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Seagrass and Aluminium are Strange Bedfellows: A Science-art Collaboration Via the Power of STEAM

Synopsis:

This paper describes the collaboration of a project team consisting of two educators, an artist and a scientist who are producing a community event in the form of an art-science installation. The public event has not yet happened, but the journey to arrive at an unveiling of public art is well documented. The reasoning for undertaking the journey is a belief in the arts being a conduit to communicate science knowledge, thus shaping the way a community views their environment.

Seagrass and Aluminium are Strange Bedfellows:
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Context

Australia is a diverse country rich with resources including mineral, oil and gas deposits. Situated on the southernmost tip of the Great Barrier Reef, in the costal locality of Port Curtis, Gladstone is a port city in Central Queensland, Australia. Gladstone has a diversified industrial economy and some of Australia's largest industries. The Port of Gladstone is Queensland's largest multi-commodity port, handling over 30 different products. Major cargoes include coal, bauxite, alumina, aluminium, cement and Liquefied Natural Gas (LNG). In the 2015/16 financial year, the Port of Gladstone had a total throughput of 115.9 million tonnes, with over 1,800 vessels visiting the port. Coal exports accounted for 70.8 per cent of total port throughput, followed by alumina at 23.8 per cent and a variety of other products including cement, petroleum, grain and sugar making up the balance.

The Port of Gladstone has eight main wharf centres, comprising 20 wharves: RG Tanna Coal Terminal, Barney Point Terminal, Auckland Point Terminal, Fisherman's Landing, South Trees, Boyne Wharf, Curtis Island and Wiggins Island Coal Terminal (Gladstone Ports Corp, 2013). These wharf centres service large business enterprises: RG Tanna Coal Terminal is the world's fifth largest coal export terminal; Queensland Aluminium is the third largest alumina refinery in the world; NRG Power Station is Queensland's largest power station; Boyne Aluminium Smelter is Australia's largest aluminium smelter; Cement Australia has Australia's largest cement kiln; Orica is one of the world's largest producers of explosives and Rio Tinto Yarwun is the first green field alumina refinery constructed worldwide since 1985 (Cameron, et. al., 2014). Against this backdrop of industry coexists many important coastal habitats, including mangroves, saltmarsh, sand and mud banks, coastal reef, sand dunes and seagrass.

Gladstone's history is unique and differentiated from the atypical story of the traditional inland mining town due to its coastal location and close proximity to the Great Barrier Reef. Gladstone has experienced the construction of not one large resource project, but many, in a short period of time. As an industrial hub for alumina, coal, and a variety of mixed commodity shipping, Gladstone does struggle with its ecological credentials, given that its shipping industry floats precariously near one of the world's nature wonders. However, there has always been, and continues to be, a voice and a place, for both environmental science, and pleasingly, the arts, in this community. This paper reports on a concept currently emerging as part of the World Science Festival event happening in Gladstone during March, 2017, and it is within this project that science (seagrass species and ecology) and industry (aluminium) will be brought together through the medium of the visual arts (sculpture and imagery).

World Science Festival is a big deal. Since its inception in 2008, New York City has been its home. The Queensland Museum was bold enough to secure the rights to host the festival in Australia in 2016, and this was the first time the festival had moved out of New York. It brings together scientists from all over the world, but more importantly it allows their imaginations to run wild with ideas to present to the public "cutting-edge science and discoveries that are shaping our futures" (Mitchell-Whittington, 2016, para. 3). In 2017, a sponsorship deal between the Queensland Museum and Queensland Gas Corporation (QGC), is allowing the festival to travel to regional areas in Queensland that have some affiliation with QGC. QGC's liquid natural gas product is now being exported through the port of Gladstone, and thus the region has alliances with QGC. This alliance has provided the opportunity for the World Science Festival event to occur in Gladstone.

Introduction

Margaret Worthington (artist) and Dr Emma Jackson (seagrass ecologist) have previously explored ways to bring local natural environments to life through the arts. Margaret has represented the Gladstone Harbour via various visual media. Her interest in the natural habitat in her community and her representation of that habitat has long been recognised. Many of her artworks, including sculptures, exist as public art in prominent positions around Gladstone city. Emma is a seagrass ecologist at Central Queensland University. Over the last four years, Emma has encouraged local community participation in seagrass restoration through public events out on the seagrass meadows, and through the use of game play which conveys knowledge of the ecology of these plants.

For this project, Dr Linda Pfeiffer and Helen Holden (two academics working in the area of education and professional development practice) proposed a vision to Margaret and Emma for an art installation focusing on their areas of expertise. The Australian Network for Art and Technology (2008, p. 1) states that such a collaboration between the arts and sciences "has the potential to create new knowledge, ideas and processes beneficial to both fields. Artists and scientists approach creativity, exploration and research in different ways and from different perspectives; when working together they open up new ways of seeing, experiencing and interpreting the world around us". From this premise, we believed that Emma's knowledge of seagrass could be conceptualised by Margaret into a public art experience, for both children and adults alike, during the World Science Festival event held in the port city of Gladstone, Queensland, Australia.

CURRICULUM PERSPECTIVES

The ARTS in the learning process

It has been widely acknowledged in school communities that an integrated curriculum is one pedagogical approach worth pursuing. Nevertheless, when the curriculum is framed in this way, it is often the arts that becomes the ornamental learning area of these units of work (Fiske, 1999). Specifically, the arts have been used merely as a way to present a final product of learning, rather than exploring 'art for art's sake'. In many ways this de-values the contribution of the arts to learning and teaching. However, when the American seminal study *Champions of change: The impact of the arts on learning* was published in 1999 it reported on how the arts could enrich learning; the proof was clear. As a result of the multiple research projects commissioned by the *Champions of Change* sponsors, empirical evidence showed that students can attain higher levels of learning through engagement in the arts (Fiske, 1999). Additionally, the 2002 report by Deasy, *Critical links: Learning in the arts and student academic and social achievement*, further cemented the notion that secondary school students "whose learning is embedded in the arts achieve better grades and overall test scores, are less likely to leave school early, rarely report boredom and have a more positive self-concept than those students who are deprived of the arts" (Ewing, 2011, p. 25). Further, Ewing cites a list of other benefits for the inclusion of the arts in the Australian school curriculum: attitudinal and behavioural benefits, health benefits, social benefits and economic benefits (Ewing, 2010).

However, in an increasingly crowded curriculum, learning and teaching programs jostle for prominence. A leader in arts education in the 20th century, Elliot Eisner, championed the cause of 'arts for art's sake'. Eisner argued that the arts were critical to the development of thinking skills, in children and the adult population. Forms of thinking needed for creating works of art, are needed in all areas of the curriculum. Moreover, he believed that the arts offered teachers a powerful guide and a way of exercising teaching practice that is innovative (Donald, 2014). To Eisner, the arts are fundamental resources through which the world is viewed, meaning is created, and the mind developed (Eisner, 2002). Much of this view can be seen in recent educational initiatives in Australia, as well as internationally. Science, Technology, Engineering and Mathematics (STEM) has recently embraced an additional 'A" and now Science, Technology, Engineering, Arts and Mathematics (STEAM) holds sway amongst the flux of educational reform.

Communicating SCIENCE through ART

Traditionally, science and art have been distinctly separate disciplines. These two areas are not widely been practiced together, despite the considerable evidence that art enhances learning in STEM related content by means of engagement and stimulating experiences (Chang, 2015). More recently, however, art has been used as a conduit to communicate science more broadly. This can only be a good thing as it has been noted that the reach of the scientific community to convey new research can be somewhat limited (Chang, 2015). The Arts have an ability to create emotional connections and this helps with communication channels to the wider community. Support for this notion is put forward by Lawrence (2008, cited in Cain & Dixon, 2013) and she concluded that the emotional response to an experience must take place before cognition and reflection.

Successful art-science collaborative projects are now being documented to show how an emotional connection does convey meaning and understanding. It must be noted this is only one way that the arts creates an impact in the collaborative process; nevertheless, it is a significant way. Music as the art form was used in *Aftershock: a science-art collaboration through sonification*. Barrett and Mair claim the collaboration produced unique materials that could not have otherwise emerged. "The methods of mapping, scaling and data reduction allowed scientific techniques to inform the art through discovery, rather than any pre-stated artistic goals taking over the work" (Barrett & Mair, 2014, p. 18). *Dancing with STEAM: creative movement generates electricity for young learners* is another example of aesthetic engagement with scientific concepts being a catalyst for transformative experiences (Pugh & Girod, cited in Steel & Fanning, 2016, p. 112). Outcomes from these partnerships seem positive for both disciplines.

At a school level in Australia the STEAM curricula is gaining momentum, especially at the secondary level. For example, St Lukes Secondary College in Karratha, Western Australia, Cecil Andrews Senior High School, Western Australia, and the Christian Outreach College, Toowoomba, Queensland all have current research projects underway to build and document their STEAM curriculum initiatives. Largely, these schools and others across Australia are embracing this wellspring of opinion that "combing science and the arts in the form of STEAM education is essential for producing a creative, scientifically literate, and ethically astute citizenry and workforce for the 21st century" (Taylor, 2016, p. 2).

Nevertheless, although there are numerous benefits to the current STEAM push, it cannot be denied there are serious challenges in this approach. Firstly, there is a tension between the two disciplines. It has been noted by Jolly that critics of this movement suggest the arts detract from the real work of science. Likewise, if the arts are merely 'wedged' in, to satisfy STEAM agendas, then this core area of learning is being diluted of its learning potential (Jolly, 2014 cited in Simpson-Steele & Fanning, 2016). And secondly, Simpson and Fanning acknowledge that science and the arts may be the two most feared curriculum areas by teachers in primary schools. Time, materials, space, and personal effort on behalf of the teacher, are needed for authentic application of the STEAM initiatives. Some teachers may find this problematic, and rightly so.

STEM … then STEAM

There is a critical shortage of students studying Science, Technology, Engineering, and Mathematics (STEM) courses at universities across Australia. Over 75 per cent of jobs now require STEM skills (Chubb et al, 2012). The government spends millions of dollars in improving STEM teaching and outreach programs for schools as there is a growing need to enhance STEM (science, technology, engineering and mathematics) education in Australia. With increasing advances in technology occurring world-wide, there is a need for an increasingly skilled workforce (Tytler, 2007). In May 2012, the Chief Scientist at the time, Professor Ian Chubb AC, released the report Mathematics, Engineering, and Science in the National Interest. The report recognised that over the past 20 years, Australia has experienced a decline in the proportion of students taking advanced STEM subjects in Year 12 and a downward trend in the proportion of university students enrolled in maths, science and engineering courses (Chubb et al, 2012). In terms of addressing this deficit, particularly at a local level, educators could look to exploit what is already happening in their communities (Pfeiffer, et. al., 2016). Seizing on the local context, educators may have opportunities to allow students to explore and learn about the world around them. The shift from STEM to STEAM can provide a link to these valuable partnerships that can be established within the community context.

THE PROJECT

Scientific background

Along the east coast of Australia, one of the world's natural wonders exists in the form of the Great Barrier Reef (GBR) World Heritage area. Seagrasses represent the last line of defence in trapping fine sediments from catchments and mitigating impacts on water quality of the GBR. Seagrass blades reduce shear bed stress, promote settling of fine material and reduce resuspension, and rhizomes bind sediments for the long term. Other ecosystem services that these intertidal seagrasses provide include nutrient cycling, sediment stabilization to improve water clarity, carbon capture and storage, nursery habitats for fish, and food for dugong and turtles. Significantly, they have recently even been shown to reduce potential human pathogens in the water (Jackson et al., 2001, Cullen-Unsworth et al., 2014, Nordlund et al., 2016, Lamb et al., 2017).

In 2011, the risk of further seagrass losses in Queensland was mapped, highlighting Port Curtis as a high risk regions (Grech et al., 2011). Costal management efforts reflect this worrying statistic. Causes of decline are attributed to multiple pressures including land reclamation, coastal development, dredging, poor catchment management and a series of sequential La Nina weather events. However, arguably the greatest threat to seagrass is apathy and a lack of local appreciation of the existence and value of these habitats. Scientific discoveries about the value of these habitats and methods for protecting and restoring them is improving. The conservation status of these habitats must engage the community, both those with a biocentric view and those without, through the appreciation of the ecosystem services provided.

Like many values, environmental values are often ingrained at a young age. Intertidal seagrass meadows in Port Curtis are teeming with life from small invertebrates, to fish, mega herbivores such as dugong and turtles, and a variety of bird life. Taking students out to the seagrass beds and introducing them to these wild and wonderful places on their "doorstep" promotes a sense of place and acknowledgement of the value of these habitats, creating seagrass “ambassadors”. Unfortunately, however, the sites where the seagrass grow can be difficult to access due to deep mud, strong currents and dangerous animals, and this limits the reach of such activities. Consequently, creative ways must be employed to communicate positive environmental messages to children, and the wider community.

The concept

To raise public awareness of the ecological importance of seagrass species, the team conceptualised a cross-disciplinary project wherein both art and science would evoke an emotional response to this local environmental phenomenon. The first step was to secure funding from the World Science Festival sponsors so that we could have a presence at this high profile event. QGC approved a grant application that proposed a collaboration between artist (Margaret) and scientist (Emma) to produce five aluminium sculptures of seagrass plants. The second step was to construct the installation for public viewing. The installation which is currently being created over the week leading up to the World Science Festival event also required images of actual seagrass meadows, images of children’s drawings representing seagrass meadows, and aerial photos of the Port Curtis seagrass environment. One final flourish for the ‘slide show’ of images was to take the completed sculptures and place them in situ on the seagrass meadow beds and capture the oversized art version of the tiny seagrass specie, with its counterpart (see Figure 1 and Figure 2). This ‘slide show’ of images will be projected through the sculptures, thus throwing shadows to the wall beyond the sculptures creating the atmosphere of the marine environment in the gallery space.

Figure 1: Seagrass meadow in Port Curtis with *Halodule uninervis* seagrass sculpture
Image: William Debois, Photopia Studios

Figure 2: Seagrass meadow in Port Curtis with *Halophila ovalis* seagrass sculpture
Image: William Debois, Photopia Studios

The aluminium sculptures developed in this project of five tropical seagrass species are designed not only to highlight the form of these plants at a larger scale, but also to capture elements of their biology, taxonomy and ecology. The five species are *Zostera muelleri*, *Halophila decipiens*, *Halophila ovalis*, *Halophila spinulosa* and *Halodule uninervis*. Attention to detail in terms of key distinctive features of each species, will allow students and adults alike to identify the different seagrasses: the cross veins on *Zostera muelleri*; hairs on the leaf of *Halophila decipiens*; and the triple pointed leaf tip of *Halodule uninervis*. The shine of the aluminium and beautiful form of the sculptures will appeal to those who appreciate art more than science, potentially capturing their attention and evoking an emotional response when the installation is unveiled over the festival event (see Figure 3 and Figure 4). This in turn will promote recognition of these plants beyond the event itself, thus raising awareness that may otherwise not have ever been considered. In this way, we are hoping to bring to life Eisner's sentiments that the arts are fundamental resources through which the world is viewed, meaning is created, and the mind developed (Eisner, 2002).

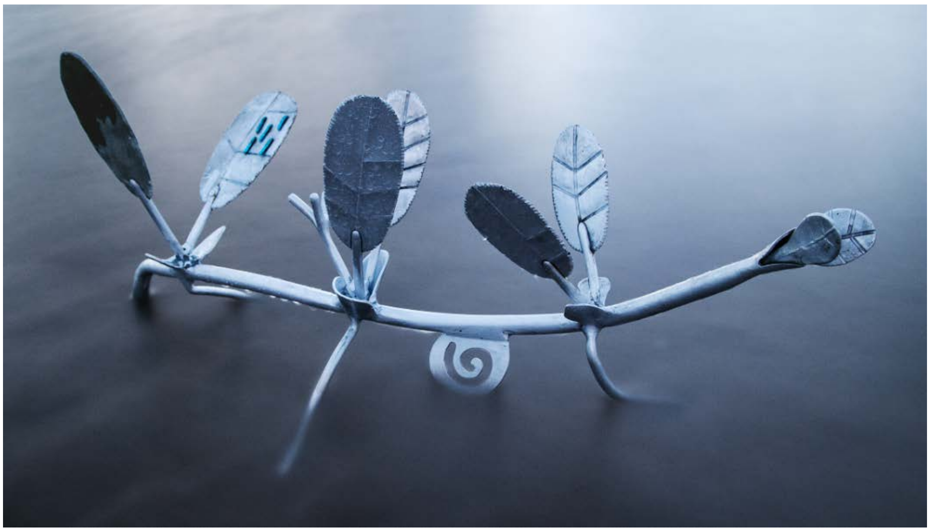

Figure 3: Sculpture of the seagrass specie *Halophila decipiens*
Image: Bill Watson

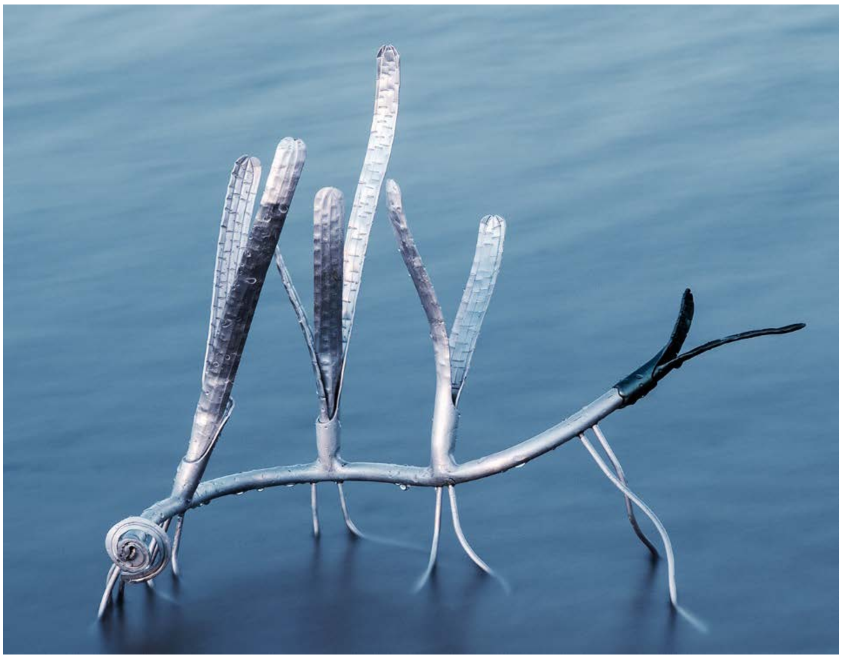

Figure 4: Sculpture of the seagrass specie *Zostera muelleri*
Image: Bill Watson

Other details are useful to prompt discussion regarding the biology of the plants. For example, dialogue can occur about the flowers and roots and this highlights the fact that these are not algae or seaweeds, but flowering plants and one of the few organisms that made the evolutionary move to go back to the sea. A discussion of reproductive modes can be visualised by students examining the rhizomes and flowers, and factoids such as the mildly astonishing detail that one seagrass seed can grow into a hectare of seagrass through vegetative rhizome growth.

Importantly, the artist and ecologist are working together to include features that promote discussion about the ecology, while hinting at the important roles these plants play in terms of the wider ecosystem. To illustrate this, one of the sculptures has bites off the end of the seagrass leaves. This is used to signify that these plants are important for grazing turtle and dugong (see Figure 5). “Magnification circles” on the leaves show plant and animal epiphytes and highlight that the seagrass themselves are an important habitat for a diverse range of organisms. Finally, the small bivalve mollusc (*Solemya* sp.) one of many lucinid bivalves globally known to have a three-way symbiotic relationship with seagrass—due to the protection the seagrass roots—affords the small mollusc the role of its chemotrophic gill bacteria in combating toxic sediment sulphide levels (van der Heide et al., 2012).

Figure 5: Sculpture of the seagrass specie *Halophila spinulosa*Image
Image: Bill Watson

To further enhance the installation space created for the festival event, educational activities are planned. Specifically, the sculptures will link to other resources to learn more about the ecology of the species, specifically in relation to the restoration of these species. Firstly, aquaria of live seagrass examples of each species will allow students to relate to the “real thing”. Secondly, children who visit the art installation will be given the opportunity to gameplay via a game called ‘seagrass versus zombies’ which Dr Jackson developed to encourage the participants to learn about the ecology of the different seagrass species. This game has a proven popular for past events (see Figure 6) as it provides a sensory experience. Participants in the game explore important concepts of seagrass ecology: what depth on the shore do they live and why; correct habitat placement; and examination of the impact of different pressure zombies. The ‘zombies’ are the threats to seagrass beds and have game names to signify their particular destructive power: *Burial Brute* (sedimentation due to land run off and dredging); *Reclaim Reaper* (land reclamation as part of coastal development); *Light Lyncher* (human pressures which increase the turbidity of the water); *Green Slimer* (nutrient over enrichment); and lastly, *Scouring Scurge*.

Figure 6: Students enjoying gameplay at Science Expo in 2016
Images: Peter Lawrence, Central Queensland University

THE FUTURE

Beyond the initial art event described in this paper, the portability of the five aluminium sculptures will allow them to be taken into schools and to other educational events to be used as props for learning and teaching. The project team of Emma, Margaret, Linda and Helen all acknowledge and advocate for what Lyons et al (2006) state regarding local and regional experts enhancing science understanding for educators. The benefits of collaborative approaches such as networking and professional development within education contexts have been well documented (Howitt, 2010), and it is with this pretext that our team moves forward with engagement activities that embrace a multidisciplinary approach

It is our belief that teachers are the most valuable resource available to both schools and higher education institutions in achieving global competitiveness; therefore, an investment in teacher quality and ongoing professionalism is vital (Prasser & Tracey, 2013). Investments by the Australian Government in STEM education need to include and acknowledge the arts. We are grateful that at our local level the national move to a STEAM focused curriculum is something we can support in some small way.

We believe there needs to be a collaborative approach between STEM specialists, local organisations, industry, universities, government, local artists and the community to incorporate professional development events. The Queensland Government's position echoes sentiment found in all educational facilities across Australia:

> Partnering with universities, business and industry is important to make sure our teachers and students are connected to cutting edge developments. Strengthening these relationships will see students engaged with the rich world of the STEM community and inspired to be the creators of Queensland's future (Department of Education and Training, 2015, p. 9).

In addition to the Science-Art collaborative project described in this concept paper, we have had other successful events at Central Queensland University, Gladstone Marina campus. For example, Linda conducted the *Science Education Experience* PD for educators and also the *ConocoPhillips Science Experience* for Year 9 and 10 aged students. Both of these events utilised creative arts and visual arts to enhance the STEM experiences of participants.

Conclusions

In the 1980s, psychologist Howard Gardner questioned the notion that intelligence is a single entity (Gardner, 1983). He proposed seven "types" of intelligences and later an eighth: linguistic – a feel for language; logical-mathematical – scientific and mathematical thinking; musical – pitch, tone and rhythm; body-kinaesthetic – physical; visual-spatial – art and design; interpersonal – understanding other people; intrapersonal – understanding yourself; and naturalistic – in love with the natural world. In an educational context, the challenge for all educators is catering for the needs of all learners within one classroom.

> We learn through at least seven different pathways…we should teach each lesson through at least seven different ways (Pirozzo, 2001, p. 13 cited in Pfeiffer, 2012).

Incorporating kinaesthetic learning such as sculpture and drama as well as visual learning through the arts can lead to greater understandings of scientific concepts for learners. This notion is supported by Davis (2014) who asserts that “action-learning” techniques result in up to 90 per cent retention, and further, that people learn best when they use learning styles that are sensory based. Therefore, one way of addressing this challenge for educators is to combine the physical and visual aspects of the arts with the naturalistic area of seagrass restoration in marine environments to cater for the needs of the learners. By utilising an integrated approach to curriculum, in this case the arts and marine science, educators can provide an environment in which learners can flourish.

Utilising body-kinaesthetic and visual learning within the STEM fields is one way to address the STEM challenges facing the world today. Consequently, support for teachers in the area of STEAM education should be a priority as the benefits of integration of the arts is well documented. Projects such as the one described in this paper may go some way to offering ideas by illustrating how connecting with an emotional response in people can promote the excitement needed to enhanced the learning and teaching experience.

References

Australian Network for Art and Technology. (2008). *What we do.* Retrieved from http://www.anat.org.au

Barrett, N., & Mair, K. (2014). Aftershock: A science art collaboration through sonification. *Organised Sound*. *19*(1). DOI: https://doi.org/10.1017/S1355771813000368

Cain, B., & Dixon, J. A. (2013). The arts connection: The arts and transformative learning in professional development. *Journal of Transformative Education, 11*(4), 261-274.

Cameron, R., Lewis, J., & Pfeiffer, L. (2014). The FIFO experience: A Gladstone case study. *Australian Bulletin of Labour*. vol. 40, no. 2, pp. 221–241.

Davis, B., & Summers, M. (2014). Applying Dale's Cone of Experience to increase learning and retention: A study of student learning in a foundational leadership course. *QScience Proceedings (Engineering Leaders Conference 2014).* Retrieved from http://dx.doi.org/10.5339/qproc.2015.elc2014.6

Chang, M. (2015). *Communicating environmental science through art: Scope, applications, and research agenda*. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Marine Affairs. University of Washington. Retrieved from https://digital.lib.washington.edu/researchworks/handle/1773/34009

Chubb, I., Findlay, C., Du, L., Burmester, B., & Kusa, L. (2012). *Mathematics, engineering and science in the national interest*. Canberra: Office of the Chief Scientist.

Cullen-Unsworth, L. C., Nordlund, L. M., Paddock, J., Baker, S., McKenzie, L. J., & Unsworth, R. K. (2014). Seagrass meadows globally as a coupled social–ecological system: Implications for human wellbeing. *Marine Pollution Bulletin, 83*(2), 387–397.

Department of Education and Training. (2015). *Advancing education: An action plan for education in Queensland*. Queensland: Australian Government.

Donald, B. (2014). *Stanford Professor Elliot Eisner, champion of arts education, dies*, Retrieved from https://ed.stanford.edu/news/elliot-eisner-champion-arts-education-dead-80

Eger, J. M. (2015, March 24–25). Arguing for STEAM on arts advocacy day [Web log post]. *The Huffington Post*. Retrieved from http://www.huffingtonpost.com/john-m-eger/arguing-for-steam-on-arts_b_6857066.html

Eisner, E. (2002). *The arts and the creation of mind*. New Haven, USA: Yale University Press.

Ewing, R. (2010). *The arts and Australian education: realising potential*. Camberwell, Victoria: Australian Council for Educational Research.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Gladstone Area Promotion and Development Limited. (2011). *Gladstone region socio economic profile: 2011 Census Snapshot' 18/09/2013*. Retrieved from http://www.gladstoneregion.info/Portals/3/DOCUMENTS/Resource%20Docs/2011%20Census%20Snapshot.pdf.

Gladstone Ports Corporation. (2013). *Port of Gladstone*. Retrieved from http://www.gpcl.com.au/operations/port-of-gladstone

Gladstone Area Promotion and Development Limited. (2012). *Gladstone region industry profiles - 2012*. Gladstone, GAPDL.

Government Statistician. (2013a). *Bowen and galilee basins non-resident population projections 2012-13.* Q. T. a. Trade. The State of Queensland.

Government Statistician. (2013b). *Gladstone region non-resident population projections 2012-13.* Q. T. a. Trade.

Government Statistician. (2013c). *Surat basin non-resident population projections 2012-13*. Q. T. a. Trade.

Grech, A., Coles, R., & Marsh, H. (2011). A broad-scale assessment of the risk to coastal seagrasses from cumulative threats. *Marine Policy, 35*(5), 560-567.

Howitt, C. (2010). *Science for early childhood teacher education students (ECTES): Collaboration between teacher educators, scientists and engineers*. Final Report - ALTC.

Jackson, E. L., Rowden, A. A., Attrill, M. J., Bossey, S. J., & Jones, M. B. (2001). The importance of seagrass beds as a habitat for fishery species. *Oceanography and marine biology: An annual review, 39*, 269–303.

Jolly, A. (2014). STEM vs. STEAM: Do the arts belong. *Education Week Teacher*. November. Retrieved from http://www.edweek.org/tm/articles/2014/11/18/ctq-jolly-stem-vs-steam.html

Lamb, J. B., van de Water, J. A., Bourne, D. G., Altier, C., Hein, M. Y., Fiorenza, E. A., . . . Harvell, C. D. (2017). Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates. *Science, 355*(6326), 731-733.

Mitchell-Whittington, A. (2016). World science festival Brisbane program announced. *Brisbane Times.* Retrieved from http://www.brisbanetimes.com.au/queensland/world-science-festival-brisbane-program-announced-20161102-gsgn9s.html

Nordlund, L. M., Koch, E. W., Barbier, E. B., & Creed, J. C. (2016). Seagrass ecosystem services and their variability across genera and geographical regions. *PloS One*, *11*(10), e0163091.

Pfeiffer, L. G. (2011). A comparison of the preferred learning styles of year 5, year 7 and year 9 students in science using the science laboratory environment inventory (SLEI) and a cooperative learning unit of work based on multiple intelligences. (*Doctoral* *dissertation, Curtin University, Western Australia, Australia*). Retrieved from http://espace.library.curtin.edu.au:80/R/?func=dbin-jump-full&object_id=186433&local_base=gen01-era02

Pfeiffer, L., Elliott, A., Busch, G., & Impiccini, J. (2016, April). STEM Education: what about VET qualified early childhood educators? *Paper presented at the Australian Vocational Education and Training Research Association (AVETRA) 2016 Conference*, Sydney, NSW.

Prasser. S, & Tracey, H. (2013). Beyond Gonski: Reviewing the evidence on quality schooling. The importance of making quality the key driver of school education policy. Canberra: PPI, Australian Catholic University.

Simpson Steele, J., Fulton, L., & Fanning, L. (2016). Dancing with STEAM: Creative movement generates electricity for young learners. *Journal of Dance Education. 16*(3). DOI: 10.1080/15290824.2016.1175570

Taylor, P. C. (2016). Why is a STEAM curriculum perspective crucial to the 21st century? *Research Conference*. Murdoch University Press.

Tytler, R. (2007). *Re-Imagining science education: Engaging students in science for Australia's future*. Canberra: ACER.

van der Heide, T., Govers, L. L., de Fouw, J., Olff, H., van der Geest, M., van Katwijk, M. M., . . . Smolders, A. J. (2012). A three-stage symbiosis forms the foundation of seagrass ecosystems. *Science, 336*(6087), 1432–1434.