Editorial: Special Issue “Promoting STEAM in Education”

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Lately STEAM (science, technology, engineering, art/aesthetics/architecture/all, mathematics) education has become a common notion. Yet, the theoretical and practical perspectives on STEAM, from its nature to classroom applications and its implementation in teacher education have unexamined potential. This special issue grew out of the International LUMAT Research Symposium “Promoting STEAM in Education” that took place at the University of Helsinki, Finland in June of 2020. With the challenges of organizing an online symposium in the midst of the COVID-19 pandemic, its online nature had significant advantages. The symposium drew international scholars inviting a multitude of prospective on STEAM education, while uncovering the challenges faced by educators. The issue aims at examining these challenges through a collection of papers. In this editorial, we introduce some key notions, discourses, and challenges of STEAM education, as a relatively novel concept and briefly discuss the history of STEAM and its evolution over the last decades. We also problematize STEAM and its roots through asking a question: What is “A” in STEAM representing? Then we introduce the three articles in this special issue: “Full STEAM ahead, but who has the map? – A PRISMA systematic review on the incorporation of interdisciplinary learning into schools”; Promoting STEAM learning in the early years: ‘Pequeños Científicos’ Program”; and “Promoting student interest in science: The impact of a science theatre project”. These articles challenge us to rethink STEAM education, reveal the potential of STEAM, and offer ideas for future research.

Keywords: art education, interdisciplinarity, STEM education, STEAM education, teacher education

ARTICLE DETAILS

LUMAT Special Issue
Vol 9 No 2 (2021), 1–8

Received 3 March 2021
Accepted 12 March 2021
Published 18 March 2021

Pages: 8
References: 30

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https://doi.org/10.31129/LUMAT.9.2.1559

1 Why STEAM? Why now?

1.1 Conceptualization of STEAM and exploring its drivers and potential

In recent years, the acronym STEAM has become ubiquitous in the educational literature, policy, and research. Yet despite its increasing presence, it is not entirely clear whether STEAM is to be conceptualized as a phenomenon, a movement, a pedagogical approach, a policy or a new perspective (Martinez, 2017; Perignat & Katz-Buonincontro, 2019). Furthermore, albeit four of the letters in the acronym, S-T-E-M have been historically conceptualized as “Science”, “Technology”, “Engineering” and “Mathematics”, the fifth letter ‘A’ appears to be ambiguous, most often denoting both narrow and wide conceptualizations of “Art(s)” (Ge, Ifenhaler, & Spector, 2015), but also allowing for “Aesthetic(s)” (Segarra, Natalizio, Falkenberg, Pulford, & Holmes, 2018) and even “All” (White, 2014). STEAM education is still in its infancy whilst the STEM concept has had the time to mature since its introduction by the US National Science Foundation (NSF) in the early 2000s, growing out of its earlier counterpart SMET from the 1990s (Sanders, 2009) and sharing goals with the well-established STS movement (McComas, 2014). This is, however, not to say that STEM has been clearly conceptualized (see e.g., the special issue of Science & Education, no. 4/2020 on the nature of STEM) or that there is a universal agreement on what it represents (Erduran, 2020).

While the connections of science, technology, engineering, arts, and mathematics have been an integral part of the western culture for centuries (Isaacson, 2017), the more recent constructions relevant to education, such as STEM and STEAM are man-made and were driven by many different forces, some of which lay outside of the education system. Thus, we should not necessarily expect to readily or easily arrive at universally applicable rigid and immutable definitions or conceptualizations. Rather, these conceptualizations are products of our constant explorations, discussions and negotiations with the goal of creating meaningful learning environments for the learners in order to give every student an opportunity to engage in the study of these fields from kindergarten to tertiary education, also including informal learning contexts as well as life-long learning. While nowadays, STEM education might not be driven by a cold war or a space race as it was half a century ago, (Dickson, 2001; Moritz, 1999; Pion & Lipsey, 1981), the challenges of the 21st century have provided plenty of new reasons for engaging all students in STEM. STEM-related education might help address pressing societal issues. Some of them are related to environmental degradation, climate change, and unsustainable development (UNESCO, 2017). While others reflect the growing economic gaps, lack of social mobility, and the ongoing failure to engage underrepresented groups, such as immigrants, in STEM fields (Chachashvili-Bolotin, Lissitsa, & Milner-Bolotin, 2019; Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016) .

At the same time, scholars have raised a critique of STEM approaches, such as taking for granted that an integrated instructional blending of STEM is unequivocally desired (McComas & Burgin, 2020). This should also be relevant when considering the future of STEAM education as described below.

1.2 From STEM to STEAM

Along with the discussions and research on STEM subjects, policy makers and researchers have expressed concerns about what is seen as a narrow focus of STEM education, when economic growth is seen as the major success factor in societies and STEM is seen as the means to achieve this (McComas & Burgin, 2020). In addition, the lack of family STEM engagement has been identified as one of the major factors negatively affecting student disengagement from STEM, especially the students from low socio-economic backgrounds and immigrants (Marotto & Milner-Bolotin, 2018; Milner-Bolotin & Marotto, 2018). As a result, arguments have been put forward to broaden perspectives on STEM education in order to include the previously mentioned 'A'. Thereby, expanding STEM into STEAM acknowledges other parts of human existence as equally important and valuable as the domains covered by STEM (Colucci-Gray, Burnard, Cooke, et al., 2017). Another argument for an expansion of STEM into STEAM has been to address the challenges of the 21st century, and to promote 21st century skills, such as educating citizens capable of seeing and exploring interconnections within STEM subjects and between STEM and other areas, such as everyday life (Ge et al., 2015; Hopia & Fooladi, 2019; Milner-Bolotin & Milner, 2017). In order to achieve such ambitious goals, we have to educate teachers who can support students in becoming STEAM-literate citizens and see STEM and STEAM outside the classroom walls (Harris & de Bruin, 2018; Perignat & Katz-Buonincontro, 2019). For example, it is said that in addition to educating citizens who are literate in basic science and mathematics, it is important to educate students who are curious and knowledgeable about how things work (Engineering) (Bloomfield, 2001; Milner-Bolotin & Svinicki, 2000), how science is embedded in everyday life experiences, such as cooking (Fooladi, 2013; Fooladi, 2019; Hopia & Fooladi, 2019), how technology is affecting our lives, and how all this links to other areas of society and life come together to solve omnipresent societal problems (Arts, Aesthetic(s), All). Likewise, in dealing with complex issues locally, regionally, and globally it is expected from present and future leaders to be able to see how these issues are interconnected and weaved into each other, as the basis for sound decision-making processes (Muller, 2008). This is clearly applicable to the issue of sustainable development and sustainability education. In short, to be able to address the 21st century challenges, inter-/multi-/transdisciplinary approaches are crucial, giving legitimacy to exploring interconnections between STEM and other subject domains in education.

According to Colucci-Gray and collaborators (2017, p. 31), "[t]he STEAM literature echoes a view of the arts as valuable both intrinsically and instrumentally; the arts are deemed to be social, inclusive, humanizing, and thereby significant for human development in the society (Belfiore and Bennett 2007; Canatella 2015)."Hence, the role of the 'A' can be considered *supporting* the goals of STEM, it might be considered *expanding* STEM to include broader perspectives, or it might be considered *bringing to the table something unique and different*, but significant, that is entirely different from STEM but still required for achieving some form of completion. In any case, the meeting, or integration, of STEM with 'A' represents an encounter that brings with its possibilities, challenges and power relations. As described above, 'A' can play an instrumental role in helping STEM achieve its goals, whichever those may be. At this end of the spectrum, 'A' basically plays a service role in support of STEM. At the other end of the spectrum, STEM may be brought in to support learning, or understanding, of 'A'. Between these extremes, there are a multitude of modes of collaboration and integration, for which there appears to be no consensus as to which is to be preferred or recommended along a normative scale. As STEAM is still in its infancy, a pluralist stance may be a productive path while we can follow the development of a breadth of approaches to STEAM. The three articles in this special issue indeed display a broad variation in scope, focus and style. They also represent different approaches to STEAM education implemented across the globe as opposed to focusing on STEAM education in a particular country.

1.3 The goals of the current issue

This present special issue of the LUMAT Journal builds on the 2020 International LUMAT Symposium with the title "Promoting STEAM in Education" (Aksela, Vesterinen, Herranen, & Pernaa, 2020). An open interpretation of 'A' in the STEAM acronym has been chosen deliberately, where 'A' is conceptualized to be situated closer to "All" than a traditional narrower conceptualization of A as representing the "Art(s)". Whichever definition or conceptualization is chosen for STEAM, it will inevitably shape how STEAM education is practiced and researched (Colucci-Gray, Burnard, Cooke, et al., 2017; Colucci-Gray, Burnard, Gray, & Cooke, 2017). Laying aside discussions on STEM, which is outside the scope of this special issue, the challenge remains, to discuss the relationship between STEM and the 'A'. Reviewing existing STEAM research, Colucci-Gray et al. (2017) concluded that if 'A' in STEAM includes all that is missing from STEM, a researcher's definition of STEAM would reflect what is missing or problematic in STEM, such as the ethical, aesthetic and affective dimensions (Colucci-Gray, Burnard, Gray, et al., 2017).

The aim of this special issue is to unravel the potential of STEAM in a variety of educational contexts. According to the studies in this issue, STEAM has possibilities, not yet examined or even considered. The three articles also discuss some challenges in the practical approaches to STEAM education, connected to its multidisciplinary nature, the local contexts, and the practicalities in its implementation.

2 Papers included in the current issue

The first article by Seamus Delaney and Daniel White, "*Full STEAM ahead, but who has the map? – A PRISMA systematic review on the incorporation of interdisciplinary learning into schools*", reviews existing literature on interdisciplinary STEAM learning and teaching in high schools. The reviewed articles showed that improved learning outcomes, such as better results in academic tests, could be achieved in project- and problem-learning environments. In addition, the authors find that STEAM-based approaches in interdisciplinary teaching could potentially increase student collaboration and interaction with professionals. However, in the screening phase for the review only eleven articles out of ninety-nine potential publications met the criteria for inclusion in the synthesis, namely that the research should measure in some way learning outcomes from STEAM-oriented teaching. Therefore, the authors argue that more empirical research is required on the relationship between STEAM and learning outcomes before such STEAM approaches are implemented in educational systems on a large-scale.

The second article *"Promoting STEAM learning in the early years: 'Pequeños Científicos' Program"* by Valeria Cabello, Maria Loreto Martinez, Solange Armijo Solis, and Lesly Maldonado describes and examines a non-formal education program among 3–10-year old children. Aiming at inspiring young girls' interest in STEM/STEAM subjects, the program was taught by an all-female staff of scientists and artists on topics including historical accounts of women's roles in STEM, thus seeking to curb gender-stereotypes and male domination in STEM. The article discusses the strengths, weaknesses, and opportunities of the program based on the perceptions of the students, teachers, and educators. A number of strengths of the program were identified: the students were engaged in learning processes; holistic perspectives and integration between STEM and 'A' were achieved and clear signs were found of increased motivation and interest among the participants. One of the major challenges identified in this program was the handling of young learners' emotions, frustration and behavior by an all-scientists/artist staff with limited or no pedagogical background in handling such issues.

The third article *"Promoting student interest in science: The impact of a science theatre project"* by Lydia Schulze Heuling reports on a science theatre project in a heterogeneous teaching context in a disadvantaged area, and its effects on students' interest in STEM and their artistic expression. The quantitative analysis presented in the study indicated an increased student interest in the topic of galvanization, and physics and chemistry in general. In addition, the approach resulted in increased student appreciation of artistic practices and positive classroom spirit, knowledge of cultural practices, and student self-confidence. Based on this work, the author discusses art-informed STEM education as a socially inclusive practice.

3 Conclusions

The three articles in this issue point to the holistic nature of STEAM in education, as expressed by the variety of approaches to and a multitude of motivations for STEAM in education at all levels of the education system. This should come as no surprise, as new subject and knowledge domains are included, more possibilities and challenges are introduced. In line with Colucci-Gray and collaborators, the research and education community could benefit from future studies on STEAM education extending beyond small-scale projects, while also considering the long-term implications of STEAM education (Colucci-Gray, Burnard, Cooke, et al., 2017; Colucci-Gray, Burnard, Gray, et al., 2017).

The research and education communities continue to explore and debate various aspects of STEM and their implications (Erduran, 2020; McComas & Burgin, 2020). When STEM is expanded into STEAM, a further complexity is added, as yet another element, itself highly complex and with its own challenges, is introduced into the mix.

Within STEAM, science, technology, engineering, and mathematics educators, teacher educators, and researchers must engage in a dialogue and meaningful collaborations with colleagues from other areas, such as language and literature, music, visual arts, drama, home economics, social sciences, and other subject domains (Herranen, Kousa, Fooladi, & Aksela, 2019). Whether 'A' is conceptualized as "art(s)", "aesthetics", "architecture", or "all", it is to be expected that cultural meetings between epistemologies and ontologies of different subject domains will provide exciting possibilities as well as substantial challenges. This calls for not only expertise in one's own field of work, but also insights into other subject domains, respect for your “out-of-your-field” colleagues’ way of working and thinking, and willingness to put oneself in their shoes. As such, STEAM education could also provide a path to building mutual understanding across professional cultures and knowledge domains, as well as motivate learners, and contribute to solving societal and global issues.

Acknowledgements

We are grateful to LUMA Centre Finland for their support in the preparation of this special issue.

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