Student Engagement in STEM Education: Global Trends and Implications for Cambodia

Introduction

Science, technology, engineering and mathematics (STEM) skills have long been recognised as a key driver for a nation's innovative capacity and global competitiveness. Indeed, research shows "there is a close fit between the nations with leading and dynamic economies, and the nations with the strongest performing education and/or research science systems" (Marginson et al. 2013, 14). The success of many Asian economies, including Hong Kong, Taiwan, Singapore and South Korea, which have invested heavily in science and innovation over the last several decades, is a testament to that fact. They have consistently outperformed their counterparts in international assessments of science and mathematics, such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study.

STEM skills can deliver lasting social benefits, providing innovative solutions to such development challenges as climate change and infectious diseases. At an individual level, STEM professionals have more job opportunities and command higher salaries than their non-STEM counterparts. STEM workers earn 26 percent more than their counterparts in the United States, where recent growth of STEM jobs has been three times as fast as that of non-STEM jobs (Langdon et al. 2011). Investment in STEM clearly yields competitive advantages for nations and individuals.

Despite the growing job market, enthusiasm to study STEM subjects at university has been waning. While most OECD countries have successfully expanded higher education access, they have produced three times more graduates in social sciences, law and education than in STEM, causing concern about potential undersupply of STEM workers to sustain global competitiveness. Further, the underrepresentation of women and girls and poor and minority students in STEM fields can reinforce social stereotypes, gender disparities and social stratification (Marginson et al. 2013)

STEM education is now more important than ever, especially in developing countries like Cambodia. Yet, despite 15 years of rapid higher education expansion, the majority of Cambodian students gravitate towards business majors and relatively few take STEM courses (Figure 1). The resultant mismatch between education provision and labour market needs has led to serious skill gaps, though this problem is not new to Cambodia. From 1989 to 1994, although the agriculture-based economy lacked capacity to absorb STEM graduates, universities produced relatively high numbers of graduates in basic sciences (1267) and engineering and technology (787), as opposed to commerce (371) and foreign languages (407) (MOEYS 1996 cited in Chhem 1997). Even vocational training has been of limited relevance to employment: "… what they [students] learn in school doesn't prepare them necessarily to go to work" (Allen Tan, Director of Global West Lab, cited in Phnom Penh Post, 3 July 2016).

These challenges can and must be overcome if the goal of Cambodia's Industrial Development Policy (IDP) 2015-25, to modernise its industrial structure from labour-intensive to high-skilled value-added industry by 2025, is to be achieved. The blocking of new licences for university courses in business and management announced in December 2014 has already turned attention to the skills and knowledge most in demand, including STEM.

Despite the heightened involvement of policymakers and stakeholders, the literature on Cambodia only vaguely touches upon the concept of STEM. In response, this paper aims to contribute to the better understanding and promotion of STEM education and research in Cambodia. The paper first discusses the evolution of STEM and current thinking on the design of STEM education. It then presents an overview of students' interest and enrolment in STEM at the global level. The final section reflects on STEM education in Cambodia

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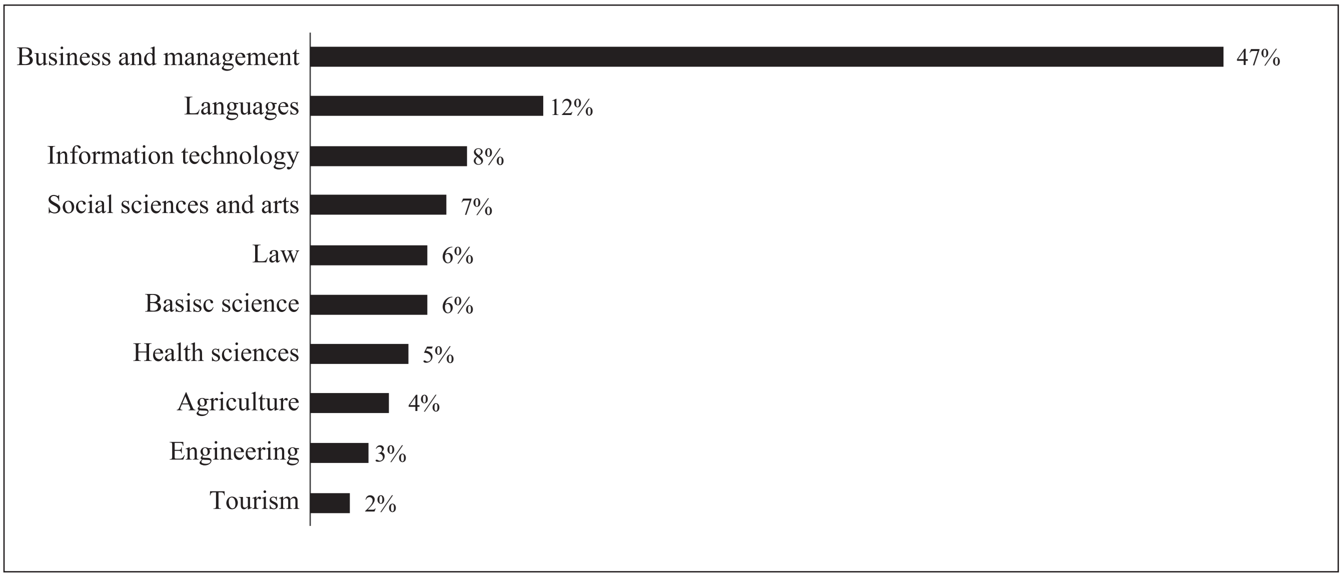
Figure 1: Undergraduate training distribution by discipline, 2011



Source: Mak 2015

and proposes some recommendations for future lines of research.

STEM concept

The acronym STEM (known in the 1990s as SMET for science, mathematics, engineering and technology) was coined in 2001 to stress the importance of these disciplines. There is no uniform definition, and thus the term often "carries different meaning for many different groups of people" (Khine 2015, 209). Its scope has been variously interpreted, with many institutions, policymakers and researchers either including or excluding health and agricultural sciences (Koonce et al. 2016). Even today there is still confusion between the term STEM and stem cell research and plant stems (Keefe 2010 cited in Bybee 2013).

There has since been a discipline shift within STEM pedagogy, bringing together traditionally separate subjects to form integrative "approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (Sanders 2009, 21). In short, the "term 'integraTIVE' implies an ongoing, dynamic, learner-centered process of teaching and learning distinct from 'integraTED,' which connotes a static, completed teacher-centered process" (Wells 2013, 29).

Indeed, some scholars contend that scientific literacy should be the aim of STEM education: "education … must involve them [students] in both learning the knowledge of STEM disciplines and reacting to situations that require them to apply that knowledge in contexts appropriate to their age and stage of development" (Bybee 2013, ix-x). Others take a more philosophical view and consider the economic, sociocultural and political aims of STEM initiatives, STEM content and the assumptions underlying STEM teaching (Chesky and Wolfmeyer 2015). A more practical standpoint holds that STEM education has to intersect high-quality STEM content, effective pedagogy, and sensitivity to equity and diversity concerns (Greene at al. 2006). What is clear is that STEM is not about teaching each subject, but a curriculum paradigm whereby the subjects are related and taught in a progressive and interactive manner.

A recent change in emphasis from STEM to STEAM to include liberal arts in the mix exemplifies the move towards integrative STEM education. Yet teaching STEM as an integrative endeavour remains a distant reality in most countries, including in the United States, where efforts to implement an integrated curriculum began some 20 years ago, with many still treating STEM subjects in isolation (Wells 2013).

Student engagement in STEM education

Students' choice of higher education major

A large body of literature suggests that higher education choices are affected by socioeconomic status, gender perceptions, cultural values and academic aspirations. Leppel, Williams and Waldauer (2001, 389) note how male "students whose fathers are in professional or executive occupations were more likely to choose to major in engineering and the sciences", traditionally male-dominated areas; also, female students with highly educated parents tended to choose science rather than female-dominated fields such as education. This is confirmed by the conclusion of Latifah's (2015) research on Malaysian students studying in the UK, that science education is more for the minority educated elite.

Parents' gender ideology can influence women's pursuit of a STEM career. An OECD study (2016, 193) on PISA questionnaires filled in by parents reveals that "Boys are significantly more likely to expect to work in science, technology, engineering and mathematics (STEM) occupations; and parents are more likely to expect their sons, rather than their daughters, to work in a STEM field, even when boys and girls perform at the same level in mathematics".

The successful promotion of STEM at all levels in many East Asian societies is "deeply rooted in eastern philosophy and cultural notion of education and influence of parental encouragements" (Khine 2015, 3). This echoes the conclusion of a cross-country analysis (Marginson et al. 2013, 14) that "success in education and science is due less to talent than to hard work" – the Confucian tradition of learning and self-cultivation.

Student aspirations do not necessarily translate into enrolment figures, as a longitudinal study of higher education in South Africa illustrates: in 2002 the enrolment rate in science, engineering and technology of 37 percent was lower than student intent of 48 percent (Cosser 2010). A similar study on students' intent to study STEM suggests that enrolments are influenced by high school maths achievement, degree aspirations, academic interaction and financial aid (Wang 2012).

Students' experience in STEM degree programs

Many studies examine educational experiences by looking at students' perceptions of teaching and learning quality. Using online-rating data, Chang and Park (2014) identified four factors that affect student satisfaction: teaching methods and practices; teacher knowledge and preparation; teacher attitudes; and student workload and teacher expectations. Similar work by Calvo, Markauskaite and Trigwell (2010) on the experience of engineering students found that supportive teachers and their ability to explain clearly are the most significant and workload and infrastructure the least significant factors affecting student satisfaction. Other factors correlated with student satisfaction and better learning experiences include course length, class size and teachers' expertise.

Other studies consider ethnicity and gender. Kendricks, Nedunuri and Arment (2013) stress how a nurturing "institutional environment" (i.e. designed to provide a sense of belonging and cultural identity) allows minority students to develop self-confidence, self-esteem and a positive outlook on their life and career. Similarly, Deemer (2015) posits that classroom experience and laboratory environment sway how students' value science education – a positive experience correlated with women science students deciding to pursue a career in their chosen field.

A comparison of undergraduates' levels of satisfaction with teaching and learning resources found that STEM students had a more positive overall experience than non-STEM students (Pawson 2012). However, non-STEM students had a better experience of teaching than their counterparts; specifically, male students reported lower satisfaction with teaching – an intriguing finding that merits attention in future research.

Relevance and practicality of STEM programs

To understand the relevance and practicality of STEM education, many studies examine the links between higher education, especially investment in science and technology, and economic growth. Advances in innovation, entrepreneurship and productivity achieved by many Asian societies in the last 50 years are largely due to their highly skilled workers and strong research capacity. Take the case of South Korea, where a seamless continuum of education policy has been aligned with structural changes in industry and employment since the shift from import substitution in the 1960s-70s to export-oriented industrialisation in the 1980s.

Heavy investment in science and technology was also responsible for rejuvenating China's economy and social base. In the 1980s, when the country embarked on economic reforms to re-join the world economy, science and technology was one of four top priorities that would set it on a robust growth path (Agelasto and Adamson 1998).

Analysis of the supply and demand for STEM talent is a useful way to understand the relevance of STEM education. Despite hesitant growth and uncertainty, demand in many European countries for STEM expertise is increasing, with some 7 million job openings forecast until 2025, in part due to high numbers of STEM workers reaching retirement age (Caprile et al. 2015). Current shortages are pronounced in technological occupations, particularly engineering and ICT, and demand for professional services and computer specialists is expected to rise.

Paradoxically, while it seems clear that the fastest growing jobs will require a science education, interest in STEM tends to decline as a country's economy grows and the standard of living improves, with students more interested in business, law and social sciences (McNeely and Hahm 2012). This trend of avoiding STEM careers is evident in South Korea, where although STEM fields are well established, university students, including those doing STEM majors, give more priority to job security; they prefer careers as government officials, teachers and doctors rather than in science and technology (Jin et al. 2012). Moreover, the competition for STEM jobs is tough, as industry demands highly qualified graduates with advanced technical knowledge (Jang and Kim 2015).

Limitations of the global literature

Much of the international literature is quantitative, with little empirical evidence from Cambodia. The use of standardised questionnaires limits responses to predefined constructs. Also, such variables as race and ethnicity are of limited relevance in Cambodia, which remains largely ethnically homogenous. Indeed, it is clear that our understanding of student engagement in STEM fields cannot be detached from social, cultural, economic and political factors. Context matters in comparative education research (Crossley and Watson 2003).

STEM education in Cambodia and implications for future research

The modest body of Cambodia-specific literature highlights the trust that many Cambodian students place in their family, especially parents, when deciding what to study at university (Peou 2015), and that they tend to choose majors to match their career aspirations rather than their values and interests (Un 2014). In a recent survey, around 60 percent of students cited personal interest as their main reason for choice of major (AUPP 2015). Notably, future skills demand barely seems to feature in higher education decisions. Even these few glimpses illustrate the complexity of cultivating STEM talent in Cambodia.

As future lines of research on Cambodian students' engagement in STEM education and careers, we propose the following topics. First is the question of what causes students who worked hard in the science stream at secondary school to opt for non-STEM majors at university. A new study on STEM learning achievement among Cambodian lower secondary school students noted that they lacked awareness of STEM opportunities and career prospects: "those [students] who took more number of extra classes in science/math, however, tended to like a career in non-science/math fields" (Eng and Szmodis 2016, 294). Even though over the last five years an average of 70 percent of grade 12 students opted for the science stream, the percentage of tertiary enrolments in basic science and engineering majors was much lower at 10 percent (Puth 2016).

To better understand students' experience of STEM and to determine the factors responsible for the problem of poor quality graduates, future studies must pay attention to the confluence of curriculum, course content, pedagogy, gender, teaching and learning resources. Such research will help improve graduates' employability skills and technical knowledge, which often do not meet the requirements of employers who complain that what students learn is of limited relevance to market needs (Khieng, Madhur and Chhem 2015).

Further analysis of STEM education as synonymous with human capital development must be grounded in sociocultural values so that economic growth can ensure social equity and harmony.

Concluding remarks from Chhem (1997, 115), which are well aligned with STEAM or integrative STEM education, remain relevant for today's Cambodia: "the accumulation of human capital … is only one instrument needed … Complete human development in Cambodia, especially of the leaders of the new millennium, is an essential aim for the full realization of the national identity of Cambodia".

In a similar vein, research on embedding STEM education and career choices within the wider macroeconomic and sociocultural context should consider such factors as public perceptions and attitudes towards gender equality, society's attitudes towards science and technology, economic development, working conditions and institutional settings (Caprile et al. 2015). In so doing, impact analysis of industry-university linkages would serve as a useful approach to ensure the relevance of STEM education to Cambodia's vision of a knowledge and skills-based economy.

The multidimensional nature of STEM education adds another layer of complexity. To obtain a full and clear picture of the topic, studies have to be pragmatic, holistic in scope and inclusive. Thus mixed methods approaches are imperative to future research on how to engage students in STEM education, as is framing such research within integrated science education or scientific literacy, including axiology (STEM purpose), ontology (STEM content) and epistemology (STEM pedagogy).

Finally, to learn from global best practices, studies addressing the development of STEM education in Cambodia should use a comparative approach. Due care and caution must be exercised, however, to avoid the ad hoc adoption of international education policies and practices without adequate consideration of whether they can properly respond to the new demands of Cambodia's labour market and the real needs of Cambodian society.

References

Agelasto, Michael, and Bob Adamson. 1998. *Higher Education in Post-Mao China*. Hong Kong University Press.

American University of Phnom Penh. 2015. "Study Shows 60% of Cambodian Students Choose Majors Based on Personal Interest." www.aupp.edu.kh/2015/07/01/.

Bybee, Rodger W. 2013. *The Case for STEM Education: Challenges and Opportunities*. Golden, CO: NSTA Press.

Calvo, Rafael Alejandro, Lina Markauskaite and Keith Trigwell. 2010. "Factors Affecting Students' Experiences and Satisfaction about Teaching Quality in Engineering." *Australasian Journal of Engineering Education* 16(2): 139–48.

Caprile, Maria, Rachel Palmen, Pablo Sanz and Giancarlo Dente. 2015. "Encouraging STEM Studies: Labour Market Situation and Comparison of Practices Targeted at Young People in Different Member States." An EU publication. doi:10.2861/519030.

Chang, Yun Jeong, and Seung Won Park. 2014. "Exploring Students' Perspectives of College STEM: An Analysis of Course Rating Websites." *International Journal of Teaching and Learning in Higher Education* 26(1): 90–101.

Chesky, Nataly Z., and Mark R. Wolfmeyer. 2015. *Philosophy of STEM Education*. Palgrave Macmillan.

Chhem, Rethy Kieth. 1997. "University and Human Capital in ASEAN Perspectives: The Case of Cambodia." PhD. diss., University of Montreal.

Cosser, Michael. 2010. "The Skills Cline: Higher Education and the Supply-Demand Complex in South Africa." *Higher Education: The International Journal of Higher Education and Educational Planning* 59(1): 43–53.

Crossley, Michael, and Keith Watson. 2003. *Comparative and International Research in Education: Globalisation, Context and Difference*. Hove: Psychology Press.

Deemer, Eric D. 2015. "Women's Science Major Satisfaction Regulatory Focus and the Critical Mass Hypothesis." *Journal of Career Development* 42(1): 60–71.

Eng Sothy and Whitney Szmodis. 2016. "STEM Learning Achievement among Cambodian Middle School Students: An Examination of Gender and Psychosocial Factors." In *Annual Review of Comparative and International Education 2015*, edited by Alexander W. Wiseman and Emily Anderson, 279–305. Bingley: Emerald Group Publishing Limited.

Greene, Jennifer C., Lizanne De Stefano, Holli Burgon and Jori Hall. 2006. "An Educative, Values-Engaged Approach to Evaluating STEM Educational Programs." *New Directions for Evaluation* (109): 53–71.

Jang, Hyewon, and Hyewon Kim. 2015. "STEM Professionals in Korea: High-level Skills and Wage Penalty." *Korean Journal of Comparative Education* 18(3): 211–40.

Jin, M., C. Song, H. Chu and H. Yoon. 2012. "Planning Educational Policies Based on the Analysis of STEM-Avoiding Phenomenon." Seoul: Korean Research Institute for Vocational Education and Training.

Kendricks, Kimberly D., K.V. Nedunuri and Anthony R. Arment. 2013. "Minority Student Perceptions of the Impact of Mentoring to Enhance Academic Performance in STEM Disciplines." *Journal of STEM Education: Innovations and Research* 14(2): 38–46.

Khieng Sothy, Srinivasa Madhur and Chhem Rethy, eds. 2015. *Cambodia Education 2015: Employment and Empowerment*. Phnom Penh: CDRI.

Khine, Myint Swe. 2015. *Science Education in East Asia*. Springer International Publishing.

Koonce, David A., Jie Zhou, Cynthia D. Anderson, Dyah A. Hening and Valerie Martin Conley. 2016. "AC 2011-289: What is STEM?" www.asee.org/file_server/papers/attachment /file/0001/0726/What_is_STEM_-_Final.pdf.

Langdon, David, George McKittrick, David Beede, Beethika Khan and Mark Doms. 2011. "STEM: Good Jobs Now and for the Future. ESA Issue Brief 03-11." US Department of Commerce. http://eric.ed.gov/?id=ED522129.

Latifah, Ismail. 2015. "Factors Influencing Malaysian Students' Choice of Major in Universities in the United Kingdom." *Online Journal of Quality in Higher Education* 2(4): 10-23. www.tojqih.net/volume/tojqih-volume02-i04.pdf#page=17.

Leppel, Karen, Mary L. Williams and Charles Waldauer. 2001. "The Impact of Parental Occupation and Socioeconomic Status on Choice of College Major." *Journal of Family and Economic Issues* 22(4): 373–94.

Mak Ngoy. 2015. "From Policies to Practices: Efforts to Excel Cambodia and to Successfully Engage in ASEAN Community." Presentation at the Professional Development Workshop, Raffles Hotel, Phnom Penh, 30 May.

Marginson, Simon, Russell Tytler, Brigid Freeman and Kelly Roberts. 2013. *STEM Country Comparisons: International Comparisons of Science, Technology, Engineering and Mathematics (STEM) Education*. Melbourne: Australian Council of Learned Academies.

McNeely, Conniel L., and Hong-On Hahm. 2012. "Global Studies Review » Blog Archive » The Global Chase for Innovation: Is STEM Education the Catalyst?" www.globality-gmu.net/archives/2972.

OECD (Organisation for Economic Co-operation and Development). 2016. "Education at a Glance 2015." www.oecd.org/edu/education-at-a-glance-19991487.htm.

Pawson, Chris. 2012. "A Comparative Analysis of Students' Satisfaction with Teaching on STEM vs. Non-STEM Programmes." *Psychology Teaching Review* 18(2): 16–21.

Peou Chivoin. 2015. "On Cambodian Higher Education and Skills Mismatch: Young People Choosing University Majors in a Context of Risk and Uncertainty." *Journal of Education and Work*: 1–13.

Puth, Samith. 2016. "Capacity-Building Workshop for GCED Curriculum Development and Integration in Cambodia." Hotel Cambodiana, Phnom Penh, 18 July.

Sanders, Mark. 2009. "STEM, STEM Education, STEMmania." *Technology Teacher* 68(4): 20–26.

Un Leang. 2014. "Upper Secondary School Curriculum Reform in Cambodia: Relevance for Employment and Tertiary Education." Phnom Penh: Royal University of Phnom Penh. www.academia.edu/6180031/.

Wang, Ming-Te. 2012. "Educational and Career Interests in Math: A Longitudinal Examination of the Links between Classroom Environment, Motivational Beliefs, and Interests." *Developmental Psychology* 48(6): 1643–57.

Wells, John G. 2013. "Integrative STEM Education at Virginia Tech: Graduate Preparation for Tomorrow's Leaders." *Technology and Engineering Teacher* 72(5): 28.