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Bridging Educational Innovations: The Alignment Between Hands-On Activities And STEAM Education

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Abstract:

STEAM Education is an integrated learning approach that combines Science, Technology, Education, Art, and Mathematics. It emphasizes interdisciplinary learning. A hands-on activity is a method of instruction in which students actively and physically work with objects, equipment, or real-world tasks to understand ideas or find solutions. This paper explores the importance of Hands-on activities and STEAM Education, the intersection between hands-on activities and STEAM education, highlighting how experiential learning methods enhance student engagement, academic performance, learning outcomes, problem-solving skills, and interdisciplinary understanding. This paper explores the convergence of hands-on activities with STEAM education using a secondary data analysis approach. Drawing on an extensive review of current literature, the study highlights how tactile, experiential learning aligns seamlessly with interdisciplinary education, fostering critical thinking, creativity, collaboration, and deeper conceptual understanding among students. The research investigates how hands-on practices enrich learning experiences across scientific experimentation, technological application, engineering design, artistic expression, and mathematical reasoning. Furthermore, it identifies the systemic and practical challenges faced in implementing such integrated approaches, including limited resources, inadequate teacher training, and assessment limitations. The paper concludes by emphasizing the transformative potential of hands-on STEAM pedagogies in nurturing 21st-century skills, offering theoretical insights and practical implications for educators, curriculum designers, and policymakers.

***Key words*- STEAM Education, Hands-on Activities, Interdisciplinary Learning, Educational Innovation**

Introduction:

Learning is reliant on the pedagogical procedures, or teaching methods, that teachers follow in the classroom. Many teaching methods are common in every school, and some of them are more effective while others are not (MHRD, n.d.). According to Duque (2022), there are many types of teaching methods, e.g., learner-centric, teacher-centric, subject-centric, collaborative approach, interactive approach, etc. Nowadays

democratization of knowledge has changed the role of the teacher as facilitator (NCTE, 2009; Namitha, 2018). Now, constructivist classrooms are developing; in these classrooms, learners construct their representations of the world and add new information to their pre-existing schemas (Mcleod, 2023). It follows as said by Confucius, "*I hear and I forget, I see and I believe, I do and I understand*". It promotes the use of many senses. Different types of media and technologies also involve multiple senses and take care of a student's unique way of understanding (Aja et al., 2017). The Indian educational system has also seen significant developments from the Vedic era to the modern computer age and e-learning (Gupta, 2017). One of these developments is art-integrated learning. Art instruction helps children develop motor, language, and social skills, risk-taking, decision-making, and inventiveness (Rege, 2022). After the introduction of these components, e.g., technology and arts, the whole scenario of teaching-learning has been changed. Teaching strategies, which are new and innovative, are always introduced for the improvement of the quality of education (Tirath, 2017). One such innovative teaching strategy is the integration of multiple disciplines in a single classroom. According to Maresca (2022), it doubles the chances that students will be engaged in a class when subjects are taught in an integrated or combined manner. An example of such integration is STEM, i.e., Science, Technology, Engineering, and Mathematics. STEM is very useful in children's skills and knowledge with practical understanding (Bahrum et al., 2017), but it lacks the creative component (Zhbanova, 2017). There is a demand for curriculum that combines STEM and the arts due to the increasing emphasis on different soft skills across businesses and roles. Considering these points, art was integrated into STEM, and it became STEAM. Children are more engaged and have more fun learning when they are exposed to the arts; it increases their creativity. The A in STEAM, or art, is where personal expression, empathy, meaning-making, and the purpose of what children are studying come into play (Truck, 2020). The value of STEAM education is undeniable as a means of developing basic skills and competencies of young students, improving the learning process, developing communication skills, and solving real-life difficulties (Chaldi & Mantzanido, 2021). In STEAM, 'A' is Art; its applications teach students about artistic content and how it can be applied to inquiry, creativity, and problem-solving. Art has two forms: one is visual art, eg, Clay modeling, drawing and painting, paper crafts, etc. The second is performing arts, eg, Music, Dance, Theatre, Puppetry, etc. (Tzanidaki & Reynolds, 2011; Britannica, 2023). When hands-on activities involve creative performance, they overlap with performing arts. Among the most impactful strategies within STEAM is the use of hands-on activities—active, tactile learning experiences that engage students both cognitively and physically. These activities do not merely support the STEAM framework; they are often its very foundation. Hands-on activities are learning experiences that involve direct manipulation of materials, physical engagement with tools or technologies, and exploration through doing rather than passively receiving information. These may include experiments, construction, prototyping, art-making, dramatization, or coding with physical devices. Rather than being limited to one discipline, such activities cut across multiple domains, making them inherently STEAM-oriented. Hands-on activities refer to instructional strategies that actively involve students in manipulating materials, conducting experiments, building models, or engaging in creative tasks. These activities are grounded in the learning-by-doing approach, engaging learners across the cognitive, affective, and psychomotor domains (Priya & Rinki, 2021). They emphasize experiential learning, allowing students to explore concepts practically, rather than passively receiving information. Such methods are particularly effective because they provide tangible experiences that bridge the gap between abstract knowledge and real-world application. For instance, modeling activities in science—like constructing a DNA double helix using physical materials—help learners understand invisible or complex phenomena (Mierdel & Bogner, 2019).

Sustainable Development Goals (SDG-4) have focused on quality education, National Education Policy- 2020 in India also emphasizes learning by doing through activity-based learning, vocational training, project-based learning, experimentation, and practical work. STEAM education as well as hands-on activities offers immense potential for nurturing the skills needed to achieve the Sustainable Development Goals (SDGs) and goals set by NEP-2020.

Objectives of the Study

1. To explore the conceptual foundations and educational value of hands-on activities in contemporary classrooms.
2. To examine the interdisciplinary integration of hands-on learning within the STEAM framework.
3. To analyze existing research findings on the effectiveness of hands-on STEAM approaches in enhancing academic and cognitive skills.
4. To identify key challenges and barriers in the implementation of hands-on STEAM practices.

Methodology

This study is based on a qualitative secondary data analysis methodology. The authors conducted an extensive literature review of published scholarly articles and empirical studies from reputed journals and databases. The collected data were thematically analyzed to synthesize existing insights on the alignment between hands-on activities and STEAM education. The methodology included content extraction, classification into thematic domains (such as importance, alignment, challenges, and opportunities), and critical interpretation. No primary data collection or field experimentation was involved. The study relied entirely on previously validated findings to draw conclusions and make recommendations.

Importance of Hands-on Activities

Hands-on activities are crucial in fostering a deeper and more lasting understanding of educational content. Tindan and Anaba (2024) conducted a systematic review that confirmed the positive impact of hands-on science education on students' academic success, critical thinking, and conceptual understanding. According to Duzenli-Gokalp and Sharma (2010), students engage more deeply with mathematical concepts such as fractions when they participate in tactile, exploratory learning tasks. Hands-on methods support interdisciplinary and constructivist learning. They not only improve content knowledge but also enhance skills such as communication, collaboration, and creativity (Priya & Rinki, 2021). Engaging students emotionally and physically increases motivation and provides meaningful learning experiences, especially when dealing with abstract topics (Hong et al., 2020). The study of Holstermann (2010) revealed that Hands-on Activity is effective in increasing the interest of students. Sadi and Cakiroglu (2011) revealed that Hands-on activities help in developing attitude and increasing science achievement of students. Kartini et al. (2022), Usman et al. (2023), Eden et al. (2023) and Raymundu (2023) revealed in their studies that hands-on activity has a significant effect in increasing the academic performance of students. James et al. (2023) concluded in the study that scientific skills, observation, classification, experimentation, and intelligence were learned by doing hands-on activities. Mierdel and Bogner (2019) in their study concluded that hands-on experience supports the development of problem-based thinking skills, and it is not gender-dependent. Zhang et al. (2022) in their paper found that students from the University of California, Los Angeles, when taught with instruction using a computer simulation hands-on activity significantly effective in understanding the shuffle function.

Importance of STEAM education

Teaching strategies, which are new and innovative, are always introduced for the improvement of the quality of education (Tirath, 2017). One such innovative teaching strategy is the integration of multiple disciplines in a single classroom. According to Maresca (2022), it doubles the chances that students will be engaged in a class when subjects are taught in an integrated or combined manner. STEM is very useful in child skills and knowledge with practical understanding (Bahrum et al., 2017). Children are more engaged and have more fun learning when they are exposed to the arts, it increases their creativity. The value of STEAM education is undeniable as a means of developing basic skills and competencies of young students, improving the learning process, developing communication skills, and solving real-life difficulties (Chaldi & Mantzanido, 2021). According to Valazquez & Rivas (2020), STEAM education offers opportunities for interdisciplinary learning, fostering creativity, critical thinking, and problem-solving skills across multiple disciplines. Integrating STEAM concepts into education can enhance students' understanding of complex real-world issues and their ability to develop innovative solutions. Advances in technology provide new

opportunities for delivering STEAM education, including online platforms, virtual laboratories, and educational apps. Digital resources can help overcome barriers related to access and affordability, expanding the reach of STEAM education can make the education scenario more cheap and accessible.

How Hands-On Activities Align with STEAM?

STEAM (Science, Technology, Engineering, Arts, and Mathematics) education inherently supports hands-on approaches by integrating multiple disciplines into meaningful, project-based experiences. According to Gu et al. (2023), STEAM activities that involve creative problem-solving across disciplines are especially effective in developing students' creative self-efficacy and higher-order thinking skills. Hands-on activities are the practical medium through which STEAM principles come alive. Alignment with examples is given

1. Science Through Experimentation: Hands-on activities offer students direct engagement with scientific phenomena, encouraging inquiry-based learning. Through experiments like growing plants under different light conditions, building simple circuits, or testing chemical reactions, students explore cause-effect relationships and apply the scientific method. These activities promote observation, data collection, and reasoning skills, making science more tangible and relevant. For instance, investigating plant growth across varied environments integrates biology, environmental science, and data analysis (Beers, 2011).

2. Technology Through Thinking: Hands-on activities serve as a powerful medium to bring the "Technology" component of STEAM education to life. When learners physically interact with tools—such as coding robots, using tablets for 3D design, or building circuits—they experience technology in action rather than theory. For example, creating a digital thermometer using a Microbit allows students to apply coding and electronics in a real-world context, reinforcing concepts from both science and technology. Such tactile engagement deepens understanding, promotes problem-solving, and connects technology with other STEAM disciplines, making learning more integrated and experiential.

3. Engineering Through Designing and Building: Engineering comes alive when students engage in the iterative process of designing, building, testing, and improving structures or systems. Activities like constructing popsicle stick bridges, designing water filtration devices, or building earthquake-resistant towers require applying knowledge of physics, materials, and design principles. These projects nurture creativity, analytical thinking, and resilience, aligning engineering education with real-world challenges (Sanders, 2009).

4. Art Through Creative Expression: Art in STEAM fosters visual literacy, creativity, and emotional expression. Hands-on artistic activities—such as drawing, sculpting, or digital storytelling—help students represent their learning in deeply personal and imaginative ways. Creating a stop-motion video to explain Newton's Laws or building a model to depict the water cycle integrates artistic expression with scientific understanding, demonstrating how art enhances meaning-making across disciplines (Wynn & Harris, 2012).

5. Mathematics Through Manipulatives: Hands-on manipulatives make abstract mathematical ideas concrete. Using fraction tiles, measuring tools, pattern blocks, or digital simulations helps students visualize and physically engage with mathematical concepts. For instance, exploring symmetry through tessellations or calculating area using unit squares helps learners develop spatial reasoning and mathematical fluency through sensory experience (Carbonneau, Marley, & Selig, 2013).

Hong et al. (2020) emphasized that inquiry-based and hands-on learning models are essential in implementing effective STEAM lesson planning, especially for early childhood education.

5. Importance of Integration: Hands-on STEAM Activities

The integration of hands-on methods within STEAM education presents several opportunities. Creativity flourishes when students engage in interdisciplinary, hands-on projects. Creativity training embedded in STEAM improves not only innovative thinking but also self-confidence in problem-solving (Gu et al., 2023). STEAM-based hands-on activities simulate professional tasks, helping students develop vocational and 21st-century skills like collaboration, decision-making, and adaptability (Hong et al., 2020). Hands-on modeling has shown particular benefits for girls in science education, helping close gender gaps by

increasing confidence and engagement (Mierdel & Bogner, 2019). Engaging children in STEAM-based hands-on learning from kindergarten fosters curiosity and scientific attitudes from a young age (Hong et al., 2020). Through the arts, students can connect emotionally with content. This integration not only deepens subject knowledge but also prepares students for interdisciplinary thinking — a critical skill for modern life and work.

6. Challenges in Implementation

Despite their benefits, hands-on STEAM approaches face several challenges. Many schools struggle with limited lab equipment, creative materials, or digital tools needed for effective hands-on instruction (Tindan & Anaba, 2024). Teachers often lack training or confidence in designing interdisciplinary, student-led lessons. Professional development is essential to overcome this barrier (Gu et al., 2023). Hands-on activities are time-intensive and may be difficult to integrate within rigid curricula or exam-focused systems (Priya & Rinki, 2021). Traditional exams rarely measure experiential learning outcomes like creativity, collaboration, or practical problem-solving, which discourages their use in classrooms (Tindan & Anaba, 2024). Educators and institutions accustomed to traditional lecture-based methods may resist transitioning to student-centered hands-on learning (Duzenli-Gokalp & Sharma, 2010).

Conclusion

Hands-on learning and STEAM education are not separate strategies; they are interdependent. The tactile, experiential nature of hands-on activities brings STEAM to life, making learning meaningful, engaging, memorable, and motivational. By bridging theory and practice, hands-on STEAM experiences empower learners to become thinkers, creators, and doers, shaping the future with both their minds and their hands. It is a challenge for Teachers to implement this in the classroom as it requires proper teacher training, sufficient time, and adequate resources. Hands-on learning and STEAM education are not isolated pedagogical strategies but are inherently interwoven. The tactile, active, and experiential nature of hands-on activities animates the abstract concepts embedded within STEAM disciplines, leading to more engaging and lasting educational outcomes. By blending theory with practice, such approaches cultivate learners who are inquisitive, collaborative, and capable of creative problem-solving. However, successful implementation depends on overcoming systemic barriers, including rigid curricula, limited resources, and insufficient teacher preparation. Addressing these issues requires institutional support, targeted teacher training programs, and curriculum reform aligned with experiential, interdisciplinary teaching. In conclusion, hands-on STEAM education holds transformative potential for preparing students to thrive in a rapidly evolving, complex world. It fosters not just academic proficiency but also the essential life skills of innovation, empathy, and adaptability. Future educational reforms must prioritize such integrative approaches to realize the full scope of learning envisioned by frameworks like NEP 2020 and the Sustainable Development Goals.

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