Research Needed on Cultural Capital, STEM Endeavours and Instructional Innovations: A Call for "Collaborations between Nations"

Peter Hudson[1] , James Hudson[2]
[1]Queensland University of Technology, Brisbane
[2]CSIRO
pb.hudson@qut.edu.au

Abstract: *New Australian curriculum documents and government initiatives advocate the inclusion of Asian perspectives, which is highly relevant to the STEM fields. For Australia and other countries, STEM education is an opportunity to develop competencies towards employment in high-demand areas, yet the world's knowledge of STEM is changing rapidly, requiring continuous analysis to meet market demands. This paper presents the need for "collaborations between nations" through research to advance each country's STEM agenda towards further globalisation of education with the sharing of knowledge. Research is needed on views of what constitutes cultural capital for STEM, which also involves understanding past and current STEM endeavours occurring within various countries. Most importantly for STEM education is uncovering instructional innovations aligned with countries' cultures and STEM endeavours. Research questions are provided in this paper to stimulate ideas for investigating in these fields. Economically, and as demonstrated recently by Greece and Spain, countries throughout the world can no longer operate independently for advancing standards of living. The world needs to recognise interdependence not only in trade and resources but also through the knowledge base that exists within countries. Learning together globally means transitioning from independence to interdependence in STEM education that will help each country meet global demands.*

Keywords: culture, STEM education, instructional innovation, science, technology, engineering, mathematics

1.Introduction

Historically, science has had a place in history for thousands of years (e.g., detailed astronomical records of 29 comets in the Book of Silk, 4th century BC). Technology gradually increased since early human inventions (e.g., compass, papermaking), rose up dramatically through the industrial revolution and escalated exponentially during the 20th and 21st centuries, particularly with the advent of the Internet. Engineering accomplishments were evident in the constructs of early civil works, including roads and structural feats such as the Great Wall of China. Mathematics was not as clearly defined BC, but the Mesopotamian abacus dating circa 2500 BC and advancements in the 2nd century AD with the Chinese abacus (suànpán, 算盘, "counting tray") paved the way into education as an essential scientific tool for calculating new possibilities. Hence, combining science, technology, engineering, and mathematics (STEM) areas should not come as a surprise but rather as a unique way of packaging what has been around for centuries. What is surprising is the very strong Western influence of STEM education literature during the 21st century though foundations have been laid centuries beforehand in Europe and Asia. However, economic growth in Asia necessitates a global change of thinking in education.

Australia's educational revolution has included the formation of a national curriculum. For Australia and other countries, STEM education is an opportunity to develop competencies in high-demand fields. Engineering education has not been included traditionally in school education; yet its burgeoning inclusion presents hands-on problem-based activities for fusing science, technology and mathematics to engage students in engineering innovations (e.g., English, Hudson, & Dawes, 2011). The scientific and mathematical undertakings towards devising technology with the assistance of Internet information and communication have facilitated engineering advancements across a range of fields (e.g., chemical, structural, mechanical, civil, software). Engineering Australia states that "the supply of engineers grew from 242,200 in 2001 to 366,600 in 2010, an overall increase of 124,400, or over 51%" (http://www.engineersaustralia.org.au/about-us/statistics#FAQ4) The abundance of engineering positions and scope for increased developments has lead towards engineering education beginning earlier within school systems (e.g., primary and middle schools). China and South East Asia are at the forefront of engineering growth as nations advance their wealth, knowledge and skills, demonstrating technological leadership on the world stage. To develop knowledge about STEM education will require much stronger "collaborations between nations" for uncovering innovative teaching practices towards advancing each country's key STEM agendas.

2.Literature review and discussion

Education systems vary across Asia with some or strong influences from other countries. For instance, Hong Kong's education system is not unlike the UK's system, particularly after extensive British governance during the 20th century. Malaysia continues to seek economic advancement through the development of an education system that draws upon world's STEM knowledge (Rahman Idris, 2005), and has partnered with other Western universities to build capacity (Hudson, Spooner-Lane, & Dooley, 2008). The Malaysian government noted these endeavours as increasing intellectual capacity within STEM areas. As a significant amount of STEM knowledge is accessible through the Internet within the lingua franca (English), some Asian countries, such as Malaysia, have variable plans to teach STEM areas using English as the Medium of Instruction (EMI), which aim to incorporate education reform measures to elicit STEM content knowledge and build cultural capital (e.g., Ministry of Education, 2008). Education systems throughout Asia continue to seek advancements in STEM areas but how do we determine the effectiveness of an education system? Some would highlight career opportunities, career outcomes, and the economic growth of a country as a measure of effective education (e.g., Brown & Lauder, 1996). How will we know an education system is at its pinnacle of effectiveness? How can we optimise our education systems?

Researchers need to investigate continually what constitutes a balanced education that prepares students for today's technologically-advanced world. Understanding this balance means understanding global education developments and how education systems are in the constant flux of re-structuring for change and analysing student outcomes as a result of such re-structuring. Investigating other education systems can provide insights into how methods and approaches in education impact on outcomes. To illustrate, a Sydney Morning Herald article (July 14, 2011) outlines that China's education system promotes extensive homework tasks that leads to very high academic results on an international scale while Australian education encourages student involvement in other curricular activities (e.g., sport, music), and each state outlines homework policies to ensure schools are not excessive with homework (e.g., http://www.curriculumsupport.education.nsw.gov.au/policies/homework/index.htm). Yet Hutchinson (2006) claims that homework not only revises school work but also mediates home-school relationships though more research is needed on what constitutes an effective homework-life balance for students. Homework may be signalled as one cultural difference between some nations.

To uncover effective instructional innovations in STEM education between countries means, among other issues, transcending language challenges. For example, Vygotsky's seminal work into social constructivism with his Russian book "Thought and language" written just before his death in 1934 was translated into English more than 40 years later. His work has become a foundation of many university courses, theoretical studies, and a psychological domain for teaching and learning in many countries. Underlying theoretical standpoints help to advance instructional innovativeness. Vygotsky's work was disseminated more widely in English, leaving the notion that many existing innovations remain dormant to the Western world until converted to English, and vice versa. This infers that instructional innovations can materalise years after discovery in countries and cultures around the world where English is not the lingua franca. Thus, purposeful planning to research teachers, teaching, and learning, particularly in specific discipline areas such as STEM education through collaborative means would help to uncover some of these innovations. Easier access to travel and global communication systems provide opportunities to form stronger "collaborations between nations" to uncover instructional effectiveness towards globalising education with the most effective knowledge available. Scientists draw upon world knowledge to advance their work (e.g., cure for cancer); similarly educators must share newfound knowledge and understanding to reach common end goals that create a global equity in educational fields. However, the exponential increase in information communication technology (ICT) places education systems under great strain to synthesise and manage large amounts of information for advancing education. Yet, the Internet, smart apps, and other technological applications as instructional innovations can also assist in sharing STEM knowledge across culture and language.

There are many research articles that provide ideas about instructional innovations within STEM education areas (e.g., Hudson, 2010; Yang, 2009); however a very large majority of articles explore their own country's education systems only. To illustrate, Yang "In China, a school-based teaching research system was built since 1952 and Teaching Research Group (TRG) exists in every school" (p. 279) and that "behind every exemplar lesson in different level, the lesson will be taught at least twice" (p. 295). Hudson also outlines how preservice teachers undertake the teaching of a specific lesson three or four times can assist their pedagogical development. Although both studies (Hudson; Yang) outline innovations, they do not consider other country perspectives on procedures that may further advance learning. Collaborations between nations can help to extend the viewpoints from other countries' systems, including the cultural perspectives and STEM endeavours. For understanding Asian culture, it appears that embedding Asian culture into Western curriculum requires a formalisation of classroom practices to extend beyond cursory cultural excursions and so forth. Reynolds (2012) outlines the findings of a study conducted with over 7000 students in Years 5 and 8 that formal structured classroom teaching "had students with a more accurate and deeper knowledge of Asia than those whose students had mainly been educated through informal activities" (p. 18). The highest performing school systems aligned with mathematics and science results are in Asia, with teachers held in high esteem and they learn continuously through large quantities of professional development (Asia Society, 2012).

STEM literacy can empower citizens for creating economic gain (e.g., for scientific literacy see Bybee, 1997). In addition, forging ahead with STEM endeavours can enhance a country's technological market place position. Thus, producing STEM education teachers who are well-versed in instructional effectiveness will be able to provide students with more career options. Importantly, innovations emerging from quality teaching needs to be reported to the education community, particularly to those who are unwilling to abandon practices not in alignment with current world needs (e.g., Mulholland, 1999).

In the field of STEM education, investigating preservice teacher development can present opportunities to compare and contrast findings between education systems. As STEM education continues in a state flux, researchers can present evidence that leads towards more effective STEM education outcomes. For various Asian countries, the education of preservice EFL teachers is a focus of attention in an effort to obtain quality EFL teaching (Haley & Rentz, 2002; Larsen-Freeman, 2000) and gain access to the world's knowledge base on STEM subjects. Indeed, for advancing an education system, there is little doubt that any instructional innovations must be included at the preservice teacher level as an investment for injecting reform into an education system (e.g., Asia Society, 2012). Lim, Cock, Lock, and Brook's (2009 cited in The State of Queensland, 2012) study present an innovative preservice teacher practice, Hong Kong Institute of Education indicated portfolio-based assessment as a tool to improve the quality of preservice teacher education programs with greater student responsibility despite challenges in implementation and moderation consistencies. The State of Queensland report (2012) also shows innovations in Singapore with an introduction of an e-portfolio for validating preservice teacher achievements with inclusions of "professional conversations between the preservice teachers, peers and mentors in the context of specific portfolio pieces of evidence, artefacts or observations" (p.

45). Importantly, the sharing of innovative practices between countries can lead towards improvements in education systems.

For over 20 years, guiding principles through Asia to change preservice teacher education courses includes developing future teachers who "...are innovative thinkers capable of creatively dealing with the challenges of education" (UNESCO, 1990, p. 56). This includes understanding teacher induction and mentoring during the early career years that draw upon instructional innovations. For instance, a Chinese study (Chi-kin Lee & Feng, 2007) shows that the mentoring focus is on the "teaching of content rather than curriculum and pedagogy" (p. 243) whereas in an Australian study mentoring programs focus heavily on curriculum and pedagogy (Hudson & Hudson, 2011). Mentoring preservice teachers and beginning teachers in STEM education presents as a new avenue for researchers to interact internationally that can lead towards real-world outcomes. Reciprocity is a key for collaborations between nations. For instance, Australia and other Western nations must understand more about Asian culture, STEM endeavours and effective instructional innovations that can lead to more fruitful interactions between East and West, particularly when devising new curricula in STEM fields. To illustrate further, the new *Australian Curriculum: Science* (ACARA, 2012) has three strands "Science Understanding", which focuses on understanding scientific knowledge, "Science as a Human Endeavour" as a way to note science influences in society over time (including applications, and ethical and social implications), and the development of "Science Inquiry Skills". To understand how to embed Asian culture, STEM endeavours and instructional innovations will require investigating each of these areas and how Asia can contribute to Western curriculum. The *Australian Curriculum: Science* presents Australia's engagement with Asia as a cross curriculum priorities (ACARA, 2012) but this appears without clear knowledge on how Asia can influence this specific science curriculum. Learning about and embedding Asian cultures into Western curriculum (and vice versa) can further assist many Asians undertaking Western education, where teachers and lecturers can provide support mechanisms that address their learning needs (e.g., language, instructional approaches, teaching aids, and immersion experiences; Beaven, Calderisi, & Tantral, 1998). Awareness of other countries' STEM curricula can help nations to understand curriculum directions and possibly innovations that have been translated into practices.

Cultural capital includes learning through educative processes in fields perceived to have social and economic value (Hall, 2011), yet there can be inequities as a result of fast moving expansion. For example, Heckman and Yi (2012) emphasise that negating inequities in China due to economic growth will require expanding access to all levels of education. Access to education will also mean the social construction of knowledge as central to developing cultural capital. However, more research is required on the effects of cultural capital and educative processes associated with STEM fields (e.g., Yamamoto & Brinton, 2010). To illustrate, many Asian students perform higher on international tests (e.g., Trends in International Mathematics and Science Studies [TIMSS], e.g., Figure 10 in http://nces.ed.gov/pubs2009/2009001.pdf) than other students around the world, though confidence and self esteem appear lower than Western students (Leung & Wong, 1997). The high results by Asian students living in Western countries may be related to the Asian culture regarding the value of education (and as previously mentioned, dedication to education with long hours of homework). However, Western views of Asian education mainly report on rote learning in teacher-directed classrooms, despite other reports outline the culture of Asian education with positive family attitudes, setting high academic standards, the length of the school day to include more socialisation, and instructional duration, responsibilities and methods (http://www.tdl.com/~schafer/Asian.htm). Understanding how students can best position themselves for a career needs to be investigated in terms of culture, STEM endeavours and the effects of instructional innovations.

It is reasonable to conclude that investigating STEM education issues in isolation, and without clearly defined partnerships, will more than likely limit the global application of any findings. Sadiman (2004), Director of SEAMEO, advocates raising educational standards in South-East Asia by promoting equity and quality in education, including establishing partnerships and improving the teaching-learning processes by educating teachers in effective instructional techniques. STEM partnership arrangements necessitate an understanding of cultures, that is, any Western-Asian partnership requires both to learn about each other's cultures and their respective STEM endeavours. Partnerships can include, but not limited to, university academics (e.g., Beijing Normal University & Queensland University of Technology), education departments and schools, government agencies associated with the STEM fields (e.g., Australia's CSIRO, Queensland Resource Council), and STEM industries (e.g., Rio Tinto, resources, mining). International education forums provide opportunities to establish partnerships to investigate and understand education systems (e.g., http://ace.iafor.org/; STEM2012) though there is little research on the uptake of such opportunities.

Researchers must ask questions for understanding education systems and how they prepare students for global STEM involvement such as: How are Asian education systems, schools and individual teachers embedding instructional STEM innovations? What are the perceived needs of Asian countries that lead to effective instructional approaches for STEM education? What is a balanced education system for STEM involvement in today's world? How are Asian schools promoting inquisitive problem solving in STEM education? What skills do students need to contribute successfully to their respective societies and globally in STEM fields? How are preservice teachers being educated in the STEM education? These questions can be reversed for Western education.

Apart from benefits of advancing STEM knowledge, another potential advantage of collaborating with partners across nations can include "soft diplomacy". For example, soft diplomacy between countries may be an outcome from the Olympic Games. Indeed, governments seek opportunities for diplomatic relationships to communicate messages for which collaborative research may provide soft diplomacy in negotiating across STEM matters. How does international partnering for STEM education research lend itself to soft diplomacy in STEM fields?

3.Conclusion

Western and Asian educational curricula can be advanced considerably by drawing upon respective knowledge in the fields of STEM. Any such curriculum will require demonstrating culture, STEM endeavours and instructional innovations from both Western and Asian curricula that can impact on students' learning in the STEM fields. To achieve integrated globalised education will require nations to embrace each other's history, culture, and STEM advancements, along with problem solving on the multitude of issues that piggyback in high-growth STEM areas. A way to commence this global education is for internationalising research around cultures, STEM endeavours and instructional innovations. Australian is undergoing curriculum change with the imminent Australian Curriculum as a national educational revolution. This change comes about largely for political reasons (e.g., national testing and a more nationally cohesive curriculum) but also presents opportunities to incorporate global changes in education that will impact on future Australians. Globally, embedding culture, STEM endeavours and instructional innovations will advance such a curriculum and increase potential global opportunities for graduating students.

Forums such as STEM in Education conferences (http://stem.ed.qut.edu.au/) provided a platform for educators to share knowledge in and across their respective disciplines but also present opportunities to engage with global educational research. As STEM education holds promise for educating current youth into high-demand STEM careers emanating from a world-wide growth in developing and manipulating resources, embedding research into culture, STEM endeavours and instructional innovations into Western and Asian curricula would assist to bridge gaps towards a more integrated global education. Learning together globally means transitioning from independence to interdependence in STEM education to help each country meet global demands that may also lead towards greater prosperity for all.

References

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2012). *The Australian Curriculum: Science.* Canberra: ACARA. Retrieved from http://www.australiancurriculum.edu.au/Science/Curriculum/F-10

Asia Society. (2012). *How the best school systems invest in teachers.* Retrieved from http://asiasociety.org/education/learning-world/how-best-school-systems-invest-teachers

Beaven, M., Calderisi, M., & Tantral, P. (1998, March). *Barriers to learning experienced by Asian students in American accounting classes.* Paper was presented at the American Accounting Association Mid Atlantic Regional Meeting. Retrieved from http://www.learn-accounting-visually.com/barriers.html

Bray, M., & Koo, R. (2005). *Education and society in Hong Kong and Macao: Comparative perspectives on continuity and change.* Hong Kong: Springer Press.

Brown, P., & Lauder, H. (1996). Education, globalization and economic development. *Journal of Education Policy, 11*(1), 1-25.

Bybee, R. W. (1997). *Achieving scientific literacy*. Portsmouth, NH: Heinemann.

Chi-kin Lee, J., & Feng, S. (2007). Mentoring support and the professional development of beginning teachers: A Chinese perspective. *Mentoring & Tutoring: Partnership in Learning, 15*(3), 243-262.

English, L. D., Hudson, P., & Dawes, L. (2011). Perceived gender differences in STEM learning within the middle school. *International Journal of Engineering Education, 27*(2), 389-398.

Haley, M. H., & Rentz, P. (2002). Applying SLA research and theory to practice: What can a teacher do? *TESL-EJ, 5* (4).

Hall, S. (2011). Educational ties, social capital and translocal (re)production of MBA alumni networks. *Global Networks, 11*(1), 118-138.

Heckman, J. J., & Yi, J. (2012). Human capital, economic growth, and inequities in China. Discussion paper series No. 6550. Retrieved from http://hdl.handle.net/10419/58663

Hudson, P. (2010). School-based experiences: Developing primary science preservice teachers' practices. *Journal of Science and Mathematics in Southeast Asia, 33*(2), 149-167.

Hudson, P., & Hudson, S. (2011). Converting theory to practice: University-school collaboration on devising strategies for mentoring pedagogical knowledge. *International Journal of Learning, 18*(2), 319-330.

Hudson, P., Spooner-Lane, R., & Dooley, K. (2008). Capacity building: Home and away. *Malaysian Journal of Learning & Instruction, 4*(1), 55-70.

Hutchison, K. (2006). *Rethinking homework in contemporary Australia: A feminist sociocultural analysis,* PhD thesis, School of Education, Deakin University.

Larsen-Freeman, D. (2000). *Techniques and principles in language teaching (2nd edn.)*. New York: Oxford University Press.

Leung, K. S., & Wong, P. K. (1997). Hong Kong pupils' mathematics achievement in the international comparison. In N. Law (Ed), *Science and mathematics achievements at the mid-primary level in Hong Kong* (pp. 25-39). University of Hong Kong.

Ministry of Education. (2008). *Malaysia, education for all: Mid-decade assessment report 2000-2007.* Retrieved from http://planipolis.iiep.unesco.org/upload/Malaysia/Malaysia_EFA_MDA.pdf

Mulholland, J. A. (1999). *Beginning teachers and primary science: Learning and teaching science in the preservice to inservice transition.* Unpublished PhD thesis, Curtin University, Perth, WA.

Rahman Idris, A. (2005, July). *Conference on progress and challenges in human development in Malaysia: Ideas for the Ninth Malaysia Plan*.

Reynolds, R. (2012). *Teaching history, geography & sose in the primary school.* Melbourne, VIC: Oxford Press.

Sadiman, A. S. (2004, November). *Challenges in education in South-East Asia.* Paper presented at the International Seminar on "Towards Cross Border Cooperation between South and Southeast Asia: The Importance of India's North East Playing Bridge and Buffer Role", Kaziranga, India. Retrieved from http://www.seameo.org/vl/library/dlwelcome/publications/paper/india04.htm

The State of Queensland. (2012). *An investigation of best practice in evidence-based assessment within preservice teacher education programs and other professions.* Toowong, QLD: Queensland College of Teachers.

UNESCO. (1990). *Innovations and initiatives in teacher education in Asia and the Pacific Region.* UNECO Principal Regional Office for Asia and the Pacific, Bangkok, Thailand. Retrieved from http://www.unesco.org/education/pdf/412_35a.pdf

Yamamoto, Y., & Brinton, M. C. (2010). Cultural capital in East Asian educational systems: The case of Japan. *Sociology of Education, 83*(1), 67-83.

Yang, Y. (2009). How a Chinese teacher improved classroom teaching in teaching research group: A case study on Pythagoras theorem teaching in Shanghai. *ZDM Mathematics Education*, *41,* 279-296, DOI: 10.1007/s11858-009-0171-y.