TEACH Journal of Christian Education

Volume 11 | Issue 1 Article 10

7-2017

STEM Down the Track: Two Christian Schools' Further Experiences

Peter W. Kilgour
Avondale College, peter.kilgour@avondale.edu.au

Phil Fitzsimmons
Avondale College of Higher Education, phil.fitzsimmons@avondale.edu.au

Tieren Kilgour
Kempsey Adventist School, tieren.kilgour@kas.adventist.edu.au

Jennifer Merriman
Avondale School, jmerriman@avondaleschool.nsw.edu.au

Follow this and additional works at: http://research.avondale.edu.au/teach

Part of the Education Commons

Recommended Citation

Kilgour, Peter W.; Fitzsimmons, Phil; Kilgour, Tieren; and Merriman, Jennifer (2017) "STEM Down the Track: Two Christian Schools' Further Experiences," *TEACH Journal of Christian Education*: Vol. 11 : Iss. 1 , Article 10.
Available at: http://research.avondale.edu.au/teach/vol11/iss1/10

This Research & Scholarship is brought to you for free and open access by ResearchOnline@Avondale. It has been accepted for inclusion in TEACH Journal of Christian Education by an authorized editor of ResearchOnline@Avondale. For more information, please contact alicia.starr@avondale.edu.au.

TEACH[R]

STEM down the track: Two Christian schools' further experiences

Peter Kilgour
Senior Lecturer, Research Centre Director, Discipline of Education, Avondale College of Higher Education, Cooranbong NSW

Phil Fitzsimmons
Associate Professor, Assistant Dean (Research), Discipline of Education, Avondale College of Higher Education, Cooranbong NSW

Tieren Kilgour
Mathematics Teacher, Kempsey Adventist School, Kempsey, NSW

Jennifer Merriman
Technological and Applied Studies Teacher, Avondale School, Cooranbong, NSW

Key words: STEM, STEAM, science, mathematics, technology, engineering, inquiry, constructive

Abstract

Students' perceptions of what STEM is and how it has been implemented in their schools is reported in this paper. Students were asked in focus groups about what STEM is and how they had seen the progress their two respective schools had made in its implementation. The data showed that students were very familiar with what STEM is and how it was developing in their schools. While younger students enjoyed the fun and the challenge, secondary students could see the potential for the STEM they are doing at school to help in their future employment. Another interesting factor revealed in the study was the alignment of student answers with each of the cognitive levels of Blooms Taxonomy of Educational Objectives.

> *"linkages to authentic pedagogical applications … is being misunderstood or misplaced because "the meaning or significance of STEM is not clear and distinct""*

Introduction

This paper is the second in a series of qualitative case study investigations (Creswell, 2007) that have focused on STEM education. The last edition of this journal (Kilgour, Fitzsimmons, Baywood & Merriman, 2016) reported the first stage of this research and investigated the perceptions of teachers on the introduction of STEM based learning into their schools. As stated, this paper reports on the second phase of the study that tracked the implementation of a STEM based program into two K-12 schools that started their STEM journey at approximately the same time. This phase of the investigation looks into the perceptions of students, in both the primary years and secondary years at the same schools, about their beliefs of what STEM is and where it has taken them and their school.

Background

Who's Listening?

Notwithstanding sparse instances of case study reporting by researchers such as Bissaker (2014), where a scattering of schools such as the Australian Science and Mathematics School in Adelaide, South Australia, have begun to move forward in a strategic and whole school approach, it would seem that generally across the globe the teaching of STEM (Science, Technology, Engineering and Maths) has reached a critical point of educational inertia. It has become increasingly clear that in regard to STEM praxes, linkages to authentic pedagogical applications within classrooms is being misunderstood or misplaced because "the meaning or significance of STEM is not clear and distinct" (Bybee 2013, p. x). Bang and Luft (2013) concur believing that amongst many educators, computer hardware in itself is the steppingstone to 21st century teaching with the tacit "assumption that these devices will automatically bring about revolutionary changes in teaching and learning processes" (p. 118).

While lack of epistemological clarity and stalled ontological momentum is typical of all paradigm shifts, according to Tytler (2007) and comments by Banks and Barlax (2014) regarding STEM, the teaching of science at the classroom level is simply bogged down in an outdated mode of relevance and connectivity to student's current world view. Tytler's (2007) comments regarding the Australian context is also indicative of another critical point globally in that teachers, and obviously academics, often focus on one of the STEM areas without making specific links to the others (Attard & Northcote, 2011).

For most of the reasons mentioned previously, Mohr-Schroeder, Cavalcanti and Blyman (2015) suggest that STEM has been in stagnation for over three decades. Kumtepe and Kumtepe (2015) have come to the same conclusion, asking the question: "We talk the talk, but why don't we walk the walk?" (p. 1). It is becoming increasingly clear that unless there is a comprehensive stock-take of the current situation, no amount of discussion on the nature of the issues through "constant cycles of academic education speak" (Fitzsimmons & Lanphar, 2012, p. 212) will enable STEM to move out of its current paradigm paralysis.

What Is It We Are Not Hearing?

As intimated in the previous section, even the most cursory review of the research literature related to STEM education reveals a global educational situation that is somewhat depressing, given the importance governments have placed on generating a STEM based foci in schools. "Prowess in STEM education is the new educational 'arms race', and governments are prepared to invest heavily in it" (Banks & Barlax 2014, p. xi). This is a critical issue in itself in that while governments are 'talking' they are failing to back up their rhetoric with sufficient funds for professional development, classroom based research and infrastructure or curricula documents that not only provide insight into how to teach STEM authentically, but also how to generate authentic integration of the STEM disciplines. One could reasonably assume that this is why there are declining numbers of Australian students taking on Maths and Science in the post-compulsory years of senior high school (Masters, 2016). Indeed, in both Masters' (2006) and Tytler's (2007) commissioned reports dealing with STEM, the term 'crisis' was a reoccurring theme.

Such was Tytler's (2007) concern for the issues underpinning STEM education in Australia that he called "for a significant 're-imagining' of science education as opposed to the mere refinement of curriculum and assessment" (2007, p. 15) in Australia. It has been assumed that what was meant by this statement was the need for a 'significant re-imagining of STEM education.' Several researchers such as Banks and Barlax (2014), Chesky and Wolfmeyer (2015) and Bowers (2016) have been calling for both governments and education systems to push the re-set button on STEM in their respective countries. It should be noted that while discussing their respective educational settings they are very clear that the issues they find are global.

Bowers (2016) believes that globally one of the most deleterious points in education is the all pervading ideals of the scientific paradigm in high schools. While not opposed to scientific research in schools, what he does take issue with is the ideal that it is this paradigm alone that leads to authentic understanding of how the world functions. In other words, Bowers (2016) and Marshal (2010) believe that schools must engender critical examination through an array of investigative perspectives. A constant reliance and focus on the scientific method of research "leads to the notion that what we learn through the method is true, correct, objective, and value-free. We now understand the method to be a blind faith in a process that is almost always entirely embedded within subjectivities and political/economic contexts" (Chesky & Wolfmeyer, 2015, p. 24). Bowers (2016) and Chesky and Wolfmeyer (2015) maintain that this has actually severely inhibited an authentic functional application of STEM. In fact, so entrenched is the 'world view' that a raft of researchers and commentators have contended it to be part of a much broader cultural landscape, or international ideological perception. Chesky and Wolfmeyer (2015) further believe that this all pervasive viewpoint has actually lead to social injustices.

Echoing the contentions of Emdin (2012), Chesky and Wolfmeyer, (2015) also believe that not investigating the ideological underpinnings of STEM "is a grave mistake since mathematics and science, the foundational knowledge needed in technology and engineering, are both fields deeply entrenched in historical, cultural, and philosophical perspectives" (p. 14). There is clear evidence to suggest that educational institutions from pre-school to university not only continue this global mindset, but also cause this viewpoint to become even more firmly entrenched. "Unfortunately, there is unlikely to be an in-depth discussion of the nature of traditions and the many ways they are carried forward—even in the thinking of scientists" (Bowers, 2016, p. 25).

"not investigating the ideological under-pinnings of STEM "is a grave mistake since mathematics and science, … are both fields deeply entrenched in historical, cultural, and philosophical perspectives"

Ambrose and Sternber (2016) believe that deeply connected to this issue is the "ongoing narrowing of education at a time when embracing diversity of pedagogical approaches would be more purposeful" (p. 12). Page (2007) and Manning (2009) have been echoing similar sentiments believing that in "essence, the homogenization of education around the world suppresses and distorts creativity just when the forces of globalization are demanding that young people become more creative" (Ambrose & Sternber, 2016, p. 12).

And so, the question remains: what ideological and axiological aspects should STEM be grounded in? Editorial space does not allow for a full response to this question, but suffice it to say that embedded in the STEM literature are threads of recommendations that could provide for "a value set more sympathetic to critical, social reconstructionist schooling" (Chesky & Wolfmeyer, 2015, p. 15).

> *students would become inter-disciplinary, creative as well as entre-preneurial and wise*

The first important thread appears to have arisen at the turn of the century with Leu's (2000) warning that there was scant time available to make the shift from traditional schooling to a STEM focus, and that what was needed to do this was to enable children to be creative thinkers and problem solvers. It is these latter two points that have become revisited facets within the STEM literature but appear to be somewhat subsumed by the mechanical "unthought slavery of numericality itself" (Badiou, 2008, p. 213). In regard to creativity, Battey, Kafal, Nixon and Kao (2007) believe this should be central to STEM as inquiry based learning.

The concept of creativity in itself has tended to fade from educational systems in more recent times, but as Jeffrey and Craft (2004) contend, creativity is not about teaching creatively or the creative arts but about developing an overall mindset whereby they work with their classes through flexible pedagogy and flexible reflexivity. That is, at the classroom level students should be given time and opportunity to solve real problems as cooperative groups before the teacher, or rather facilitator, steps in to offer possible solutions. Sternberg (2006), Marshall (2010) and Jensen (2010) believe that this approach would have a flow on effect whereby students develop great metacognitive processes and thus learn about learning more powerfully, with the potential to "creatively integrate ideas within and between domains. ... developing their own internal authority for learning and a fluid repertoire of learning strategies essential for deep conceptual understanding, creative inquiry, innovative problem resolution, and ethical leadership" (Marshall, 2010, p. 57).

This may necessitate a rethinking of classroom approaches as a key implication is that all lessons, and in fact all lesson programs, should cater and foster 'critical moments' in which important unplanned aspects arise and need an immediacy of clarification or a group think approach to solving an issue. Rinaldi (2005) put forward that these aspects are a key component of authentic learning based on a more open ended approach to STEM curriculum which is clearly evident in the early years of school, and which should then filter into the latter years. This kind of classroom could, and should, also provide students with the opportunity to solve problems and demonstrate developing understanding by integrating from other disciplines or subject areas.

The concept of integration of other disciplines, into STEM subjects, especially the creative arts, have caused some commentators to ask the question: "How Did We Get Here?" (Harris 2016, p. xvii). Just as STEM needs re-visioning, Harris also proposes that "what is clear in considering how to enhance creativity in schools—particularly secondary schools—is that thinking needs to change, more than anything else" (2016, p. xvii). While the concept of creativity and the creative arts have had lower priority in educational practice in recent times, it has also been made clear that it is the creative arts that could form the link between STEM subjects as a modality to show elements of understanding as thought processes, design awareness, aspects of divergent and convergent thinking leading to innovation and to tap into the concept of utilising Gardner's (2011) concepts of multiple intelligences. Battey et al (2007) are of the opinion that rather than being a linkage or bridge building factor, the creative arts should be central to any school based STEM inquiry and collaboration. To this central role, Marshall (2009, p. 49) maintains that students would become interdisciplinary, creative as well as "entrepreneurial and wise."

While acknowledging the limitations of any literature review, it is becoming clear that the previous ideals have not been established through case study research at best. More importantly, much of the recommendations regarding STEM education in general unpacks elements that are not based on actual in-situ research, or at best only reveals academic suggestions or the voice of teachers (Stone-MacDonald, Wendell, Douglass, & Lu Love et al 2016). One has to wonder what results would arise if any voice was given over to students?

Method

According to Creswell (2007), one conducts qualitative research "because we need a complex, detailed understanding of the issue. This detail can only be established by talking directly with people, going to their homes or places of work, and allowing them to tell their stories unencumbered by what we expect to find" (p. 40). The particular branch of qualitative research this study aligns with is a case study approach involving two schools, two cohorts (primary and secondary) in each school, and multiple students in each cohort. A case study, according to Creswell (2007, p. 40) is "where the researcher is studying an event, a program, an activity, more than one individual".

Two focus groups were held at each school - one each for primary and secondary. The questions were semi-structured (Thomas 2010), with the interviewer acting as a "smart", or a "human as instrument, … one that can locate and strike a target without having been programmed to do so" (Lincoln & Guba 1989, p. 194). In other words, in responding to the interview questions students were permitted to lead the discussion away from the main question at times in order to clarify, amplify or demystify their responses. The key information being sought from the students was: do they know what STEM is, what do they like about STEM, where would they would rank STEM in their subject list, how do they apply STEM, what they did in the STEM symposium in Sydney, how they felt about their school's performance at the STEM symposium, and what advice they would give parents about the benefits of STEM.

In order to place qualitative 'distance between data' and minimize the subjective 'distance between colleagues', once the recordings of the focus groups were transcribed, a reflective triptych was applied to the data. This reflective overlay interrogated the data collectively and individually by the researchers by asking key focus questions such as:

1. What is the core essence in the data?
2. What facets support the core element or essence?
3. Does prior research resonate with this data?

This 'reflective distancing of critical friends' was undertaken several times, and to paraphrase Kelchtermans and Hamilton (2004, p. 789): "the data was read, critiqued, and reflected on; readings and the critical friends both supported and helped reframe ideas within the study."

Findings and discussion

The answers given by students in the focus groups indicated that they had a growing knowledge of what STEM is, how it is being implemented in their schools, and what the possible benefits to them may be. There was a stark, but not unexpected, difference between the answers given by primary students and those of the secondary students. A clear resonance with the educational literature was illustrated by the types of answer given by each cohort. The primary group answered more at Piaget's Concrete Operational Stage of answering what STEM is and how much fun they have with it. The secondary group reflected Piaget's Formal Operational Stage and were more interested in talking about how STEM works, and how it is good for their school. They also saw that it will benefit the students in the long term.

"There was a stark … difference between the answers given by primary students and those of the secondary students"

As the data was reflectively analyzed, it became clearly evident that when taking the primary and secondary student answers together for both schools, each category of Bloom's Taxonomy of Education Objectives (Seaman, 2011) was covered. In fact, the revised taxonomy as proposed by Krathwohl (2002) with its updated categories, and used in this analysis, aligned closely with the comments made by students. Table 1 provides

Table 1: Student comments by Bloom's Revised Taxonomy of Educational Objectives

Blooms revised categories	Accompanying skills	Sample student comments
Remember	State, list, memorise, define, etc.	I learned from the other schools what they were doing
Understand	Explain, recognise. Discuss, describe, classify, etc.	The good thing about the building is that you understand why each part is there and what makes the robot go
Apply	Implement, demonstrate, execute, interpret, etc.	You are actually applying all the skills you have learned in previous years and bringing them into the one arena
Analyse	Question, contrast, compare, relate, experiment, etc.	It is hands on and you get to think through the problem and solve it
Evaluate	Critique, judge, defend, argue, appraise, etc.	We have done robotics and learned about gears and angles. We built it and did challenges and problems
Create	Construct, design, assemble, Formulate, investigate, etc.	I did a lot with mathematics or more specifically Boolean Algebra and also some simple electronics to create calculators

sample student data to illustrate this fit. This coverage indicates that the process and application of STEM lends itself to the desirable outcome of exposing students to the full range of cognitive outcomes and clearly places the emphasis back onto student learning. This was the objective of Bloom as reported by Seaman (2011) and referring to the decade of the 1960s: "Its (the taxonomy) concern regarding students' learning instead of teachers' actions became a focus of other research and evaluation." (p. 29).

Student knowledge of what STEM is

It was clear from the data that students at both primary and secondary level were very clear on what STEM is and what it is trying to achieve in their schools. Common answers indicated that schools' attempted to integrate several learning areas. The older students knew that doing STEM in many cases simulated workplace scenarios and they appreciated the efforts made to prepare them for employment.

> *It is a new way of learning - more hands on and interactive. It helps with new jobs in the future*

> *"it is good because they (students) are more freely available to take their problem even further and not be restricted by … the teacher"*

Student opportunity for self-directed learning

Students agreed that while the presence of a teacher was important for order and organisation, there were advantages in being left alone to learn. One student even made a comment that teachers can restrict learning:

> *I believe it is good because they (students) are more freely available to take their problem even further and not be restricted by what the teacher wants them to do.*

Student knowledge of the full benefits of STEM

Advantages such as enabling independent thought, engaging problem solving techniques, providing more interest and enjoyment were regularly cited by the students. One student was quite passionate about the techniques and learning they were experiencing. One student commented:

> *I think this method should go beyond maths and science and into maybe English – just the process of starting with a plan and then developing on that plan.*

This student made this comment without the knowledge of an innovation STEAM (Science, Technology, Engineering, Arts and Mathematics) and that their school is in the process of following this initiative and are in fact building a dedicated STEAM building on their campus.

Student feelings about where their school is positioned with STEM

Again as expected, primary students were more excited about how their schools were positioned with STEM than the secondary students. The primary students made comments like:

> *I reckon we did pretty well as a small school or for a school that had just started STEM,*

while secondary students were likely to say:

> *I felt we were pretty basic.*

While the secondary students were not as animated about where their school was placed compared to other schools at the STEM symposium in Sydney, they were also very accommodating and philosophical about how they were positioned:

> *What we do is good but we could improve a lot.*

> *Some others were a little more sophisticated but that doesn't mean ours was worse.*

> *Going to Sydney should help us improve.*

The answers the students gave should be an encouragement to the schools involved in this study. A primary student exuberantly declared:

> *It felt pretty amazing to be a student at [name of school].*

Future research directions or recommendations

The initial research at these two schools reported in Kilgour, Fitzsimmons, Baywood and Merriman (2016) included teacher comments that STEM may just turn out to be *one more acronym for teachers to deal with*. As these schools progress their initiatives to be at the forefront of twenty-first century education, more 'acronyms' are surfacing that some would see are taking over from STEM. One school in particular is working towards PBL which is traditionally Problem Based Learning but is now being called Project Based Learning. Simultaneously STEAM is being used more than STEM as Arts is added to the previous acronym and humanities becomes integrated with the sciences. While the cynical may say that their predications of the very fast entrance and exit of STEM is coming true, these schools would say that each new development does not mean the demise of STEM, but rather an enriching addition to STEM. Avenues for further research are numerous as this development continues.

Conclusion

The future of STEM as it is or as it will become is unknown. What is known however is that schools will continue to have external pressures for the improvement of student performance in the science, mathematics and technology areas and that students will need to be focusing more on practical applications that lead to employment. In many ways this objective requires a broadening of the curriculum and of the pedagogical approach of teachers which is 'in the opposite corner' to the fixation in Australia at the moment with NAPLAN testing and the demise of Australian school students compared to the rest of the world in standardised testing, that as a consequence actually narrows classroom practice to the level of 'teaching to the test'.

This study revealed that students actually value the ideas imported by the integration of subject areas, of being able to work independently, and of being involved in activities at school that will help with their future employment.

References

Ambrose, D., & Sternber, R. (2016). Previewing a collaborative exploration of creative intelligence in the 21st century. In D. Ambrose and R. Sternberg (Eds.), *Creative Intelligence in the 21st Century: Grappling with enormous problems and huge opportunities* (pp. 3-20). Rotterdam: Sense.

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Complete edition). New York, NY: Longman.

Attard, C., & Northcote, M. (2011). Teaching with technology. *Australian Primary Mathematics Classroom, 16*(4), 29-31.

Badiou, A. (2008). *Number and numbers*. Malden, MA: Polity.

Bang, E., & Luft, J. (2013). Secondary science teachers' use of technology in the classroom during their first 5 years. *Journal of Digital Learning In Teacher Education, 29*(4), 118-126.

Banks, F., & Barlax, D. (2014). *Teaching STEM in the secondary school: Helping teachers meet the challenge*. London, United Kingdom: Routledge.

Battey, D., Kafal, Y., Nixon, A. S., & Kao, L. (2007). Professional development for teachers on gender equity in the sciences: Initiating the conversation. *Teachers College Record, 109* (1), 221–243.

Bissaker, K. (2014). Transforming STEM Education in an innovative Australian school: The role of teachers' and academics' professional partnerships. *Theory Into Practice, 53*, 55–63.

Bowers, C. (2016). *A critical examination of STEM: Issues and challenges*. New York, NY: Routledge.

Bybee, R. (2013). *The case for STEM Education: Challenges and opportunities*. Arlington, VA.: National Science Teachers Association of America. Retrieved 12 December 2016 from http://static.nsta.org/files/PB337Xweb.pdf.

Chesky, N., & Wolfmeyer, R. (2015). *Philosophy of STEM Education: A critical investigation*. New York, NY: Palgrave MacMillan.

Creswell, J. W. (2007). Qualitative inquiry and research design: Choosing among five traditions. Thousand Oaks, CA.

Emdin, C. (2012). Reality pedagogy and urban science education: Towards a comprehensive understanding of urban science classrooms. In B.J. Fraser, K.G. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 59-68). Dordrecht: Springer.

Fitzsimmons, P., & Lanphar, E. (2012). The surfacing of spiritual facets in the classroom as an everyday event. In M. Fowler, J. Martin III and J. Hochheimer (Eds.), *Spirituality: Theory, praxis and pedagogy* (pp. 211-218). Oxford, United Kingdom: IdNet Press.

Gardner, H. (2011). *Frames of mind: The theory of multiple intelligences* (3rd ed.). New York, NY: Basic Books.

Harris, A. (2016). *Creativity and education*. London, United Kingdom: Palgrave MacMillan.

Jeffrey, B., & Craft, A. (2004). Teaching creatively and teaching for creativity: Distinctions and relationships. *Educational Studies, 30*(1), 77-87.

Jensen, B. (2012). *Catching up: Learning from the best school systems in East Asia*. Melbourne, Australia: Grattan Institute.

Kelchtermans, G., & Hamilton, M. L. (2004). The dialectics of passion and theory: Exploring the relation between self-study and emotion. In J. Loughran, M. L. Hamilton, V. LaBoskey & T. Russell (Eds.), *International handbook of self-study of teaching and teacher education practices* (pp. 785–810). Dordrecht: Kluwer.

Kilgour, P. W., Fitzsimmons, P., Baywood, V., & Merriman, J. (2016). Getting on board with the STEM revolution: Two Christian schools' experiences, *TEACH Journal of Christian Education, 10*(2), 35-42.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice, 41*(4), 212-218. doi:10.1207/s15430421tip4104_2

Kumtepe, A., & Kumtepe, E. (2015). STEM in early childhood education: We talk the talk why don't we walk the walk? In Mehdi Khosrow-Pour (Ed.), *STEM education: Concepts, methodologies, tools and applications*. Hershey, PA.: IGI International.

Leu, D. (2000). Our children's future: Changing the focus of literacy and literacy instruction. *The Reading Teachers, 53*(5), 424-430.

Lincoln, Y., & Guba, E. (1989). *Fourth generation evaluation*. Thousand Oaks, CA.: Sage.

Manning, E. (2009). *Relationscapes: Movement, art, philosophy*. Cambridge, MA: MIT Press.

Mohr-Schroeder, M. J., Cavalcanti, M., & Blyman, K. (2015). STEM education: Understanding the changing landscape. In A. Sahin (Ed.), *A practice based model of STEM teaching: STEM students on the stage* (pp. 3-14). Rotterdam: Sense.

Marshall, S. (2010). Re-imagining specialized STEM academies: Igniting and nurturing *decidedly different minds*, by design. *Roeper Review, 32*(1), 48-60. Retrieved February 4, 2017 from http://digitalcommons.imsa.edu/cgi/viewcontent.cgi?article=1008&context=marshall

Masters, G. (2006). *Boosting science learning*. Retrieved 1 March 2017 from http://research.acer.edu.au/research_conference_2006/4

Page, S. (2007). *The difference: How the power of diversity creates better groups, firms, schools, and societies*. Princeton, NJ: Princeton University Press.

Remember Piaget? (2010, 09). *Leadership for Student Activities, 39*, 21. Retrieved from https://search.proquest.com/docview/747993959?accountid=26359

Rinaldi, C. (2005). *In dialogue with Reggio Emilia: Contextualising, interpreting and evaluating*. New York, NY: Routledge.

Seaman, M. (2011). Bloom's Taxonomy: Its evolution, revision, and use in the field of education. *Curriculum and Teaching Dialogue, 13*(1&2), 29-43.

Sternberg, R. (2006). The nature of creativity. *Creativity Research Journal, 18*(1), 87-98.

Stone-MacDonald, A., Wendell, K., Douglass, A., & Lu Love, M. (2016). *Engaging young engineers: Teaching problem solving skills through STEM*. Baltimore, MD: Brookes.

Thomas, G. (2010). *How to do your research project: A guide for students in education and applied social sciences*. London, England: Sage.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future. Australian Education Review*. Camberwell, Australia: Australian Council for Educational Research Press. Retrieved 1 March 2017 from http://research.acer.edu.au/aer/3/

> *"this objective requires a broadening of the curriculum and of the pedagogical approach … which is 'in the opposite corner' to the fixation in Australia at the moment with … testing"*