gov.au/__data/assets/pdf_file/0013/171301/Advancing-Australia-as-a-Digital-Economy-PDF.pdf

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*(8), 694-706. doi: 10.1111/j.1949-8594.1990.tb12048.x

Enochs, L. G., Riggs, I. M., & Ellis, J. D. (1993). The development and partial validation of microcomputer utilization in teaching efficacy beliefs instrument in a science setting. *School Science and Mathematics, 93*(5), 257-263. doi: 10.1111/j.1949-8594.1993.tb12240.x

Freeman, B. (2013). *Science, mathematics, engineering and technology (STEM) in Australia: practice, policy and programs.* Melbourne: Australian Council of Learned Academies.

Lindsay, E., Murray, S., & Stumpers, B. D. (2011). *A toolkit for remote laboratory design and development.* Paper presented at the Frontiers in Education conference (FIE), The United States.

Lowe, D., Newcombe, P., & Stumpers, B. (2012). Evaluation of the use of remote laboratories for secondary school science education. *Research in Science Education, 43*(3), 1197-1219. doi: 10.1007/s11165-012-9304-3

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). *STEM: Country comparisons*. Australian Council of Learned Academies. Melbourne. Retrieved from http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-2

Maxwell, A., Fogarty, R., Gibbings, P., Noble, K., Kist, A. A., & Midgley, W. (2013). *Robot RAL-ly international-Promoting STEM in elementary school across international boundaries using remote access technology.* Paper presented at the Proceedings of the 10th International Conference on Remote Engineering and Virtual Instrumentation (REV 2013).

Ministerial Council on Education Employment Training and Youth Affairs. (2008). *Melbourne declaration on eduational goals for young Australians*. Retrieved from http://www.mceecdya.edu.au/mceecdya/melbourne_declaration,25979.html

Office of the Chief Scientist. (2013). *Science, technology, engineering and mathematics in the national interest: A strategic approach*. Canberra. Retrieved from http://www.chiefscientist.gov.au/2013/07/science-technology-engineering-and-mathematics-in-the-national-interest-a-strategic-approach/

Ping, R. M., Bradley, C., Gunderson, E. A., Ramirez, G., Beilock, S. L., & Levine, S. C. (2011). *Alleviating anxiety about spatial ability in elementary school teachers.* Paper presented at the Annual Meeting of the Cognitive Science Society, Boston, MA.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637.

Van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education, 96*(1), 158-182.

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Remote Access Laboratories Enhancing STEM Education

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Remote Access Laboratories (RAL) have potential as a vehicle to influence pre-service teachers' self-efficacy to teach STEM subjects. This research is investigating ways in which engagement with RAL influences pre-service teachers' self-efficacy. Bandura's self-efficacy theory is the conceptual framework in this research. Mixed methods approach will be used. Surveys will trace changes in their self-efficacy to investigate in what ways engagement with RAL influences their self-efficacy. Interviews will be used to investigate why their self-efficacy changed. The outcome of this research is to find out ways to impact on pre-service teachers' self-efficacy to teach STEM.

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The STEM Education Crisis

There is a gap between the rhetoric and reality surrounding STEM education in Australian schools. In rhetoric, various researchers and policy makers have highlighted the significance of Science, Technology, Engineering and Mathematics (STEM) learning (Office of the Chief Scientist, 2013). STEM is important for society because it contributes to new knowledge and sustainable technologies which benefit national prosperity and social welfare. STEM education is important not only for those who pursue STEM careers but for everyone who is a 21st century citizen as well. STEM education will enhance Australia's competitiveness in the global digital economy and underpin Australian citizens' digital literacy skills and digital confidence (Department of Broadband Communications and the Digital Economy, 2013). Therefore STEM education is essential to stimulate creativity, productivity and economic growth for Australia. Schools should offer motivating and engaging STEM lessons to encourage students to continue STEM learning throughout their education.

However, in reality few students are completing STEM degrees and few are coming from schools with STEM subjects. Fewer tertiary students choose to study STEM as a career path because there is a high dropout rate from STEM learning in secondary school. One reason for the decline in STEM interest in secondary schooling is that there is little time spent on STEM teaching in primary schools (Office of the Chief Scientist, 2013). The shortfall of STEM graduates entering the workforce is attributed to their early withdrawal from STEM subjects during their primary and secondary school years. Therefore, it is important to engage and motivate students to learn STEM when they are young children.

Primary school teachers are not well prepared to teach STEM to fulfill the requirements of the newly developed Australian Curriculum. There is evidence that "primary school teachers are not adequately trained to teach science" (Van Aalderen-Smeets, Walma van der Molen, & Asma, 2012, p. 159). Moreover, there are insufficient training and professional learning programs in STEM subjects, especially for primary school teachers who are required to teach the primary school science and technology curriculum without specific discipline training (Freeman, 2013). It is important to provide professional learning programs for primary school teachers which are in line with the *Australian Professional Standards for Teachers* (AITSL, 2011) and the *Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA, 2008). Professional learning related to STEM is needed for primary school teachers to build up their confidence and capacity to teach STEM in motivating and engaging ways.

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Remote Access Laboratories (RAL)

Remote Access Laboratories (RAL) can be part of the solution to bridge the gap to make STEM experiments accessible to students. RAL provides a virtual space which is beneficial to share knowledge and resources for STEM subject learning (Lowe et al., 2012). RAL enables schools to share access to high quality facilities and resources to offset costs (Lindsay, Murray, & Stumpers, 2011). Thus RAL provides more opportunities for children to learn STEM and maintain their interest over the long term.

RAL experiments used in this research will be provided by the Remote Access Laboratories for Fun, Innovation and Education (RALfie) project at the University of Southern Queensland (USQ), Australia. The activities can be face-to-face or virtual and the equipment includes cameras, sensors, Legos and robots. The RALfie box interface has been designed to enable experiments to be installed and connected to the Internet so that schools and share them, thereby avoiding the cost of unnecessary duplication.

One example of a RALfie activity is Robot RAL-ly. Children in Japan designed a track that was constructed and connected by their peers in Australia. The Japanese students then navigated the track which was located in Australia with remotely controlled robots using the RAL system. The setup included a number of camera feeds which allowed the students to observe the robots and the track (Maxwell, Fogarty, Gibbings, Noble, Kist, & Midgley, 2013). Therefore, the distributable characteristic of RAL allows the flexibility and accessibility of RAL to be used in educational cooperation.

Teacher Preparation

In order to improve STEM teaching in primary schools, there are some initiatives which focus on "allocating more time" to STEM education (Van Aalderen-Smeets et al., 2012, p. 159). However, merely adding more time to STEM teaching does not solve the problem for unqualified or less qualified STEM teachers in primary schools. In order to improve STEM teaching in primary schools, teachers need professional learning about how to teach STEM in an engaging way. When teachers are confident about their professional knowledge, they are more likely to increase their self-efficacy to teach effectively (Beilock, Gunderson, Ramirez, & Levine, 2010).

Self-efficacy is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances"(Bandura, 1986, p. 391). Self-efficacy strongly influences how people make choices, how much effort people exert and how long people persist in the face of adversity. Self-efficacy beliefs are derived from four principal sources of information, namely *enactive mastery experience*, *vicarious experience*, *verbal persuasion*, and *physiological and emotional status* (Bandura, 1997). Successful or *mastery experiences* have the most robust influence on people's personal efficacy, whereas failures undermine it, especially when failures precede the firm establishment of their self-efficacy. *Vicarious experiences* also contribute significantly to self-efficacy. When people perceive others with similar skills or situations, such as classmates, colleagues and competitors, succeed in a similar event it serves as a positive model for their efficacy appraisals (Bandura, 1997). *Verbal persuasion* provides a further means of strengthening people's efficacy. People who are persuaded that they have the ability to achieve a given task are more likely to exert greater effort and sustain it, whereas people who doubt their personal ability and dwell on personal deficiencies are more likely to quit when adversity arises (Bandura, 1997). *Physiological and emotional state* is indicated by somatic information which is relevant to physical accomplishments, health

functioning and coping with stressors.

This Study

This study is investigating pre-service primary teachers' self-efficacy to teach STEM content. RAL is a vehicle to impact and influence pre-service teachers' confidence and capacity to teach STEM. This study will expand the understanding of the relationship between teachers' self-efficacy and their capacity for teaching STEM.

RALfie activities cover programming, connectivity and designing skills which are in line with the Australian Curriculum. RALfie activities will enhance students' abilities, including communicative skills, collaborative skills, problem solving skills and creativity which are in line with the requirements of the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2010). Participants in this study are primary pre-service teachers who are enrolled in an undergraduate program at USQ.

Based on Bandura' theory (1997) the *Science Teaching Efficacy Belief Instrument* (STEBI) has been developed and validated and has become one of the most widely used instruments targeting teachers' self-efficacy for teaching science (Albion & Spence, 2013). STEBI-A is used for in-service teachers (Riggs & Enochs, 1990), whereas STEBI-B has been adapted and developed for pre-service teachers (Enochs & Riggs, 1990). The original STEBI has been modified as the basis for similar instruments. It is a valid and reliable instrument, which has been justified and used in different numerous research studies. For this study the STEBI-B has been modified for the measurement of pre-service teachers' self-efficacy to teach technology. The modified instrument is the Technology Teaching Efficacy Belief Instrument (T-TEBI) and is used for participants enrolled in technology courses. Some wording has been adjusted to suit the Australian context.

Because self-efficacy is a specific construct, it will be linked directly and specifically to RAL skills. The RALfie project includes a variety of RAL activities. The common and basic learning requirements for pre-service teachers are to be able to construct an experiment, connect the experiment to a server to test networks, program the interface, transmit data and remote control the experiment. These are in line with the requirements of the *Australian Curriculum: Technologies* for Year 5 to Year 6 (ACARA: Australian Curriculum Assessment and Reporting Authority, 2013). These RAL skills will be used to develop specific RAL self-efficacy questions, which will follow the pattern of the T-TEBI and STEBI-B but be analysed separately. The T-TEBI and RAL related self-efficacy questions will be administered in pre- and post- surveys to enable tracking of the changes in pre-service teachers' self-efficacy for STEM teaching and for using RAL.

The study will use mixed methods. Interviews, observations, reflections, lesson plans, and online group discussions will be used to collect qualitative data. Semi-structured interviews will take place at the end of semesters using questions based on self-efficacy theory (Bandura, 1997). Observations of pre-service teachers working with RALfie will focus on behaviours that might indicate presence or absence of self-efficacy. Thematic analysis will be adopted to analyze qualitative data.

The study is in its early stages with pilots being undertaken in 2014 to test techniques to be used for data collection and analysis. The major data collection is scheduled for early 2015. Preliminary findings from the pilots will be presented at the conference.

Conclusion

In rhetoric, STEM is very important for society and STEM education is of great significant for the innovation and sustainability in the digital future. However, in reality there are several STEM crises which impede the success of STEM education. Remote Access Laboratories can be part of the solution to make STEM experiences accessible to both teachers and students to fulfill the requirements of the newly developed Australian Curriculum. RAL will be used as a vehicle to enhance pre-service teachers' self-efficacy to teach STEM. Therefore, teachers can have a broader understanding of the Australian Curriculum and to be better prepared to teach STEM in the 21st century.

Acknowledgement: This research is supported through the Australian Government's Collaborative Research Networks (CRN) program.

References

ACARA: Australian Curriculum Assessment and Reporting Authority. (2013). *Australian curriculum: Technologies*. Sydney. Retrieved from http://www.australiancurriculum.edu.au/technologies/

AITSL: Australian Institute for Teaching and School Leadership. (2011). *Australian professional standards for teachers*. Retrieved from http://www.aitsl.edu.au/australian-professional-standards-for-teachers

Albion, P. R., & Spence, K. G. (2013). Primary Connections in a provincial Queensland school system: Relationships to science teaching self-efficacy and practices. *International Journal of Environmental & Science Education, 8*(3).

Australian Curriculum Assessment and Reporting Authority. (2010). The Australian Curriculum. Retrieved 9th of July, 2014, from http://www.australiancurriculum.edu.au/technologies/digital-technologies/Curriculum/F-10

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: WH Freeman.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Reply to Plante et al.: Girls' math achievement is related to their female teachers' math anxiety. *Proceedings of the National Academy of Sciences, 107*(20), E80-E80.

Department of Broadband Communications and the Digital Economy. (2013). *Advancing Australia as a digital economy: An update to the national digital economy strategy*. Retrieved 8th August 2014, from http://www.dbcde.gov.au/__data/assets/pdf_file/0013/171301/Advancing-Australia-as-a-Digital-Economy-PDF.pdf

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*(8), 694-706. doi: 10.1111/j.1949-8594.1990.tb12048.x

Enochs, L. G., Riggs, I. M., & Ellis, J. D. (1993). The development and partial validation of microcomputer utilization in teaching efficacy beliefs instrument in a science setting. *School Science and Mathematics, 93*(5), 257-263. doi: 10.1111/j.1949-8594.1993.tb12240.x

Freeman, B. (2013). Science, mathematics, engineering and technology (STEM) in Australia: practice, policy and programs. Melbourne: Australian Council of Learned Academies.

Lindsay, E., Murray, S., & Stumpers, B. D. (2011). *A toolkit for remote laboratory design and development.* Paper presented at the Frontiers in Education conference (FIE), The United States.

Lowe, D., Newcombe, P., & Stumpers, B. (2012). Evaluation of the use of remote laboratories for secondary school science education. *Research in Science Education, 43*(3), 1197-1219. doi: 10.1007/s11165-012-9304-3

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). *STEM: Country comparisons*. Australian Council of Learned Academies. Melbourne. from http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-2

Maxwell, A., Fogarty, R., Gibbings, P., Noble, K., Kist, A. A., & Midgley, W. (2013). *Robot RAL-ly international-Promoting STEM in elementary school across international boundaries using remote access technology.* Paper presented at the Proceedings of the 10th International Conference on Remote Engineering and Virtual Instrumentation (REV 2013).

Ministerial Council on Education Employment Training and Youth Affairs. (2008). *Melbourne declaration on eduational goals for young Australians*. Retrieved 8th August 2014, from http://www.mceecdya.edu.au/mceecdya/melbourne_declaration,25979.html

Office of the Chief Scientist. (2013). *Science, technology, engineering and mathematics in the national interest: A strategic approach*. Canberra. Retrieved 8th August 2014, from http://www.chiefscientist.gov.au/2013/07/science-technology-engineering-and-mathematics-in-the-national-interest-a-strategic-approach/

Ping, R. M., Bradley, C., Gunderson, E. A., Ramirez, G., Beilock, S. L., & Levine, S. C. (2011). *Alleviating anxiety about spatial ability in elementary school teachers.* Paper presented at the Annual Meeting of the Cognitive Science Society, Boston, MA.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637.

Van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education, 96*(1), 158-182.

Reviewers' recommendations	My response to the recommendations
Reviewer C: A planned study to investigate trainee teacher readiness and belief that they can teach in STEM and	Thank you. It is a good suggestion. With consultation with my principal supervisor Peter Albion, it is feasible to present preliminary findings at ASCILITE.

also how that changes with use of remote labs. REVISION: I think it needs a statement in the paper that they will present their preliminary findings at the conference. Currently it is only a proposal to do the study -- may be too early for significant findings, but they should be able to present preliminary findings at ascilite. Paper recommendation: Accept Paper with Minor Revisions	See words coloured in yellow.

ascilite2014

Australasian Society for Computers in Learning in Tertiary Education

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Monday, October 27, 2014

Wu Ting
University of Southern Queensland

Dear Wu,

Confirmation of Presentation at ascilite2014 Conference 23-26 November 2014

Details of your confirmed presentation/s as follows:

Presentation Details

Abstract Title:	Enhancing Queensland Primary and Secondary Pre-service Teachers' Self-efficacy to Teach Technology Using Remote Access Laboratories
Presentation Type:	Poster
Session:	Poster Session
Date:	Monday, November 24, 2014
Session Start Time:	5:00 PM
Location:	St David Lobby

Abstract Title:	Remote Access Laboratories Enhancing STEM Education
Author:	Wu Ting, Peter Albion
Presentation Type:	Concise
Session:	Session 8.2
Date:	Wednesday, November 26, 2014
Session Start Time:	1:40 PM
Location:	St David Room 1

Full papers are allocated a total of 25 minutes (recommend 20 mins presentation / 5 mins for discussion). Concise papers are allocated a total of 15 minutes (10 mins presentation, 5 mins discussion).

Sharing Practice Only
Sharing Practice presentations are allocated 25 minutes unless we have agreed in writing to 50 minutes. Please email submissions.ascilite@otago.ac.nz if you are unsure. The equipment/facilities you requested for your presentation are listed above - if there is a change to this or if this is incorrect, please let us know as soon as possible by email to submissions.ascilite@otago.ac.nz with SPSUPPORT in the subject line
The draft programme is now available on the website here:
http://ascilite2014.otago.ac.nz/preliminary-programme/

Please do check the programme ahead of time to ensure that you know when and where you are

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scheduled to give your presentation.

If for any reason you are unable to present at your allocated time please email ascilite.submissions@otago.ac.nz before the conference or notify the registration desk staff during the conference.

PRESENTER AND POSTER GUIDELINES
Full information on presentations and posters is available on the conference website here:
http://ascilite2014.otago.ac.nz/info-4-authors/

Guidelines for uploading presentation files ahead of the conference and linking these to the conference programme are also provided on this page:
http://ascilite2014.otago.ac.nz/info-4-authors/

REGISTRATION
If you have not already done so, please do ensure that you register to attend ascilite2014. We cannot guarantee that your paper will appear in the published proceedings if you do not register to attend the conference. Please contact the conference organiser ascilite2014@events4you.co.nz as soon as possible if you or any of your co-authors are unable to attend and present the paper.

You can register for ascilite2014 here:
http://ascilite2014.otago.ac.nz/register/

Kind regards,
Jenny McDonald
Co-convenor - ascilite2014

From: **Ting Wu** Ting.Wu@usq.edu.au
Subject: FW: [ascilite2014] Editorial Decision on Concise Paper
Date: 1 September 2014 9:24 am
To: Peter Albion Peter.Albion@usq.edu.au, Warren Midgley Warren.Midgley@usq.edu.au, Lindy Orwin Lindy.Orwin@usq.edu.au

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Hi my dear supervisors,
My concise paper to ASCILITE has been accepted.
Thank you for your great effort in helping me.
Warm regards
Wu Ting

-----Original Message-----
From: Dr Bronwyn Ann Hegarty [mailto:ascilite.submissions@otago.ac.nz]
Sent: Saturday, 30 August 2014 10:40 AM
To: Ting Wu
Subject: [ascilite2014] Editorial Decision on Concise Paper

Wu Ting:

After a careful review of your submission, "Remote Access Laboratories Enhancing STEM Education" is accepted for presentation as a Concise Paper at ascilite annual conference subject to revisions suggested by the reviewers (see below).

To finalise your paper for publication in the proceedings, please add:

1. The names and affiliations of all authors (placed between your paper title and abstract);
2. Other author-identifying information (e.g., references, organisations etc.) which were omitted for the review process;
3. Acknowledgements;
4. Changes required by the reviewers*;
5. Final typographical edits.

*In addition, we require an explanatory notes document which outlines the changes you have made in response to reviewer recommendations (see below).
We suggest you do this as a 2-column table, with reviewer recommendations listed in the left-hand column and your response to the recommendations listed in the right-hand column.

To upload your revised paper and explanatory notes document, please go to the online submission system at: https://ascilite2014.otago.ac.nz/ocs/. Click on your submission title > "Review" > "Upload Author Version".

Please also go to the online submission system (https://ascilite2014.otago.ac.nz/ocs/) and click on your submission title > "Summary" > "Edit Metadata" to proof-read and if necessary update your abstract. This abstract will be published in the conference programme.

Revised papers, explanatory notes and abstracts are due by 17th September 2014 (NZ standard time). The Programme Committee cannot guarantee that your paper will be published in the conference proceedings if you submit changes after 17th September.

To ensure publication in the conference proceedings, you must register for the conference. To register, go to http://ascilite2014.otago.ac.nz/register/. Please remember that Earlybird rates close on 3rd October 2014.

Additional information about presentations will be announced on our conference website (http://ascilite2014.otago.ac.nz) before the end of October. If you are unable to present, please notify us as soon as possible:
ascilite.submissions@otago.ac.nz.

Thank you and we look forward to your participation in this event.

Dr Bronwyn Ann Hegarty
Otago Polytechnic
Phone +6421735438
ascilite.submissions@otago.ac.nz

Reviewer A:

Quality of research / scholarship (35%):
Agree

Originality and scholarly contribution (35%):
Strongly Agree

Relevance and suitability to ascilite 2014 (15%):
Strongly Agree

Quality of written presentation (15%):

Strongly Agree

Summary of contribution:
This proposed research project has the potential to address a major shortcoming in both school education and pre-service teacher education. It is well-theorised and builds on exisiting work.

Paper recommendation:
Accept Paper

Reviewer C:

Quality of research / scholarship (35%):
Agree

Originality and scholarly contribution (35%):
Neutral

Relevance and suitability to ascilite 2014 (15%):
Agree

Quality of written presentation (15%):
Agree

Summary of contribution:
A planned study to investigate trainee teacher readiness and belief that they can teach in STEM and also how that changes with use of remote labs.
REVISION: I think it needs a statement in the paper that they will present their preliminary findings at the conference. Currently it is only a proposal to do the study -- may be too early for significant findings, but they should be able to present preliminary findings at ascilite.

Paper recommendation:
Accept Paper with Minor Revisions
