Journal of Social & Organizational Matters

Vol 5 No 1 (2026): 259-274

Inclusive STEAM Education for Sustainable Development: Bridging Equity Gaps through SDG-Aligned Pedagogies

Lubna Oad[1], Neelofar Shaikh[2], Muhammad Imran*[3]

[1]Assistant Professor, Department of Education, Benazir Bhutto Shaheed University Lyari Karachi,Sindh, Pakistan.

[2]Assistant Professor, College Education Department, Government of Sindh, Pakistan.

[3*]Department of Education, Al-Ghazali University, Karachi, Pakistan.

Corresponding author: imran.g5830@gmail.com

Keywords: *Inclusive STEAM Education, Sustainable Development Goals, Educational Equity, Sustainable Learning, Inclusive Pedagogy, Education for Sustainability*

DOI No:
https://doi.org/10.56976/jsom.v5i1.397

The present study explains how inclusive STEAM education founded on the Sustainable Development Goals (SDGs) may help to reduce equity gaps and support sustainable learning. A qualitative research design was adopted through the adoption of an interpretive approach. The researchers employed the semi-structured interview of educators and school leaders who worked with the curriculum based on STEAM and implemented it in their schools. The data was analyzed through thematic analysis to establish important patterns within the context of inclusion, pedagogy, and sustainability. The results indicate that inclusive STEAM education improves equal participation and engagement of learners alongside relevance through collaboration, creativity, and solving real-life problems. The relevance to SDG-oriented themes enhanced sustainability awareness and skills in the learners. The barriers to successful implementation were noted to be the issues of limited resources and teacher preparation as well as the institutional backup support. Study fulfill the gap in the literature by incorporating inclusion, STEAM education, and the SDGs into a single pedagogical model to provide insights into the work of educators, policymakers, and organisations interested in promoting equitable and sustainable education.

1. Introduction

There is a general consensus that education is also among the most important sources of sustainable development and social change (Chohan & Haq, 2025). Since the intricate global problems are well documented, climate change, technology disruption, inequality, economic uncertainty, etc, education systems are feeling the need to be able to provide interdisciplinary expertise, critical thinking, creativity, and problem solving to learners in response (Shoukat, et al., 2025; Abuhassna & Ting, 2025). In that case, STEAM learning or the combination of Science, Technology, Engineering, Arts and Mathematics has turned out to be an remarkable pedagogic model that promotes innovation, creativity and addresses the real world issues (Qazi, et al., 2025; Yakman and Lee, 2012). Having a combination of technical and artistic and creative perspectives, STEAM education offers an all-inclusive approach to making the students answer sustainability challenges.

The applicability of STEAM education is directly related to the United Nations Sustainable Development Goals (SDGs) and, specifically, SDG-4 Quality Education that revolves around the opportunities and access to inclusive and equitable education and lifelong learning (Malik et al., 2025). The SDG-4 is enabled by the STEAM education in terms of interaction between learners, interdisciplinary studies, and critical thinking. Alongside it, STEAM applies to SDG-9 (Industry, Innovation and Infrastructure) and SDG-13 (Climate Action) in the establishment of the capacity of innovation and scientific literacy that is needed to continue the technological advancement (Abuhassna et al., 2025; UNESCO, 2017). Nevertheless, the potential of STEAM education exists in enormous measures, even though it is not distributed equally. Inequalities in equity, which continue to occur persistently based on gender, socioeconomic status, disability, place of location, and access to resources, are also observed to be a problem in the area of STEAM learning (Tripon, 2025; Marginson et al., 2013). These inequalities undermine the transformational project of STEAM education, and they contradict the non-discriminatory objective of the SDGs, in particular, SDG-5 (Gender Equality) and SDG-10 (Reduced Inequalities).

Inclusive education attempts to address these inequities by offering a meaningful access to good learning opportunities to every learner regardless of his or her backgrounds and abilities (Ainscow, 2015). When applied to STEAM education, inclusion would imply pedagogical practices that consider learner diversity and address structural limits as well as promote asking and inclusion. Inclusive STEAM education does not therefore only focus on access but also encompasses the instructional methods, the curriculum, the evaluation and the learning environment that values diversity and social justice (Pham & Håkansson, 2025; Bybee, 2013). The inclusion of SDG-aligned pedagogies in STEAM learning is one of the possible paths to the minimization of equity difference in sustainable learning. SDG-oriented pedagogies are concerned with situational learning, real-life problem-solving (Shaikh, 2024; Shaikh, 2025), cooperative learning as well as ethical responsibility (UNESCO, 2017). Once these principles of education have been added to the STEAM education, they can support sustainability skills and inclusive education. As an example, STEAM projects which address locally-specific environmental or societal issues may be crafted to become more local, involve learners and be more inclusive, particularly to marginalized learners (Pareek & Pandey, 2025).

Even though inclusion, the STEAM pedagogy, and sustainable development increasingly have empirical and conceptual interrelations, a significant part of empirical and conceptual work has not yet combined these three dimensions of policy and academic interest in STEAM education and the SDGs (Chohan & Haq, 2025; Qazi, et al., 2025; Malik et al., 2025). The programs most of the STEAM programs are leaning more towards innovation and workforce preparedness issues but have not addressed the aspect of equity and inclusion. As a result, instead of promoting sustainable and inclusive development, STEAM education will be a source of an ongoing inequality perpetuation. Reviewing the existing literature indicates that a few important gaps exist that justify the present-day research (Sayadi & Pangandaman, 2025). First, despite having been popularized as being a way to attain innovativeness and competencies of the 21 st century, most of the research covers only cognitive achievement and economic achievement, yet not equity and inclusion (Perales & Aróstegui, 2024; Jamali et al., 2023; Yakman & Lee, 2012; Bybee, 2013). Scarcity of research to investigate ways in which STEAM pedagogies can be proactively employed to reduce educational differences exists.

Second, the STEAM education directly related to the SDGs is quite new and conceptualized, in general. Although policy documents emphasize the significant role of education in the sustainable development process, the systematic literature leaves a gap that demonstrates the execution of SDG-congruent pedagogies in inclusive STEAM classes (Chansaengsee, 2024; Aguayo, et al., 2023; UNESCO, 2017). The lack of this prevents the amount of knowledge about how the goals of global sustainability can be translated into the daily teaching and learning processes (Rafiq, Malik & Bano, 2025). Third, inclusion and sustainability are frequently addressed as two separate goals in the existing studies rather than the outputs of the pedagogical practice that are mutually dependent (Pham & Håkansson, 2025). The use of inclusive STEAM education as a means to support equitable participation and sustainability competencies have received insufficient research, including in diverse and under-resourced settings (Namdev & Prajapati, 2024). It is especially applicable to developing countries where the problem of educational inequalities and sustainability is a more noticeable one (Kang et al., 2025).

Finally, one of the gaps that can be identified in the literature in the area of methodology is the absence of the use of combined models that will conceptualize inclusive STEAM education as a path to sustainable development (Nyaaba et al., 2024). Without these frameworks, there will be no clear picture of how educators and policymakers can create and implement STEAM pedagogies that are consistent with SDG-4, SDG-5, and SDG-10. To address these gaps, the current study focuses on inclusive STEAM education and sustainable development and the manner in which sustainable learning can be closed by SDG-oriented pedagogies in establishing the equity gap of sustainable learning. The study has brought additions to the theory, practice, and policy to ensure that the education systems are equitable and sustainable through integrating inclusion, STEAM education and SDGs as a single analytical framework.

1.1 Research Objectives

1. To examine how STEAM inclusive pedagogies are planned and operationalized to achieve sustainable developments in learning institutions.

2. To understand how the SDG-oriented STEAM education can enhance equity and inclusion between different groups of students..
3. To study how perceived contribution to sustainable learning outcomes, such as sustainability awareness, problem-solving skills, and learner engagement, inclusive STEAM education can help**.**

1.2 Research Questions

1. What are the ways inclusive STEAM pedagogies can be congruent with the Sustainable Development Goals being applied in school?
2. What is the solution to equity inequity in gender, socioeconomic status, and student diversity in inclusive STEAM learning?
3. What are the perceptions of educators and learners regarding the effects of inclusive STEAM education on sustainable learning outcomes and competencies regarding sustainable development?

2. Literature Review

2.1 STEAM Education: Concept and Evolution

STEAM learning has come out as a multidisciplinary teaching model that combines Science, Technology, Engineering, Arts, and Mathematics to promote creativeness, innovation, and problem-solving abilities. Contrary to the traditional STEM education, where the focus is mostly on the technical skills, STEAM integrates the arts to facilitate creativity, critical thinking, and human-centered design (Perales & Aróstegui, 2024; Jamali, Ebrahim & Jamali, 2023; Yakman and Lee, 2012). This integration shows a deeper conceptualization of learning as a holistic process, which is an integration of cognitive, creative, and socio-emotional aspects. It is believed based on research that STEAM education fosters the interest and motivation of learners in that they relate abstract ideas to the real world (Daraz et al., 2025; Land, 2013). STEAM teaches interdisciplinary knowledge through project-based and inquiry-driven learning to have learners apply their knowledge in solving real life problems (Chansaengsee, 2024; Aguayo et al., 2023). These properties render STEAM education especially useful when solving complex global problems that demand an integrated solution, e.g. environmental sustainability, technological innovation, and social equity.

2.2 STEAM Education and Sustainable Development

Education has been given a lot of focus in the global policy systems, particularly the United Nations Sustainable Development Goals (SDGs), on how to ensure sustainable development. The SDG-4 (Quality Education) highlights the importance of inclusive, equitable and quality education that means lifelong learning and the other objectives, SDG-9 (Industry, Innovation and Infrastructure) and SDG-13 (Climate Action) also focus on scientific literacy and innovation in relation to sustainability (United Nations, 2015). STEAM education is also directly associated with education suggesting sustainable development (ESD) due to its promotion of the opportunity to think of the system (systems thinking), creativity, and problem-solving (Namdev & Prajapati, 2024; UNESCO, 2017). The studies indicate that STEAM-related learning environment may contribute to the development of the knowledge of learners on the concepts of sustainability since they will engage in the inter-disciplinary projects related

to the environment protection, renewable energy, as well as responsible consumption (Kang, Dehghan & Abu-Aridah,2025; Bybee, 2013). These are the learning experiences that help learners to gain skills to sustainable development including critical thinking, collaboration, and morality thinking. However, despite the fact that STEAM education is reported to be a sustainable initiative, critics find that the implementation of the program is usually based on the economic competitiveness and workforce preparation, but not on the social and environmental responsibility (Nyaaba, Akanzire & Mohammed, 2024; Sterling, 2016). This resistance shows that SDG-based pedagogies are needed, where the concepts of sustainability and ethics are directly presented in STEAM learning.

2.3 Inclusive Education and Equity in STEAM

The idea of inclusive education is based on the premise that all learners, irrespective of his or her gender, socioeconomic status, disability, and cultural disposition, must have equal access to quality education (Ainscow, 2015). With regards to STEAM education, inclusion entails the consideration of structural barriers that prevent inclusion and performance of marginalized individuals. It is recorded that the participation and the achievement in STEAM has been known to have equity disparities. Gender inequality is not fully resolved yet and women and girls are not represented in most sciences and engineering professions (Perales & Aróstegui, 2024; Jamali et al., 2023; Marginson et al., 2013). Social and economic differences also influence the opportunities to access STEAM, higher levels of work, extracurricular activities, etc., especially in under-resourced schools and communities (Rosyida, Prahani & Kurtuluş, 2025; OECD, 2019). Students with a rural or marginalized background and newly disabled ones have a few more issues with access and organization of instructions and the support of the institutions. Inclusive STEAM education is aimed at overcoming these differences through the pedagogical strategy, which acknowledges the differences between learners and makes them collaborate on an inclusive basis. The effective practices that are identified to be applied in promoting inclusiveness in STEAM classrooms are universal design learning, culturally responsive teaching, and collaborative learning strategies (Rose & Meyer, 2002; Gay, 2018). Once the notion of inclusiveness is introduced into the STEAM pedagogy, the learners will be in a better position to feel that they are important, active, and can excel.

2.4 Pedagogical Approaches for Inclusive STEAM Education

Pedagogy also matters in deciding whether STEAM education is an inclusion-based or reproduction-based educational process. Project-based learning (PBL) is commonly considered as a powerful STEAM pedagogy that helps to achieve engagement and inclusion. With PBL, students are able to collaboratively work on projects that have significance and use different strengths and experiences ((Kang et al., 2025; Bell, 2010). Contextually relevant, culturally responsive projects have the ability to increase participation with marginalized learners. Another major strategy of inclusive STEAM learning is inquiry-based learning (Perales & Aróstegui, 2024; Jamali et al., 2023). Inquiry-based pedagogy empowers learners to become self-owners of their learning process and build confidence in their skills by promoting questioning, exploring and experimenting (Namdev & Prajapati, 2024; Hmelo-Silver et al., 2007). These are especially useful to students who might feel marginalized by the conventional teacher-centered learning. The inclusion is further enabled by the integration of arts in STEAM

as it offers a variety of modes of expression and learning (Chansaengsee, 2024; Aguayo, et al., 2023). The arts-based methods enable the learners to approach scientific and mathematical ideas creatively and make learning more available and meaningful (Henriksen, 2014). This can be particularly beneficial to students who are possibly not strong in the formal academic structures.

2.5 SDG-Aligned Pedagogies and Inclusive STEAM Education

SDG-oriented pedagogies focus on the experiences of learning that are relevant, participatory, and problem-solving (UNESCO, 2017). SDG-aligned pedagogies include planning learning experiences that can tackle sustainability issues and facilitate a needless learning process in an inclusive STEAM experience in ways that support social justice and equity (Kang et al., 2025). As an example, STEAM projects aiming at addressing the problems that are local to the area or the social problems will assist in helping the learners relate the global SDGs to the lives they are living (Namdev & Prajapati, 2024). Contextualized learning promotes relevance and engagement especially among the learners in marginalized communities (Nyaaba et al., 2024; Sterling, 2016). Participatory and collaborative pedagogies are also in support of inclusion in that they promote dialogue, collective responsibility and respect. Despite their potential, unequal in the application of SDG-related pedagogies to STEAM is still evident in education. Numerous institutions of education, however, do not have resources, training, or curricular flexibility to effectively incorporate sustainability and inclusion. This has the negative impact of making SDG alignment more of a policy rhetoric than a classroom activity.

2.6 Teachers' Role in Inclusive and Sustainable STEAM Education

Inclusive and sustainable principles of STEAM are highly applicable with the assistance of teachers (Chansaengsee, 2024; Aguayo, et al., 2023). Teacher beliefs, pedagogical knowledge, and professional competencies form significant part of determining the implementation of STEAM education (Rehman, et al., 2025; Darling-Hammond et al., 2017). Making inclusive pedagogy and sustainability education a part of professional improvement is therefore vital to successful execution of STEAM practices (OECD, 2019).Research studies have demonstrated that issues of curriculum overload, pressure in assessment and institutional support exist in the implementation of inclusive STEAM practices (OECD, 2019). Without appropriate training and materials, the teachers will not be in a good position to develop learning experiences that can support inclusion and sustainability goals.

2.7 Policy Perspectives on Inclusive STEAM and the SDGs

On the policy level, the international organizations underline the significance of the integration of the STEAM education and sustainable development and inclusion. UNESCO (2017) focuses on the significance of interdisciplinary education to achieve the SDGs, and OECD (2019) expects the science education to be equity-oriented (Kang et al., 2025). Implementation of policies is varied in various circumstances and policy dreams and classroom realities do not necessarily accompany each other.

2.8 Synthesis and Research Gap

The literature review shows that STEAM education has great potential, which can be applied to the sustainable development process and the encouragement of inclusive learning. However, several gaps remain (Nyaaba et al., 2024). To begin with, STEAM education, inclusion, and sustainability are frequently regarded as individual research fields, to which little or none of the research is integrated into a comprehensive pedagogical approach. Second, there is limited empirical research on the operation of inclusive STEAM pedagogies based on how they are being implemented in accordance to the SDGs (Namdev & Prajapati, 2024). Third, the existing context-specific research lacks a developing and under-resourced context, where inequity disparities and sustainability issues are most pronounced. These gaps are filled in the current paper, which will discuss inclusive STEAM education as a sustainable institution of development grounded on SDG-aligned pedagogies, as a tool of overcoming the inequity divide in sustainable learning (Perales & Aróstegui, 2024; Jamali et al., 2023). Through a combination of STEAM education, inclusion, and SDGs as part of one analytical framework, the study can contribute to theory, practice, and policy with the goal of developing equitable and sustainable education systems.

3. Methodology

The research design used in this study was qualitative research design in order to investigate the role of inclusive STEAM education in the achievement of the Sustainable Development Goals in mitigating equity disparities in sustainable learning. A qualitative design was deemed to be suitable since the research aimed to include the views, experiences, and pedagogical practices of educators in terms of inclusion, STEAM practice, and sustainability, which are arts-based and socially constructed that are context-dependent. The interpretive paradigm informed the research; as a result, it was possible to develop a comprehensive perception of the meanings that the participants give to inclusive and SDG-aligned STEAM pedagogies. The research was carried out in the selected secondary and higher institutions of education with STEAM-related practices. The participants of the study included STEAM teachers, curriculum development heads, and school administrators who participated in the planning or delivery of STEAM. The purposive sampling method was used to take participants with a direct experience in the teaching of STEAM and inclusive practices. Others had to possess a minimum of three years teaching or leadership experience in STeAM related areas. The saturation of data occurred upon the interviewing of about 15 interviewees.

Semi-structured interviews were used to collect data, and this gave the participants a chance to explain their experiences, as well as to guarantee that they remained within the objectives of the research. The interview guide consisted of the inclusive STEAM pedagogies, equity issues, and alignment towards the SDGs and the perceived effects on sustainable learning. The interviews were made in person or through the internet and the duration of the interviews was between 30 and 45 minutes which was audio-recorded by the consent of the participants. All the interviews were transcribed literally before analysis. Thematic analysis was applied to analyze the data according to the systematic approach proposed by Braun and Clarke that implies familiarization, coding, development, and interpretation of themes. Member checking was applied to check the interpretations of the research in an attempt to increase

trustworthiness, and reflexive notes were kept to reduce researcher bias. Informed consent, confidentiality, anonymity and voluntary participation were also provided and ethical approval was obtained before data collection.

4. Findings

Thematic analysis of the interview data led to the emergence of five themes that are interconnected and explain how an inclusive STEAM education as it is scaffolded by the Sustainable Development Goals (SDGs) can help address equity gaps and promote sustainable learning. These themes refer to lived experiences of participants, pedagogical practice, and views of inclusion, sustainability, and engagement of learners.

Theme 1: Inclusive STEAM as a Pathway for Equal Participation and Access

Respondents always referred to inclusive STEAM education as the way of increasing access and engagement of students of different backgrounds. The educators pointed out that STEAM activities enabled students of varying abilities, learning styles, and social economic status to participate constructively in learning.

One teacher stated:

"STEAM provides all students with an opportunity to make a contribution. There are those students who might not be good in theory, yet are good in designing, building or presenting ideas." (T3)

School leaders highlighted that inclusive STEAM practices helped reduce participation gaps, particularly for girls and marginalized learners:

"We observed that when project-based and creative learning takes place, more girls and quiet students are involved." (L2)

This topic is relevant in that inclusive STEAM education is proposed as a practical approach to the achievement of equity gaps in learning opportunities.

Theme 2: SDG-Aligned STEAM Pedagogies Enhancing Relevance and Engagement

The respondents reported that the relevance and involvement of learners was greater in case STEAM projects were correlated with real-life sustainability issues. According to the teachers, STEAM activities associated with the SDGs, such as climate action, clean energy, and sustainable communities were valuable to learn.

A teacher explained:

"Students feel responsible and inspired to learn when they are working on the projects concerning environmental issues within the community that they live in." (T6)

Another participant added:

"Learning about STEAM based on SDGs enables students to learn why learning is important to them outside the exams." (T1)

The theme shows that STEAM pedagogies that are in accordance with SDG enhance the engagement of learners by linking the academic curriculum to global and local sustainability issues.

Theme 3: Collaborative and Creative Learning Supporting Inclusion

Cooperation and innovation became the leading attributes of inclusive STEAM education. The participants mentioned group-based projects and integration of arts as some of the enablers of inclusive participation where learners could make contributions in a variety of ways.

One teacher noted:

"Steam projects undertaken by groups enable students to learn with one another. Each individual will contribute something different." (T8)

Another teacher highlighted the role of creativity:

"Students who normally feel excluded feel confident when art and creativity is incorporated in STEAM.." (T5)

This theme is an example of how collaborative and creative pedagogies can help learners to create productive learning environments and to respect each other.

Theme 4: Inclusive STEAM Developing Sustainability Competencies

The participants also found inclusive STEAM education to build competencies of sustainable development, such as problem-solving, critical thinking, collaboration, and ethical awareness to be instrumental.

A school leader shared:

"STEAM projects can make the students think critically in reference to real problems and obtain a long-term solution." (L4)

Another place of growth was sustainability awareness of learners which was noted by teachers:

"Students start thinking about how their actions affect the environment and society." (T9)

This theme can be seen as highlighting how inclusive STEAM education can equip learners to live sustainable lives with skills and values required.

Theme 5: Challenges in Implementing Inclusive and SDG-Aligned STEAM

In spite of the advantages, the participants cited issues related to eschewing SDG-oriented and inclusive STEAM education. These involved lack of resources, lack of teacher training, time, and fixed curriculums.

One teacher remarked:

"We would like to establish inclusive STEAM, yet we are not able to do it due to the lack of resources and training." (T2)

A leader added:

"It is not easily maintained due to the absence of the support of the STEAM initiatives at the levels of policy and professional development.." (L1)

This is a significant theme as it implies the need to maintain the system as a whole to bring about sustainability and efficiency of inclusive STEAM practices.

Overall, the findings show that inclusive STEAM education that is aligned with the SDGs plays a significant part in eliminating the equity gap and sustainable learning. The primary strengths were found to include inclusion, SDG alignment relevance, collaborative creativity, and sustainability competencies, and structural and capacity related barriers are viewed as the hindrances to effective implementation.

4.1 Discussion

The purpose of this research was to debate the importance of working with inclusive STEAM education in accordance with the Sustainable Development Goals in equity gap bridging and sustainable learning (Abuhassna, Qi & Ting, 2025). The findings indicate that inclusive and SDG-related STEAM pedagogies are a powerful approach to teaching and learning that can be employed to develop equity, interest in learning, and sustainability skills simultaneously (Nyaaba, Akanzire & Mohammed, 2024). Tripon (2025) stated that inclusive STEAM education transcends the technical portion of skill building, to the greater social and development goals, through the combination of creativity, teamwork, and problem solving in the real world (Pham & Håkansson, 2025). The findings indicate that in an inclusive STEAM education, equal participation is enhanced by means of provision of diverse access to education (Namdev & Prajapati, 2024). This assists in proving the argument of inclusive education theory that emphasizes the notion that the meaningful inclusion cannot be achieved solely by access; rather, it concerns the practice of pedagogy that would help to support the learner diversity ((Daraz, Ahmad, Hussain & Ali, 2025; Ainscow, 2015). Similar to the current literature, arts, design and cooperative problem solving as a whole enabled the students of different abilities and background to participate in the learning processes actively (Pham & Håkansson, 2025; Henriksen, 2014; Land, 2013). This once again confirms the notion that STEAM education could be applied in an inclusive manner, to cut across traditional hierarchies of academic ability that are more favorable to certain groups of learners, as opposed to others.

As a cumbersome result of the high concentration on SDG-oriented pedagogies, the contextualization and relevance of sustainable learning is highlighted (Shoukat et al., 2025). According to the respondents, the extent of engagement by learners was high when STEAM projects were implemented in the real-life sustainability problems such as conserving the environment and building communities (Perales & Aróstegui, 2024; Jamali et al., 2023). This finding aligns with the education of sustainable development literature that highlights the fact that learning must be contextual, participatory and problem-oriented to foster sustainability competencies (Rosyida et al., 2025; UNESCO, 2017; Sterling, 2016). The inclusion in STEAM education made learning to perceive the social significance of learning, which allowed SDG-4 to prioritize education through quality and relevance. Inclusion was also introduced to STEAM classrooms as a part of teamwork and innovation (Chansaengsee, 2024; Aguayo, et al., 2023). This finding is consistent with the other researchers who suggest that project-based and inquiry-based learning environments promote collective responsibility, learning among peers, and respect (Pareek & Pandey, 2025; Bell, 2010; Hmelo-Silver et al., 2007). The inclusion through inclusion of arts in STEAM also enhanced inclusion through the justification of the multiple ways of expressing and building knowledge (Nyaaba et al., 2024). The SDG-10 (Reduced Inequalities) agenda has especially found these strategies to be applicable due to their lack of

orientation of the narrow conceptualization of academic success and recognition of various strengths of learners (Kang et al., 2025).

Inclusive STEAM education is also discovered to facilitate the sustainability competencies of critical thinking, collaboration, ethical awareness, and problem solving (Sayadi & Pangandaman, 2025). This is not isolated as it is found in the literature that interdisciplinary learning systems are desirable in the formation of competencies that are required to solve complex sustainability issues (Bybee, 2013; UNESCO, 2017). The study expands this body of literature by demonstrating that sustainability competencies are most effectively obtained when the STEAM pedagogies are strategically inclusive, thereby being in a position to ensure that not only learners with the highest performance or advantages are benefited through sustainability-oriented education, but everyone is. Despite these strengths, the study determined that there were significant challenges in matters relating to resource availability, teacher preparedness and policy encouragement (Namdev & Prajapati, 2024). These data are in line with the literature that determined structural barriers to inclusive and sustainable alternatives of the application of STEAM in particular under-resourced contexts (Rehman et al., 2025; OECD, 2019; Darling-Hammond et al., 2017). Without adequate professional development and institutional encouragement, the educators may fail to develop and sustain inclusive and SDG oriented STEAM practices. This presents the need of systematic alignment of curriculum, teacher training and education policy to have the promise of STEAM education fulfil its inclusive and sustainability-based promise come to pass (Sayadi & Pangandaman, 2025).

Overall, the findings can be generalized to the scientific literature related to STEAM education since it offers objective data on how inclusion and sustainability can be integrated into one pedagogical strategy (Kang et al., 2025). The paper goes more than treating STEAM as an innovative tool/workforce development tool and introduces it as the groundbreaking method of equity and sustainable development (Perales & Aróstegui, 2024; Jamali et al., 2023). It is possible to consider the study as the provision of evidence that inclusive STEAM education can be considered a strategic method to achieve global developmental objectives because it directly links it to SDG-4 (Quality Education), SDG-5 (Gender Equality), and SDG-10 (Reduced Inequalities). On the whole, the article is an important addition to the overall research of inclusive STEAM education since it is the description of the pedagogical situation when it is possible to apply STEAM to promote equity and sustainability (Namdev & Prajapati, 2024). These findings suggest the inclusion, SDG-based STEAM pedagogies can potentially transform the culture of learning, empower marginalized learners and enable all students to become relevant in the sustainable future.

5. Conclusion

This study has discussed the role of inclusive STEAM education that can be met by considering the Sustainable Development Goals in closing equity gaps and creating sustainable learning. The results prove that inclusive, SDG-oriented STEAM pedagogies offer valuable learning experience to diverse learners through facilitated participation, creativity, collaboration, problem solving in the real world. Through the multidisciplinary approach to learning science, technology, engineering, arts, and mathematics in inclusive and contextually

applicable learning communities, STEAM education can be considered an effective way of promoting the equity and sustainability of education. The paper points out that inclusive STEAM education is helpful in the attainment of SDG-4 (Quality Education) as it makes learning interesting, relevant and available to all learners. Meanwhile, it is relevant to SDG-5 (Gender Equality) and SDG-10 (Reduced Inequalities) since it helps to tackle structural and pedagogical obstacles that restrict engagement of marginalized populations. Most notably, the findings show that the sustainability competencies, such as critical thinking, collaboration, ethical awareness, and problem-solving can be taught most effectively when the STEAM education will be modeled in a manner that will be specifically focused on being inclusive. However, the paper also reveals certain long-term problems in regards to the lack of resources, poor preparation of the teachers, and institutional and policy backing. These issues imply that the transformative potential of inclusive STEAM education cannot be achieved simply in terms of classroom practice but instead needs a systematic alignment of that practice with curriculum, teacher education, and policy of education. In general, the research is significant to the existing body of literature by making inclusive STEAM education one of the strategic paths to sustainable development due to equitable and valuable learning.

5.1 Recommendations

1. The teachers are expected to embrace the trend of inclusive learning like project-based learning, teaching in a group and integrating arts with the aim of accommodating various learning abilities among the learners and offer them equal opportunities in learning STEAM.
2. Curriculum developers should intentionally introduce SDG themes in STEAM learning exercises in the hope that learners can apply academic content to social issues and real life challenges of sustainability.
3. Teacher-focused and specific development programs should be created to provide teachers with the necessary pedagogical skills and sustainability knowledge of how to introduce inclusive and SDG-based STEAM education.
4. Government departments and schools need to invest resources, provide infrastructural assistance and develop flexible models of curricular models that will facilitate the realization of inclusive STEAM programs in the long-run.
5. In order to make equity and sustainability one of the priorities of educative reform activities, inclusive STEAM education needs to be given a specific place in the education policies as one of the tools of SDG-4, SDG-5 and SDG-10 achievement.
6. It is upon this that education systems will be in a place to amplify the contribution of the inclusive STEAM education towards sustainable development, social equity and meaningful learning by all learners.

5.2 Limitations and Future Research

Though this study has its contributions, there are a number of limitations associated with the research. To begin with, the research design was qualitative and the sample size used in this study was quite small and therefore the research results cannot be generalized. Although the qualitative method offered deep and comprehensive information on the experience of educators on inclusive and SDG-based STEAM education, the findings might not be applicable

to other educational settings and areas. Future research may utilize larger sample and/or quantitative designs to increase generalizability. Second, the research was based on self-report information on teachers and school principals, and as such, it can fall prey to social desirability bias. The participants might have highlighted the positive practices or underreported the difficulties connected to the implementation of inclusive STEAM. In the future, triangulation of data sources can be used, including classroom observations, document analysis, or the student perspective to obtain further information.

Third, the authors identified majorly the perceptions of educators of inclusive STEAM education, and not the actual learning outcomes of students. Although participants indicated that they have been positively influenced in the engagement and sustainability competencies, there is limited empirical data on how learners perform in their academic performance, their attitudes, and behaviors of sustainability in the long-term. The direct effect of inclusive STEAM pedagogies on student outcomes should be studied in future research in longitudinal or mixed-method studies. Moreover, the contextual factors which affected the two-year outcomes like school leadership, policy environments, or resources availability were not explored in detail during the study. Future research might explore the role of institutional and policy-level moderators and mediators of the effectiveness of inclusive and SDG-oriented STEAM education, especially in under-resourced environments. Lastly, it is recommended that future studies should try to involve comparative and cross-cultural research to determine the contribution of inclusive STEAM education to sustainable development in various educational systems. Such a type of researches would be beneficial in studying the context-based issues and best practices, which will even contribute to the worldwide applicability of inclusive STEAM education in the achievement of the Sustainable Development Goals.

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