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THE EMERGENCE OF STEAM AND ITS PEDAGOGICAL IMPLICATIONS: A RE-EVALUATION OF THE PSYCHOMOTOR DOMAIN

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Abstract

The complex challenges of the 21st century necessitated the integration of traditionally discrete disciplines to form the meta-discipline of Science, Technology, Engineering and Mathematics (STEM) as a body of enquiry. However, the increasingly complex challenges of the present world have resulted in the reframing of STEM education to emphasis the enhancement of students' ability to find solutions to complex societal challenges. This new move has seen the integration of Arts into STEM to create the transdiscipline of STEAM with more emphasis on nurturing creativity and innovative competency. This paper, therefore, examines the implication of this development on the psychomotor domain of learning as well as promote psycho-productive competency as a viable domain with focus on creative competency of students. The integrative methodology for the review of literature was adopted to examine and comprehend the definitions and descriptions of STEAM education. The article highlighted the rationales, core objectives, and implications of STEAM education for the psychomotor domain. It also recommended pedagogical frameworks and required teacher competences for STEAM education.

Keywords: *STEAM, psychomotor domain, psycho-productive competency, competency-based education, design-based learning.*

1. Introduction

The complex challenges of the 21st century have necessitated the integration of traditional discrete disciplines to form the meta-discipline of Science, Technology, Engineering and Mathematics (STEM) as a body of enquiry (Belbase et al., 2021). Such integration represents a bid to eliminate the established barriers between the disciplines of science, technology, engineering and mathematics, and foster creativity as well as the application of new and innovative practices to create solutions to complex contextual situations (Kennedy & Odell, 2023). However, the increasingly complex challenges of the present world have resulted in the reframing of STEM education to emphasis the enhancement of students' ability to find solutions to complex societal challenges. This provided the basis for an integration of the humanities (Arts) into the highly crucial domain of STEM, thereby birthing the acronym STEAM which stands for Science, Technology, Engineering, Arts and Mathematics (Land, 2013; EducationCloset, 2019).

Findings by Swaminathan and Schellenberg (2015) have demonstrated that programmes in the Arts enhance cognitive skills such as abstract thinking, spatial reasoning, divergent thinking, creative self-efficacy, openness to experience, and curiosity. Therefore, acquiring the capability to implement both sets of skills can be considered an elite requirement for the global competiveness of the modern society. For better comprehension of the creative-workforce's inspired educational and research landscape of STEAM (Katz-Buonincontro, 2018), it is essential to review the rationale for the integration of Arts into STEM, the goals of STEAM education and explore the implication on the psychomotor domain of educational objectives.

1.1. Conceptualisation of STEAM

There is no generally accepted comprehensive definition of STEAM. However, there are as varying descriptions of STEAM as there are suggestions regarding its implementation (Katz-Buonincontro, 2018). This article, therefore, would adhere to the definitions that align with the study's focus. Perales and Aróstegui (2021) defined STEAM education as a body of knowledge which proposes an integrated teaching of scientific-technological, artistic and, in general, humanistic competencies, with an integration that is understood in a progressive sense, moving from interdisciplinarity to transdisciplinarity.

2. Methodology

The integrative review of literature was adopted to examine and comprehend the definitions and descriptions of STEAM education. Studies such as Torraco (2005) and Whittemore and Knafl (2005) identified integrative review as a particular review method which analyzes and synthesizes literature with the purpose of broadly comprehending the particular topic. These methods of review are suitable for reevaluating studies on new and/or emerging topics in diverse disciplines such as STEAM education, so that robust comprehension of the discussion, analysis and application of STEAM in literature could be achieved.

3. Discussions

3.1. The rationale for the integration of arts into STEM

Several rationales have been identified by studies for the integration of Arts into STEM thereby forming the meta-discipline of STEAM. Some of these rationales include "the integration and use of Arts in the STEM curriculum to aid students' expression of STEM concepts" (Sharapan, 2012); "the integration of arts in order to enhance the involvement of students who are customarily not part of STEM" (Quigley & Herro, 2016); "a body of knowledge that underlines the importance of Arts for the engagement of more students with differing learning characteristics" (Bush et al., 2016); and "an approach for encouraging greater interest in STEM disciplines and enhancing career aspirations among secondary (K-12) students" (Kant et al., 2018).

From the pedagogical perspective, Bequette and Bequette (2012) reviewed the rationale for STEAM by arguing that "when the Arts are seen as tipping point of STEAM education, not just an initiating stage of more sophisticated STEM topics, carefully designed STEAM curricula would be capable of enhancing continuous cross-disciplinary learning within the secondary (K-12) settings".

Creative problem-solving, Creative thinking, the development of creative skills, or creativity is frequently highlighted in majority of studies as an outcome of STEAM. The conception of creativity is associated with the Arts, and it is described as a key objective of STEAM education (Tesconi & de Aymerich, 2020).

3.2. Objectives of STEAM education

STEAM educational objectives are broad, ranging from increasing academic participation, engagement, and retention through art and design thinking (e.g., creativity), to core subject mastery in STEM fields like astronomy and engineering gained through interactive multimedia projects (Clapper, Fagen, Garcia, & Lopez, 2013); and hands-on exploration in the arts (Liao, 2019). Creativity holds a central place in STEAM education, recognized as a valuable asset in a competitive society (Chen & Ding, 2024). Therefore, the development of students' competencies is regarded as the sole goal of STEAM education for both self-actualisation and as a resource for the industrial sectors.

3.3. Implications of STEAM education: From psychomotor to psycho-productive competency

The psychomotor domain of Bloom's Taxonomy focuses on physical movement, coordination, and motor-skill application, emphasizing speed, precision, and control. While it includes tasks from simple to complex, this article shifts focus to psycho-productive competency, which blends creativity with productive skills. Drawing on studies by Ombugus and Umaru (2017), Ombugus et al. (2019), and Onanuga and Banjo (2021), the article defines psycho-productive competency as the ability of students to demonstrate observable, skill-based outputs reflective of classroom instruction, under real-world conditions. Unlike traditional skill-based approaches, this article views psycho-productivity through a competency lens, integrating creativity and humanistic values. As Torres (2022) explains, competency encompasses knowledge, behavior, skills, and attitudes essential for successful task completion. Thus, psycho-productive competency refers to students' ability to produce tangible evidence of learning—demonstrating not only skills but also sound judgment, creative application, and deep understanding of concepts taught during instruction.

3.4. Challenges of STEAM education

Studies such as Quigley and Herro (2016) and Herro, Quigley and Cian. (2018) have shown how difficult it is to implement STEAM, with teachers reporting challenges such as increased workload, and understanding STEAM integration. STEAM instruction can pose pedagogical challenges, especially, as teachers attempt to move toward a facilitator role in instruction (Quigley, Herro, King & Plank, 2020). Teachers' epistemic worldview could underpin their perception and readiness to implement STEAM instruction. Nonetheless, creative and design skills which are naturally the focus Art and design disciplines might not be of great interest to science and engineering students (Che & Ip, 2024). Another challenge is how teachers would deliver technical content in core STEM subjects such as mathematics, programming, and other related contents that are very influential to students' motivation and interest in the field. Furthermore, Che and Ip (2024) asserts that assessment of learning outcomes presents another challenge as grading creative outputs could frequently lead to subjective remarks.

3.5. Framework for STEAM education: Instructional implementation of STEAM education

The successful implementation of STEAM requires approaches with the capacity to address STEAM's particular objectives. Various approaches have been highlighted in literature.

- One consideration is Competency-Based education. According to Sullivan and Downey (2015), organisations such as the Carnegie Institute and the United Nations are increasingly placing more emphasis on Competency-Based Instruction in education reform efforts. Rajapaksha and Hirsch (2017) studied philosophy and the practice of competency-based instruction of college physics. The study emphasizes that focusing on competencies in physics enhances the development of many transdisciplinary and transferable skills that learners can employ in other fields of human endeavour, independent of the physics discipline.
- Another suggested approach for STEAM education is Design-based learning. Design-based learning combines design thinking and the design process into the instructional exercises, where the students are engaged in a real-life context (Bertrand & Namukasa, 2023). It can be described as a natural approach to STEAM, as well as a vital element of an authentic STEAM program (Liao, 2016).

3.6. Required teaching competencies for STEAM education

Based on the learning principles outlined for STEAM education, Kim and Kim (2016) categorized STEAM teaching competencies to include:

- Subject-matter cognitive Ability: This is described by the ability to comprehend and using convergent knowledge;
- Advanced thinking ability: This is defined by teachers' creative, problem-solving, decision-making and critical thinking abilities, as well as the ability to use information;
- Ability to contribute to the community: This is defined by the capacity to communicate, engage in social relationships, and collaborate with others;
- Individual emotional intelligence: This is defined as self-respect, positive emotion, consideration, and civil awareness.

Adaptive expertise is another essential teaching competency required for the implementation of STEAM educational objectives. Hatano and Inagaki (1986) recommended three factors that boost the development of adaptive expertise:

- an arbitrary context that compels professionals to adapt their skills, due to careful observation and interaction;
- an environment that is safe where rewards is not dependent on performance;
- a functioning context that values quality over efficiency.

The challenge of reconciling and integrating creative competence into STEM could be considered a complex task, making adaptive expertise a crucial skill in STEAM education.

4. Conclusion

This article underscores the need for an integrated education that advances both scientific and humanistic competencies. It explores STEAM education from two perspectives: as an extension of STEM through the inclusion of the Arts, and as a transformative framework that impacts society and the educational landscape. The review reveals that STEAM promotes principal and transversal competencies across educational levels, emphasizing psycho-productive competencies linked to creativity. Studies highlight creative thinking, problem-solving, and skill development as key outcomes of STEAM education. The article calls for a reexamination of the psychomotor domain in educational objectives, aligning with the renewed focus on creativity. However, the transition to STEAM poses challenges for instructors and students, including pedagogical, design, and assessment issues. Science and engineering educators may face difficulties in integrating technical content with creative approaches. To address these challenges, the article proposes competency-based instruction and design-based learning as effective models for developing and teaching STEAM curricula.

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