The Transformation from STEM to STREAM Education at Engineering and Technology Institutions of Higher Education

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Abstract. The scope of STEM based academic programs such as engineering and technology education should be widened to include Science, Technology, Reading, Engineering, Arts and Mathematics (STREAM) to enable future STEM graduates to be able to respond to the rapid changes of IR 4.0 and be ready for STEM based professions of the 21st century. A STREAM based curriculum for STEM focused programs will promote 21st century skills including collaboration, communication, creativity and critical thinking. STREAM has been gaining much popularity globally, given its ability to provide opportunities for learners to develop 21st century skills and the 4Cs necessary to strive in the future workplace. In this paper, we provide a succinct review of current debates surrounding this issue, drawing upon examples from across the globe, in Malaysia and Vietnam.

1. Introduction

Originally known as Science, Mathematics, Engineering and Technology (Sanders, 2008), STEM is an educational initiative developed by the National Science Foundation (NSF) with the aim of nurturing students with critical thinking and problem-solving skills, to enable them to be more competitive in the increasingly challenging workforce. STEM education, which is considered to be an interdisciplinary approach to learning (Meng *et al*., 2014), is deemed to be instrumental in reinforcing the professional skills essential for future careers and economic development (Colucci-Gray *et al*., 2017).

The limitations of STEM were brought to fore during the American Arts-National Policy Roundtable in 2007, following which the STEAM approach was agreed to be a more sustainable approach to use to nurture students' engagement and competences in STEM based professional fields (Allina, 2018). According to Land (2013), it is a must to encourage the younger generation to find out multiple solutions to complicated issues. The addition of

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the arts within STEM can address this issue. Adding the Arts component to STEM education allows for the expansion and reinforcement of creativity within STEM learners.

In responding to the rapid changes within the context of Industrial Revolution 4.0 (IR4.0), it has also been found that the "Three Rs" (Reading, wRiting, and aRithmetic) are no longer sufficient to address the developmental needs of STEM learners (NEA, 2012). A STREAM based curriculum can bridge this gap, as it will be able to promote 21st century skills including "collaboration, communication, creativity and critical thinking" (Debroy, 2017).

In this paper, we provide a succinct review of current debates surrounding this issue, drawing upon examples from around the globe, in Malaysia and Vietnam.

2. Literature Review

2.1. Current debates surrounding STEM, STEAM and STREAM

This section highlights debates surrounding STEM, STEAM and STREAM. We first look at some debates within STEM.

According to Zaher and Damaj (2018), STEM curriculum mainly focuses on addressing "facts and problems" by giving well-known and clear solutions rather than orienting students to seek a variety of solutions. Therefore, to deal with these issues, Pringle *et al*. (2015) propose that technology-supported collaborative learning be promoted to make students ready for the 21st century working environment in STEM areas.

Gordon (2014) highlights the need for the STEM professional workforce of the future to be skillful in the following competences to be able to sustain their relevance: (1) Applying digital tools for collaboration and problem solving; (2) Developing presentations via multimedia; and (3) Transforming information into knowledge through web seeking and examining. This addition is critical, as educators have also pointed out that such competences would strongly enhance 21st century skills among students.

McMullin and Reeve (2014) have found that lecturers play a crucial role in contributing towards the success of STEM implementation. Using intricate teaching designs and suitable teaching techniques in STEM classes, lecturers are also able to inspire students' interest in developing their capability to innovate (Chen *et al*., 2019). Additionally, there should also be openness and transparency (Margot & Kettler, 2019).

In debates surrounding STEAM, Lathan (2015) for instance found that STEAM promoted lecturers' capabilities in applying project-based learning (PBL), besides enhancing an inclusive learning environment where all students could participate. It has also been found that lecturers' STEAM teaching competence could be improved via professional development using collaborative and reflective approaches. Kang (2019) on the other hand has proposed for STEAM professional development programs to be looked into more intently (Kang, 2019).

Interestingly, STREAM has been gaining popularity in many countries for the following reasons: (1) Enhances 21st century skills; (2) Releases creativity; (3) Enables learning and practice; and (4) Promotes student centered learning (Root-Bernstein, 2011).

2.2. Developments in Malaysia and Vietnam

In Malaysia, the need for STEM professionals is critical to accelerate the development of the nation. Projections by the Ministry of Education (2015) of Malaysia indicates that it is necessary to align inquiry-based learning, contextual learning, collaborative learning, and project-based learning with STEM. The future direction of STEM education in Malaysia is projected to be enhanced through the quality of the STEM curriculum, professional development for STEM staff and employing more teaching and learning methods oriented to the young generation (Shahali *et al*., 2017).

Above and beyond promoting the interest of students in STEM, Maat (2017) is of the opinion that it is crucial to choose appropriate pedagogy where creativity and communication skills are developed, where critical thinking is fostered and where collaboration and innovation is critical. The Ministry of Education has also made clear the critical need for Malaysian institutions of higher learning to shift from STEM to STREAM. With the transition from STEM to STREAM, the Malaysian education system would be seen to be able to develop the soft skills of Malaysian students beyond "science" courses (Lim, 2019).

The development of STEM and STEAM education in Vietnam has not been as rapid as it has been in Malaysia. In 2017, Prime Minister Nguyen Xuan Phuc issued a directive to develop the country's ability to access the fourth industrial revolution. In this directive, the Ministry of Education and Training (MOET) was assigned to do the following critical tasks: (1) Foster teaching science, technology, engineering and mathematics (STEM) in the universal education curriculum; (2) Launch pilot programs of STEM teaching at several high schools; (3) Build up the capabilities of "researching and teaching" in institutions of higher learning; and (4) Promote teaching fundamental skills and knowledge, developing creative thinking and adaptability to keep up with the needs of Industrial Revolution 4.0 .

Even so, there is limited practice of the above in the Vietnamese education system at present. Vietnamese lecturers with diversified academic background have also not been appropriately and professionally trained to teach STEAM (Fullbright, 2019). Recent research conducted by Nguyen *et al*. (2020) has however noted that most Vietnamese education stakeholders had positive perceptions on STEM education. The Nguyen et al (2020) study also found that there is a need to standardize academic and training qualifications to create sustainable STEM development in Vietnam. The study further recommends that professional development programs for academics be focused on STEM thinking, and awareness of STEM jobs (Nguyen *et al*., 2020).

3. Conclusion

From the literature discussed above, it can somewhat be deduced that many challenges lie ahead in developing STEM, STEAM and STREAM. It is interesting that institutions the world over, in Malaysia and in Vietnam have begun to recognize that a STREAM based curriculum for STEM focused programs will promote 21st century skills including collaboration, communication, creativity and critical thinking. To the knowledge of the researchers, there are limited studies exploring notions of possibilities of engineering and technology based institutions of higher education transforming from STEM to STREAM education within an Industrial Revolution 4.0 context, specifically within Malaysia and Vietnam. Therefore, it is recommended that further empirical studies be conducted to understand this issue better. It is suggested that researchers explore this issue from a policy, curriculum design, pedagogy and professional development angles. Opportunities, challenges and solutions surrounding successful transformation from STEM to STREAM is also recommended to be investigated.

References

1. Allina, B. (2018). The Development of Steam Educational Policy to Promote Student Creativity and Social Empowerment. *Arts Education Policy Review*, *119*(2), 77–87. https://doi.org/10.1080/10632913.2017.1296392
2. Cameron, Pham, & Atherton. (2018). *FutureVietnameseDigitalEconomy.pdf* (No. 1stt; The Vietnam's Future Digital Economy Project, p. 60).
3. Chen, W., Tang, X., & Mou, T. (2019). Course design and teaching practice in STEAM education at distance via an interactive e-learning platform: A case study. *Asian Association of Open Universities Journal*, *14*(2), 122–133. https://doi.org/10.1108/AAOUJ-07-2019-0027
4. Colucci-Gray, L., Burnard, P., Cooke, C., Davies, R., Gray, D., & Trowsdale, J. (2017). *Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21st learning: How can school curricula be broadened towards a more responsive, dynamic, and inclusive form of education?* BERA. https://www.bera.ac.uk/project/bera-research-commissions/reviewing-the-potential-and-challenges-of-developing-steam-education-2
5. Debroy, A. (2017, October 7). *What is STREAM Education & Why is It Gaining Popularity? - EdTechReview*. What Is STREAM Education & Why Is It Gaining Popularity? https://edtechreview.in/trends-insights/insights/2968-what-is-stream-education
6. Fullbright. (2019, April 22). *STEAM Education in Vietnam: Prospects and Drawbacks*. Fulbright University Vietnam. https://fulbright.edu.vn/steam-education-in-vietnam-prospects-and-drawbacks/
7. Gordon, H. R. D. (2014). *The History and Growth of Career and Technical Education in America: Fourth Edition*. Waveland Press.
8. Kang, N.-H. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education*, *5*(1), 6. https://doi.org/10.1186/s41029-019-0034-y
9. Lathan, J. (2015). *STEAM Education: A 21st Century Approach to Learning*. University of San Diego. https://onlinedegrees.sandiego.edu/steam-education-in-schools/
10. Lim, M. (2019, March 27). The move from STEM to STREAM will boost employment. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/opinion/2019/03/27/the-move-from-stem-to-stream-will-boost-employment/
11. Maat, S. M. (2017, November 27). *Use 4Cs in STEM education*. NST Online. https://www.nst.com.my/opinion/letters/2017/11/307869/use-4cs-stem-education
12. Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education*, *6*(1), 2. https://doi.org/10.1186/s40594-018-0151-2
13. McMullin, K., & Reeve, E. (2014). Identifying Perceptions That Contribute to the Development of Successful Project Lead the Way Pre-Engineering Programs in Utah. *Journal of Technology Education*, *26*(1), 22–46.
14. Ministry of Education. (2015). *Malaysia Education Blueprint 2015 2025 (Higher Education)* (p. 40). http://mohe.gov.my/muat-turun/awam/penerbitan/pppm-2015-2025-pt/5-malaysia-education-blueprint-2015-2025-higher-education
15. National Education Association. (2012). *Preparing 21st century students for a global society: An educator's guide to the "Four Cs*. http://www.nea.org//tools/52217.htm

16. National Research Council (U.S.) (Ed.). (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. The National Academies Press.
17. Nguyen, T. T. K., Nguyen, V. B., Pei-Ling Lin, Lin, J., & Chang, C.-Y. (2020). Measuring Teachers' Perceptions to Sustain STEM Education Development. *Sustainability*, *12*(4), 1531. https://doi.org/10.3390/su12041531
18. Pringle, R. M., Dawson, K., & Ritzhaupt, A. D. (2015). Integrating Science and Technology: Using Technological Pedagogical Content Knowledge as a Framework to Study the Practices of Science Teachers. *Journal of Science Education and Technology*, *24*(5), 648–662. https://doi.org/10.1007/s10956-015-9553-9
19. Root-Bernstein, R. (2011, March 16). *From STEM to STEAM to STREAM: WRiting as an Essential Component of Science Education*. Psychology Today. http://www.psychologytoday.com/blog/imagine/201103/stem-steam-stream-writing-essential-component-science-education
20. Sanders, M. E. (2008). *STEM, STEM Education, STEMmania*. https://vtechworks.lib.vt.edu/handle/10919/51616
21. Sani, R. (2019, February 20). *Demand for soft skills in the workplace*. NST Online. https://www.nst.com.my/education/2019/02/461884/demand-soft-skills-workplace
22. Shahali, E. H. M., Ismail, I., & Halim, L. (2017). STEM Education in Malaysia: Policy, Trajectories and Initiatives. *Asian Research Policy Science and Technology Trends*, 122–133.
23. Talib, C. A., Mohd Rafi, I. B., Rajan, S. T., Abd Hakim, N. W., Ali, M., & Thoe, N. K. (2019). STEAM TEACHING STRATEGIES IN RELATED SUBJECT. *Education, Sustainability And Society*, *2*(4), 14–18. https://doi.org/10.26480/ess.04.2019.14.18
24. Ulsoy, A. G. (2005). *A 21st Century Engineering Education for Leading Concurrent Discovery and Innovation*.
25. Viegas, C., Marques, A., & Alves, G. R. (2017). 21st Century Challenges in Engineering and Technological learning. *Proceedings of the 5th International Conference on Technological Ecosystems for Enhancing Multiculturality - TEEM 2017*, 1–3. https://doi.org/10.1145/3144826.3145359
26. Zaher, A., & Damaj, I. (2018). Extending STEM Education to Engineering Programs at the Undergraduate College Level. *International Journal of Engineering Pedagogy*, *8*(3), 4–16.