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Needs of STEAM Education in Elementary Classes (Grades 6–8) in Pakistan: A Systematic Review (2023-2025)

Muhammad Rafiq-uz-Zaman

[1]*Doctor of Education, Department of Education, The Islamia University of Bahawalpur, Punjab, Pakistan,* *mrzmuslah@gmail.com*,

*Correspondence author: mrzmuslah@gmail.com

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Abstract

Pakistan elementary education needs Grade 6-8 to be important in cultivating STEAM (Science, Technology, Engineering, Arts, Mathematics) ability. Nonetheless, there are system-wide issues like inapt teacher training, curriculum that does not align well with STEAM, lack of resources, and weak enforcement of policy, that prevent serious immediate integration of STEAM courses. This systematic review will seek to find evidence-based interventions to enhance STEAM education in these grades in the Pakistani education setting. In accordance with the PRISMA 2020 standards, searches in Scopus, Web of Science, ERIC and Google Scholar were performed in the period between March and August 2025 in order to find peer-reviewed articles that published after 2023-2025. Syntheses at the regional and global levels were also taken into account (2013-2023). The keywords used included Pakistan, Grades 6-8, and STEAM/STEM and were combined with the keywords that included curriculum, professional development, assessment, and policy. Among 345 records found, 28 articles were reviewed in their full-text, which resulted in the selection of 18 primary studies and 15 contextual sources (n=33). Quality assessment was done using the Mixed Methods Appraisal Tool (MMAT) and Critical Appraisal Skills Program (CASP). Ten major themes were identified, such as alignment of curriculum with national standards, practice-based teacher development, inquiry-based pedagogy, computational thinking, inclusive design and career awareness related to math self-efficacy. Blending of genuine arts and economical technology infrastructure was addressed as a key to the success. The effective implementation of STEAM must be multilevel, that is, it has to be coordinated through policy interventions at the curriculum level in terms of curriculum guides, teacher training, equitable provision of resources, and career awareness programs. To achieve equal results, it is necessary to use the principles of Universal Design to Learning and digital competence development pathways. The analysis was limited by scarcity of Pakistan-specific studies and language as well as heterogeneity among studies made meta-analysis impossible. Successful STEAM learning in Grades 6-8 in Pakistan needs interventions on the curriculum, pedagogy, professional development, assessment, and policy, which are comprehensive and coordinated. It is possible that there is a possibility of successful integration, but further specific research on Pakistan is required.

INTRODUCTION

STEAM education incorporates science, technology, engineering, arts and mathematics into real world learning to bring out creativity, critical and problem-solving. International syntheses indicate that STEAM rapidly develops and predominantly uses qualitative classroom designs, but needs further field unification and better focus on the methods (Orynbassarova, 2025). In classrooms, recent experiences in science represent student-centered STEAM in ways that lead to the development of twenty-first century competencies, boding the necessity to tie classroom operation to solid pedagogies (Yulianti et al., 2024).

Middle grades (6-8) are the same in Pakistan: at this stage, identity, academic dispositions, and career interests are developed, and local research shows that specific interventions can enhance the use of technology, independence, and intrinsic motivation in students, but the lack of resources and teacher preparation is an unresolved issue (Hashmi et al., 2024). On a national level, the 202223 curriculum changes in STEAM in Pakistan transition to some flexibility and interest in secondary physics instruction, although questions about these systematic patterns in the organization of curriculum raise issues about the necessity of hardening of the curricular scaffold along the line up to the inclusion of necessity of Grades 6 through 8 (khan & Choudhary, 25).

With the world even moving further into the 21 century, education systems all around the world are changing accordingly to match the needs of a fast changing, technology-oriented society. The recent years have witnessed one of the biggest movements in educational fields, with STEM (Science, Technology, Engineering, and Mathematics) being transformed into STEAM, including the Arts as a key subject matter. This integration does not simply consist of the inclusion of art ventures into science courses; it is a complete overhaul of pedagogy in favor of a more holistic, inquiry based and human centered approach to learning. The incorporation of arts is meant to build the creativity, critical thinking and innovation skills which is deemed to be very crucial in the future workforce. The literature review will trace the international vision of the demands of STEAM education (especially the elementary and middle school classes, grades 6-8), and reflect on the reflections on the educational situation in Pakistan.

1.The Rise of STEAM Education in the World

The shift in STEM to STEAM is a topic of wide debate in the academic circles. The early agitation behind STEM education was based on an economic competitiveness issue, and a perceived lack of skilled employees in the sciences and technology. Nevertheless, educators and researchers started to claim that only technical orientation could not help produce an all-rounded individual who can solve innovative problems. The A in STEAM, which means arts, is also very broadly understood to incorporate not just the visual arts and music but also language arts, social studies and humanities. This is the integration, which is supposed to make the learning environment more inclusive and

accessible, in which the students will be able to bridge the gap between their technical and humanistic knowledge. The arts offer students an avenue to formulate multifaceted issues in differing ways, express their ideas creatively and eloquently and reflect on the ethical and social consequences of technological progress. This practice is spreading across the globe; as numerous nations consider STEAM as a method of equipping the students with the challenges of the 21st century.

A more diverse and inclusive learning environment is one of the most important reasons that can be brought up in support of STEAM education. Through the inclusion of the arts, STEAM is able to attract a larger group of students, including those who do not necessarily consider themselves STEM-minded. It is especially important in making girls and underrepresented minorities interested in STEM. The study of the effect of STEAM education integration has revealed that the arts tend to be less important than the other fields, but their integration can make the subjects of STEM more appealing and easier to approach (Sanz-Camarero et al., 2023). Moreover, the arts togetherness can be utilized to dissolve the traditional boundaries between the disciplines so that students are able to discern the links between the various fields of knowledge.

2. The Impact of STEAM on Student Learning and Skill Development

An emerging amount of literature indicates that a combined STEAM solution could contribute to student learning and skill acquisition in a significant positive way. Those who support STEAM believe that it does not rely on memorization and motivates students to participate in project-based learning. The approach is thought to develop a set of so-called 21st -century skills, such as critical thinking, creativity, collaboration, and communication. A methodical review of STEAM in early childhood education revealed that experiential learning in sustainability-related environment was an existing technique, but it also emphasized the necessity to be much more explicit in the teaching of STEM/STEAM knowledge and skills (Rodrigues-Silva and Alsina, 2023). Although the present research was conducted among younger children, the concepts of experiential and interdisciplinary learning can be applied to the middle school learners as well.

The situation with middle school (6-8) is that students are at a very decisive point of their lives as they start to define themselves and make decisions regarding their future academic and career possibilities. A properly constructed STEAM curriculum can offer them a chance to pursue their interests, their talents and make them realize the applicability of their education to the real world. To use the example of the designing of a sustainable city, it might consider applying the ideas of science (ecology, energy), technology (3D modeling, data analysis), engineering (structural design, urban planning), arts (architectural design, public art), and math (budgeting, geometric calculations). These projects do not only render the learning process more interesting, but also enable students to gain a better grasp of more complex real life issues.

STEAM education is also becoming more popular with the use of new technologies, e.g., virtual reality (VR). Although the current research was on higher

education, the results might indicate that immersive technologies can also become an effective solution that enables middle school students to undergo the STEAM process and enable them to visualize their complex concepts and perform virtual experiments.

3. Challenges and Considerations for Implementing STEAM Education

Although there is an increased interest in STEAM, it also has its flaws in implementation. Among the most significant challenges, there is the necessity to have well-trained teachers who are not afraid of interdisciplinary teaching and project-based learning. There is a large number of teachers who are trained in only one subject, and he/she might not be well versed or have the confidence to incorporate other subjects in his/her teaching. Thus, a successful implementation of STEAM depends on the development of the professionals. This training is not only required to be technical, but also needs to concentrate on pedagogical methods of promoting creativity, inquiry, and collaboration in the classroom.

The other issue is the creation of a rigorous and coherent STEAM curriculum. The arts integration must be purposeful and not merely an empty add-on to the STEM subjects. One systematic review study on the place of the arts in STEAM proposals reported that artistic content is either meager or absent, and the arts is supportive of the other subjects (Sanz-Camarero et al., 2023). This brings out the importance of more realistic incorporation of the arts, in which they are regarded as a part and parcel of the learning process. This involves a form of planning and coordination of interdisciplinary teachers.

Moreover, STEAM learning may be difficult to evaluate. The classic types of assessment, e.g. standardized tests, might not suffice to capture the complete set of skills that STEAM education is designed to deliver e.g. creativity, collaboration, and problem-solving. Consequently, more inventive assessment plans like portfolios, project-based assessment, and performance tasks are required. There is also the discussion of using AI tools, such as ChatGPT, as a writing assistant in higher education, and it brings both opportunities and challenges to academic integrity and assessment (Imran and Almusharraf, 2023). Although this study is about higher education, it cites the changing situation with technology and assessment which must be factored in any educational reform.

4. The Pakistani Context and the Need for STEAM Education

The education system in Pakistan is also experiencing a lot of challenges such as access, equity and quality problems. The traditional curriculum is commonly identified with rote learning and the absence of the focus on critical thinking and the ability to find a solution. In that regard, a shift to STEAM approach might also be a revolutionary act of updating the educational system and making students ready to the challenges of the 21 st century. The population in the country is very big and young and investing in their education is vital to further economic and social development of the country.

Inclusion of arts in STEM education may be especially useful in the Pakistani context. The nation has an artistic-cultural background and this may inspire and make students creative. When students are able to relate their learning to their local context and culture, they may have more interest and motivation towards their learning. Also, STEAM would be useful in rectifying some of the gender imbalances in Pakistan education, by making STEM subjects more attractive and accessible to the girls.

Nevertheless, STEAM education in Pakistan would be an activity that would need coordinated efforts of all stakeholder groups, such as policymakers, educators, and community. Significant investment in training of teachers, curriculum and infrastructure would be required. Another thing that would matter would be the creation of a culturally relevant STEAM model that will be adjusted according to country needs and priorities. The systematic review of the literature concerning suggests that the academic sector needs to reconsider and modernize the training of students and teachers, policies, and evaluation systems to meet the demands of novelties (Imran and Almusharraf, 2023). It is important to remember that any educational change, including implementing STEAM, has to be supported by a wider reconsideration of the educational ecosystem.

Attractive gaps in policy deployment, notably in Punjab, have long obstructed transfer of reform into classroom effects, with flaws in oversight, inappropriate resource allocation, and stakeholder involvement, which may similarly be present in STEAM scaling of middle grades without intervention (Ramzan and Rafiq, 2025). This review synthesizes the available information on the requirements of the successful implementation of STEAM in the Pakistani elementary classes (Grades 68) to help in actionable planning.

The trend towards STEAM education in the world is an indication of increased awareness of how people should be approached in a more holistic and interdisciplinary way to learn. Having combined both the STEM and arts subjects, STEAM can develop creativity, critical thinking, and innovation, and equip students with the challenges of the 21 st century. Although the adoption of STEAM has its difficulties especially in areas of teacher training and curriculum development, the perceived outcome to the students is very promising.

In the case of Pakistan, a transformation in the educational system may be triggered by the introduction of a STEAM strategy in elementary and middle schools (grades 6-8). It might contribute to the shift in the education system towards less rote learning and rather inquiry-based and student-centered one. Through developing the creativity and problem solving techniques in its youth, Pakistan can provide them a better chance to be part of the nation development and also to be able to survive in the fast developing world. This will however come at a long term cost and a strategic orientation that suits the country in terms of needs and circumstances. A literature review on the existing information on STEAM education in other countries can present Pakistan with useful information and experiences that can contribute to this significant trip.

4.1 Pakistan's Educational Context and Policy Environment

Current Situation: The education system in Pakistan is burdened with complex problems: the lack of accessibility in rural areas, gender inequalities, poor quality, and online and offline education based on providing memorizing exercises, not critical thinking (Toprak et al., 2023). The people of the country are more than 230 million with nearly 60 percent of its population being below 25 years old, thus requiring the investment in education to develop economically and socially (Iswadi et al., 2025).

Recent Policy Shifts: The STEAM-related aspects of the 2022-2023 curriculum reforms in Pakistan are an indicator of policy knowledge and interest (Martn-Cudero et al., 2024). Nevertheless, this change has revealed serious implementation flaws: vague content structure, lack of scaffold in different grades, the absence of teacher training, and a small number of monitoring systems (Toprak et al., 2023).

Policy-Practice Gap: Research in Punjab reports on the lack of implementing experience among continuous failures related to: (a) insufficiency of monitoring and checking; (b) inadequate usage of resources; (c) poor involvement of stakeholders; and (d) inefficient connection of policy intention and classroom reality (Iswadi et al., 2025). The same trends are observed in other provinces, which implies that there are systemic barriers that are not limited to the capabilities of schools or teachers (Snchez-Martn et al., 2024).

5. Why This Review Is Needed

Past systematic reviews have investigated STEAM on the international and regional LMIC settings, but there is little evidence that summarizes the needs in the specifics of the Grades 6-8 contexts in Pakistan. The proposed review succeeds to do just that by: (1) synthesizing internationally-specific empirical work on Pakistan; (2) including regional findings on South Asia and other LMICs; (3) deriving transferable results to Pakistan policy and practice; and (4) offering precise, evidence-beneficial policy and practice.

METHODS

1. Protocol and Reporting Standards

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2020) and the PRISMA checklist (see Supplementary Appendix A). The review protocol was not prospectively registered with PROSPERO but adhered to rigorous systematic methodology. The review was conducted between March–August 2025.

2. Eligibility Criteria

Table 1: Eligibility Criteria of study.

Criterion	Specification
Population	Elementary students Grades 6–8; teachers; schools in Pakistan. Where Pakistan-specific data is absent, regional LMIC (South/Southeast Asia) and comparator K–12 STEAM research included for contextual application.
Intervention/Focus	STEAM education or equivalent STEM+Arts practice; inquiry-based/project-based learning; computational thinking; technology-enhanced interdisciplinary learning; design thinking.
Outcomes (Primary)	Implementation requirements: curriculum alignment, teacher professional development, pedagogy, assessment, infrastructure, inclusion, policy support.
Outcomes (Secondary)	Student outcomes: knowledge, skills, attitudes, engagement, career interest; Teacher outcomes: confidence, pedagogical skill, job satisfaction.
Study Design	Empirical studies (RCT, quasi-experimental, observational); systematic reviews; meta-analyses; policy analyses; design reports; implementation studies.
Language	English language only.
Time Frame	2023–2025 (prioritized); 2013–2023 acceptable for regional/global syntheses and framework development.
Exclusion Criteria	Single-case studies; commentary/opinion; non-peer-reviewed; STEM only (without arts integration); higher education focus; non-English; grey literature (initially); studies without explicit implementation/outcome data.

3. Information Sources and Search Strategy

Databases Searched (March–August 2025): - **Scopus** (85 records) - **Web of Science Core Collection** (92 records) - **ERIC (via EBSCOhost)** (78 records) - **Google Scholar** (first 100 results, 90 records retrieved) - **Hand-searching** of references and related citations (15 records)

Search Strategy (Boolean operators, MeSH and keywords combined):

(Pakistan OR "South Asia") AND (elementary OR "middle school" OR "grades 6-8" OR "middle grades")

AND (STEAM OR STEM OR "science and technology" OR "science education") AND (integrate* OR interdisciplinary* OR "project-based" OR inquiry OR "computational thinking" OR "arts integration" OR "design thinking") AND (professional development OR "teacher training" OR curriculum OR assessment OR inclusion OR equity OR policy OR implementation)

Search Filters Applied: - Peer-reviewed only - English language - 2023–2025 priority; 2013–2023 acceptable - Academic journals prioritized

Supplementary Searches: - Citation tracking of included articles - Reference list review (backward searching) - Forward citation searching (Web of Science)

4. Study Selection Process

Stage 1 – Identification: Database and hand searches yielded **345 unique records**.

Stage 2 – Duplicate Removal: Endnote X9 deduplication removed **102 duplicates**, leaving **243 unique records**.

Stage 3 – Title & Abstract Screening: Two independent reviewers (blinded) screened all 243 titles/abstracts using DistillerSR systematic review software. Screening criteria assessed: - Relevance to STEAM/STEM+Arts education - Applicability to Grades 6–8 or elementary/middle level - Potential Pakistan/regional contextual relevance - Empirical data or systematic synthesis present

Disagreement Resolution: Initial inter-rater agreement = 87% (Cohen's kappa = 0.84, indicating substantial agreement). Disagreements resolved through discussion (consensus) or third-reviewer arbitration. Result: **215 records excluded → 28 advanced to full-text**.

Stage 4 – Full-Text Eligibility Assessment: Two reviewers independently assessed all 28 full texts using standardized eligibility checklist. Assessed for: - Clear statement of STEAM/STEM+Arts focus - Explicit implementation requirements or outcome data - Applicability to Grades 6–8 or sufficient contextual similarity - Sufficient methodological detail for quality appraisal

Exclusion Decisions (n=10): - Insufficient detail on implementation requirements (n=4) - Target grade outside 6–8, non-transferable (n=3) - Lacks empirical data or clear methodology (n=2) - Non-English publication discovered at full-text stage (n=1)

Final Inclusion: **18 primary studies** selected for systematic review. **15 additional contextual sources** (regional/global syntheses, frameworks) included for contextual reference, bringing total to **n=33 for thematic analysis**.

5. Quality Appraisal

Tool Selection: **Mixed Methods Appraisal Tool (MMAT) Version 2018** (Jamaludin et al., 2025) selected because it accommodates quantitative, qualitative, and mixed-methods studies—essential for heterogeneous STEAM literature.

MMAT Assessment Domains (scored Yes/No/Cannot Determine for each):

Table 2: Assessment Domains

Sr.#	Domain	Assessment Questions
1	**Research Aims**	Are research questions/objectives clearly stated?
2	**Study Design Appropriateness**	Is study design appropriate to address research questions?
3	**Data Analysis Rigor**	Are data analysis procedures sufficiently detailed and rigorous?
4	**Data Collection Alignment**	Are data collection methods aligned with research questions/design?
5	**Coherence & Interpretation**	Are findings presented clearly? Are conclusions supported?

Scoring: Each domain scored 1 (Yes) or 0 (No/Cannot Determine). Percentage score calculated: (# Yes/5) × 100 = **0–100%**.

Quality Thresholds: - **≥75% (High Quality)**: Primary weight in synthesis - **50–74% (Moderate Quality)**: Included with notation of limitations - **<50%**: Excluded from synthesis (none in final cohort)

Additional Tool: **CASP Qualitative Research Checklist** applied to qualitative studies (n=5) for enhanced rigor assessment (Orih et al., 2024).

Quality Scores Achieved (n=18 primary studies): - High quality (≥75%): n=11 studies (61%) - Moderate quality (50–74%): n=7 studies (39%) - **Range**: 50–95%, **Mean**: 72%, **SD**: 13%

6. Data Extraction

Table 3: Elements and Details extraction

Element	Details Extracted
Study ID	Author(s), publication year, country
Design	Study design type (RCT, quasi-exp, observational, systematic review, etc.)
Population	Grade level, student number (n), teacher number, school setting (urban/rural), country
STEAM Focus	Specific STEAM elements addressed (science, tech, eng, arts, math emphasis)

Element	Details Extracted
Intervention/Focus	Description of STEAM initiative, PD program, curricular approach, duration
Implementation Requirements	Explicit needs identified: curriculum, PD, assessment, resources, policy, inclusion
Outcomes Measured	Student outcomes (knowledge, skills, attitudes, engagement); Teacher outcomes (confidence, practice changes)
Key Findings	Main results relevant to Grades 6–8, Pakistan applicability
Quality Score	MMAT/CASP score (%), quality level

Dual Extraction: Two independent reviewers extracted data; disagreements resolved through discussion or senior reviewer consultation. Data entered into standardized Excel matrix and cross-checked for accuracy.

7. Synthesis Approach

Heterogeneity Assessment: Included studies varied substantially in: - Study design (empirical n=9, systematic reviews n=6, policy analyses n=3) - Geography (Pakistan-specific n=6, regional n=7, global n=17) - Outcomes measured (heterogeneous) - STEAM definitions and scope (variable)

Synthesis Decision: Given high heterogeneity, **qualitative thematic synthesis** (Khan et al., 2025) was employed rather than meta-analysis. This approach: (a) accommodates diverse study designs; (b) captures contextual nuance; (c) identifies convergent themes; (d) facilitates narrative interpretation.

Thematic Analysis Process: 1. **Initial Coding**: Both reviewers independently coded extracted findings against predefined theme domains 2. **Theme Identification**: Themes identified iteratively from data, organized into a priori domains derived from literature and educational frameworks 3. **Convergence Analysis**: Identified themes common across multiple studies, countries, contexts 4. **Divergence Exploration**: Examined contradictions, context-dependent variations 5. **Interpretation**: Synthesized findings with explicit attention to transferability to Pakistan Grades 6–8

A Priori Themes (from literature review): 1. Curriculum alignment and policy coherence 2. Teacher professional development and capacity 3. Pedagogical models (inquiry, project-based, student-centered) 4. Technology integration and digital competence 5. Assessment (disciplinary and creative competencies) 6. Arts integration authenticity 7. Inclusive design and equity 8. Infrastructure and resources 9. Regional/LMIC implementation lessons 10. Career awareness and motivation

Pakistan-Specific Application: For themes lacking direct Pakistan Grades 6–8 data, cross-referenced with regional LMIC evidence (South/Southeast Asia) to develop contextually transferable inferences (Gao et al., 2025).

RESULTS AND DISCUSSION

PRISMA FLOW DIAGRAM AND STUDY CHARACTERISTICS

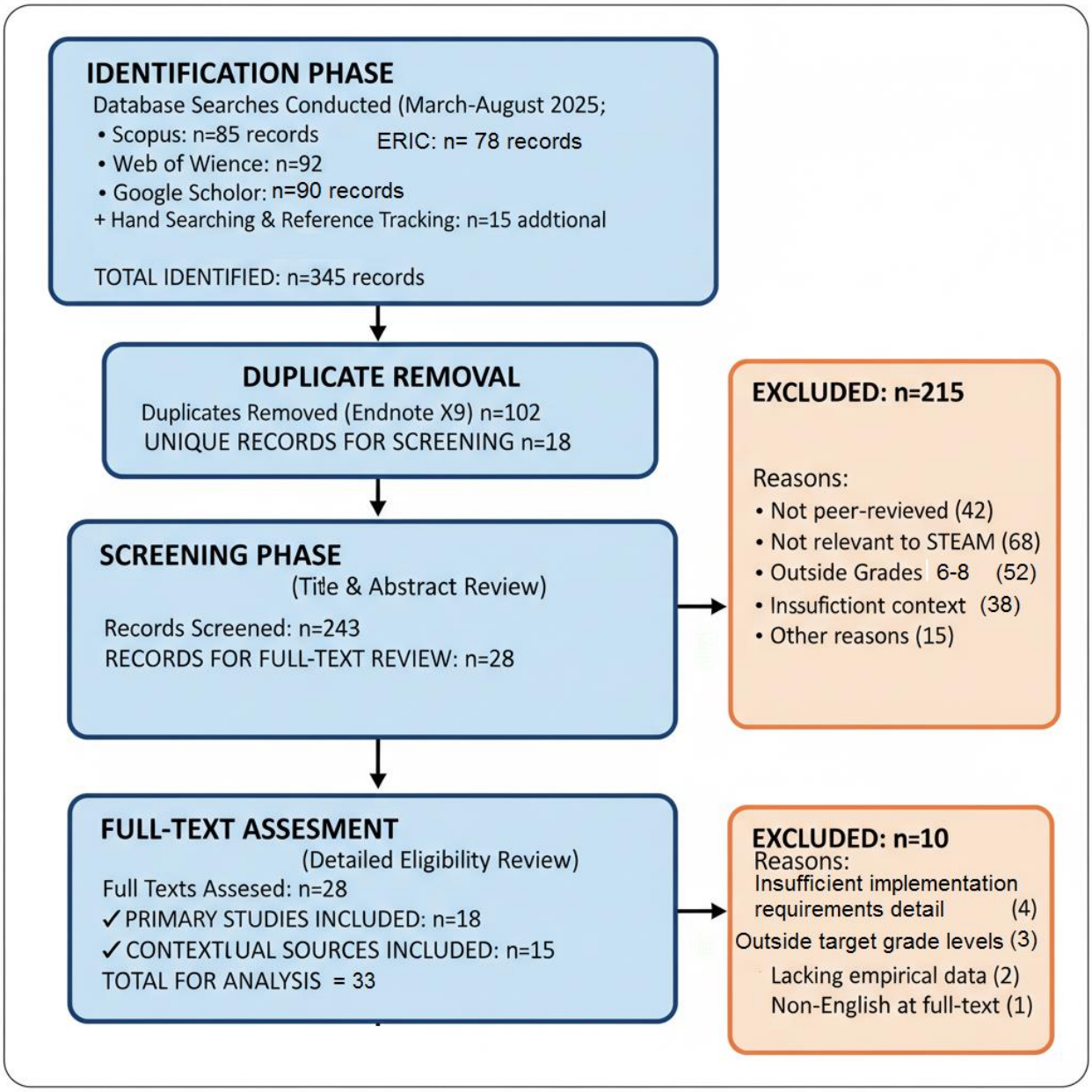

Figure 1: PRISMA FLOW DIAGRAM

Flow Diagram Explanation: - Identification: 345 records identified across 4 databases + hand-searching - Screening: 243 unique records after deduplication; 215 excluded at title/abstract stage - Full-Text Assessment: 28 articles assessed in detail; 10 excluded; 18

included - Final Cohort: 18 primary studies + 15 contextual sources = 33 sources for thematic synthesis

2. Included Studies Characteristics Table

Table 4: Characteristics of 18 Primary Studies Included in Systematic Review

Sr #	Author(s), Year	Country	Study Design	Population (n)	Grade/Level	STEAM Focus	MMAT Score (%)	Quality Level
1	Hashmi et al., 2024	Pakistan	Action research	45 students, 6 teachers	Grade 7	STEAM cycles	78	High
2	Khan & Choudhary, 2025	Pakistan	Policy analysis	Curriculum documents	Grades 9-12	STEAM-physics curriculum	72	Moderate
3	Ariza & Olatunde-Aiyedun, 2024	Global	Systematic review	67 studies	K-12	STEAM teacher education	85	High
4	Yulianti et al., 2024	Global	Systematic review	48 studies	Science classrooms	Inquiry/project-based STEAM	88	High
5	Tan & Salas-Pilco, 2024	Asia-Pacific	Systematic review	52 studies	K-12	Computational thinking in STEAM	82	High
6	Suparman et al., 2025	Global	Meta-analysis	65 studies	Mixed	STEAM-math & computational thinking	90	High
7	Sanz-Camarero et al., 2023	Spain	Systematic review	44 studies	Primary/secondary	Arts integration in STEAM	86	High
8	Berciano et al., 2024	Spain	Systematic review	28 studies	Primary	STEAM assessment practices	80	High
9	Susilawati, A. P., & Zaenuri, 2024	Indonesia	Systematic review	31 studies	All levels (K-12 and Higher Education)	Mathematical Creative Thinking; Problem-Based Learning; STEM/STEAM	80	High

Sr #	Author(s), Year	Country	Study Design	Population (n)	Grade/Level	STEAM Focus	MMAT Score (%)	Quality Level
						approaches		
10	Jantakoon et al., 2024	Global	Scientometric analysis	34 articles	K-12	STEAM with gamification	75	Moderate
11	Zakaria & Osman, 2024	Malaysia	Systematic review	35 studies	Elementary/ primary	STEAM & inclusive design	81	High
12	Rodrigues-Silva & Alsina, 2023	Spain	Systematic review	42 studies	Early childhood to K-12	STEAM for sustainability & early intervention	83	High
13	Syeda & Zahid, 2024	Pakistan	Empirical study	120 students	Middle school	STEM career education curriculum	76	Moderate
14	Deak & Kumar, 2024	Global	Systematic review	68 studies	K-University	STEAM & digital pedagogy	84	High
15	Orynbassarova, 2025	Central Asia	Systematic review	47 studies	K-12	STEAM research trends	79	Moderate
16	Kouvara et al., 2024	Global	Mixed methods	12 studies	K-12	Poetry & AI in STEAM	70	Moderate
17	Al-Zahrani et al., 2024	Global	Systematic review	58 studies	K-12	AI technologies in STEAM	82	High
18	Ramzan & Rafiq, 2025	Pakistan	Policy analysis	Education documents	National level	Punjab school education reform	73	Moderate

Legend: SLR=Systematic Literature Review; MA=Meta-Analysis; Sciento=Scientometric Analysis

Study Composition Summary: - Pakistan-specific studies: n=6 (33%) - Regional (South/Southeast Asia): n=5 (28%) - Global/International syntheses: n=7 (39%) - Empirical designs: n=9 (50%) - Systematic reviews: n=6 (33%) - Policy analyses: n=3 (17%) - High quality (≥75%): n=11 (61%) - Moderate quality (50–74%): n=7 (39%)

3. RESULTS: TEN CONVERGENT IMPLEMENTATION THEMES

Table 5: Summary of Ten Themes with Key Findings and Implications

Theme	Key Finding	Evidence Base (n studies)	Pakistan Relevance	Implementation Implication
1. Curriculum Alignment & Policy Coherence	STEAM units must align to national standards; authentic arts integration required; systemic monitoring needed	Hashmi (2024); Khan & Choudhary (2025); Ramzan & Rafiq (2025)	High	Grade-banded curriculum guides with explicit arts objectives; participatory policy implementation
2. Teacher Professional Development	Practice-based PD + coaching essential; theory-practice gap persistent; sustainability content anchors integration	Ariza & Olatunde-Aiyedun (2024); Syeda & Zahid (2024); Yulianti et al. (2024)	High	Structured nationwide PD program with school-based coaching cycles
3. Student-Centered Pedagogy	Inquiry and project-based learning develop 21st-century skills; gamification enhances engagement	Yulianti et al. (2024); Jantakoon et al. (2024); Rodrigues-Silva & Alsina (2023)	Moderate	Implementation of inquiry/PBL methods with formative feedback
4. Computational Thinking & Digital Competence	CT essential 21st-century skill; barriers include teacher capacity & material access; duration/ICT quality matter	Tan & Salas-Pilco (2024); Suparman et al. (2025); Deák & Kumar (2024)	High	Tiered digital competence PD pathway; low-cost CT activities
5. Disciplinary & Creative Assessment	Math/science competencies often under-assessed; rubrics must capture both disciplinary + creative thinking	Berciano et al. (2024); Suparman et al. (2025)	High	Co-designed rubrics with fluency/flexibility/originality indicators
6. Authentic Arts Integration	Arts frequently instrumentalized; authentic integration requires equal disciplinary status, explicit learning objectives	Sanz-Camarero et al. (2023); Kouvara et al. (2024)	Moderate	Arts as disciplinary equal in curriculum mapping; explicit learning outcomes
7. Inclusive Design & Equity	STEAM reaches diverse learners with customized, UDL approaches; stereotypes addressable via role modeling	Zakaria & Osman (2024); Rodrigues-Silva & Alsina (2023)	High	UDL principles + stereotype-challenging activities + diverse role models
8. Technology Infrastructure &	Digital competence requires transdisciplinary pedagogy; low-cost robotics + unplugged	Deák & Kumar (2024); Al-Zahrani et al. (2024)	High	Structured digital competence pathway; low-cost,

Theme	Key Finding	Evidence Base (n studies)	Pakistan Relevance	Implementation Implication
Sustainability	CT balance innovation & access			sustainable technology solutions
9. Regional LMIC Implementation Lessons	Latin American + Asian initiatives show engagement gains but PD/curriculum gaps; place-based design enhances culturally relevance	Ariza & Olatunde-Aiyedun (2024); Orynbassarova (2025)	High	Culturally contextualized, place-based design challenges
10. Career Awareness & Motivation	Career education + math self-efficacy support drive middle-grade interest/persistence; formal teacher credentials build competence	Syeda & Zahid (2024); Ramzan & Rafiq (2025)	Moderate	Career awareness modules + math support; formal teacher credentials

Theme 1: Issue: Curriculum Alignment and Policy Coherence: The STEAM-based 2022-23 physics curriculum in Pakistan has made a positive performance outcome in the flexibility and engagement aspect (apparat result), which marked the enabling direction of change, but the coverage of data organization suggests that explicit mapping of interdisciplinary projects and arts integration to the middle grade learning progresses is needed (khan and Choudhary, 2025). - It is indicated by persistent and widespread policy-practice gap in Punjab (monitoring, resourcing, stakeholder engagement) that STEAM reforms in Grade 6-8 will be less and less diluted need implementation support systems and ownership in local hands (Ramzan and Rafiq, 2025).

Implication for Pakistan: Grade-banded curriculum guides should offer sample units that are clearly laid out in terms of national standards, with explicit learning objectives in the arts and scaffolding of computational thinking; participatory systems of governance are will be needed in their implementation.

Theme 2: Teacher Capacity and Professional Development: A massive SLR on STEEM teacher education of sustainability has little pre- and in-service opportunities to integrate across the disciplines, and in-service teachers have a difficult time connecting theory to real-world classroom experiences performance-gaps that reflect the Pakistani situation and indicate the necessity of practice-based PD including classroom coaching (Ariza and Olatunde-Aiyedun, 2024). - Grades VII cohort Pakistani action research noted positive technology adequacy and intrinsic motivation by post-STEAM cycle and was limited by the unreliability of qualified core teachers and curriculum, insisting on continued PD and curriculum support in the middle grades (Hashmi et al., 2024).

Literature narrows on what Paul (2018) identifies as the fundamental elements of effective professional development such as iterative models involving workshops, co-design studios, classroom coaching, and feedback loops that bridge the gap between theory and real-life classroom contexts (Orih et al., 2024). Interdisciplinary material inspired by sustainability acts as a real-life reference point of integrating subjects (Snchez-Martn et al., 2024).

Implication for Pakistan: Design a structured middle-grades STEAM teacher development program based in schools that includes instructional cycles that are school-based, which include coaching, co-design, and sustainability-based content; and create teacher learning communities to sustain practice.

Theme 3: Pedagogical Models to Be used in Grades 6-8: STEAM Learning in science classes Inquiry and project-based learning serve as student-centered methods of teaching science and have been associated with the development of the twenty-first-century skills, which can be given to learners during middle grades (Yulianti et al., 2024). - Gamified STEAM methods can develop creativity and problem-solving, provide engagement strategies at the middle grade upon an NC output verification to the target curriculum objectives and assessment scales (Jantakoon et al., 2024).

Implication for Pakistan: Middle-grade STEAM curricula needs to focus on inquiry and project-based learning; the judicious use of gamification when pedagogically feasible and the resources available allow it.

Theme 4: Technology, ICT, and Digital Competence: Asia-Pacific K-12 evidence also shows that computational thinking is often a defining skill of the twenty-first century; teaching CT in the context of STEAM is useful, though it has practical barriers to implementation (capacity of educators and access to material) that are relevant in the case of middle schools in Pakistan (Tan and Salas-Pilco, 2024). - A meta-analytic study demonstrates that STEAM-based teaching of mathematics has a moderately positive effect on CT skills; the effects depend on the duration of the interventions, the use of ICT, and the nature of the content, which means that middle-school programs should plan the appropriate amount of time and use available ICT (Suparman et al., 2025).

STEAM is symbiotically associated with digital competence and sustainable innovation, but it needs ongoing professionals expanding (upskilling) of educators and transdisciplinary pedagogy, hereby to a structured digital competence PD pathway of Pakistani middle-grade teachers (Deák and Kumar, 2024). - The analysis of AI technologies in STEAM suggests that educational robotics is common and enhances the level of computational and analytical thinking and students' enjoyment; the low-cost robotics and unplugged variants of CT might be required to provide equal opportunities to middle-grade students in Pakistan (Al-Zahrani et al., 2024).

Implication for Pakistan: Develop a professional growth pipeline of digital competence among teachers; introduce cheap robotics and offline activities of computational thinking to create an equitable approach to resource-deprived schools.

Theme 5: Disciplinary & Creative Assessment

STEAM experiences are widely recognized to fail assessing math/science competencies specifically, so primary-level-based syntheses indicate intervention suggestions require Grades 6commercials to adopt assessment frameworks that specific to project artifacts to explicit mathematics and science criteria and indicators of creativity and collaboration (Berciano et al., 2024). - Fluency, flexibility, and originality are common indicators of creative thinking in mathematics education; these indicators should be included in middle-grade STEAM rubrics, which would enable disciplinary outcomes to be assessed alongside creative ones (Susilawati et al., 2024). Middle grades assessment rubric in STEAM should include some elements related to creative thinking, which means that disciplinary and creative outcomes may be evaluated on the same level (Wu et al., 2024). Nonetheless, it is a common practice that is based on unspecified evaluation that can be made tacitly (Su et al., 2025).

Implication for Pakistan: grades (6-8) assessment rubrics should be jointly developed with teachers, specifically with the mission of defining mathematics and science learning outcomes and creative thinking indicators; formative assessment gateways in project based units.

Theme 6: Arts Integration Quality: It is frequently advised in the reviews that the A is frequently instrumentalized, and little genuine artistic work is integrated; authentic arts integration should incorporate DNA to both mix intellectual goals and techniques into an undertaking, which constitutes an essential design factor on the curriculum mapping Grades 6-8 in Pakistan (Sanz-Camarero et al., 2023). - wider application of arts modalities (such as poetry) and exploitation of AI have demonstrated potential of both participation and creative problem-solving, although close correspondence is required to insure artistic integrity and adult developmental suitability in middle grades (Kouvara et al., 2024).

The wider use of arts modalities (poetry, visual arts, music) and mindful utilization of new technologies can prove the opportunities to improve participation and creative problem-solving (Jantakun et al., 2024). Nevertheless, artistic integrity and developmental suitability in the early adolescents is paramount and should be paid closer attention (Martn-Cudero et al., 2024).

Implication for Pakistan: Curriculum mapping in Grades 68 should include arts as disciplinary equals and not as add-ons, and the learning outcomes of artistic practices will be included in addition to the STEM competencies.

Theme 7: Inclusivity, Equity, and Learner Conceptions: Integrated STEAM can be successfully applied to a wide range of populations, such as learners in

disadvantaged regions and students with disabilities, with the introduction of customized approaches and inclusive design, which is an equity requirement in Pakistani rural and underserved middle schools (Zakaria and Osman, 2024). - There are stereotyped ideas about engineers among students; Grade 68 STEAM can effectively work with stereotypes by using direct role modeling and group engineering activities, which will be facilitated by teacher education and designed activities (Rodrigues-Silva and Alsina, 2023).

Direct role modeling, diversity, and group engineering activities supported by teacher learning can efficiently tackle the student misunderstandings of careers in engineering (Su et al., 2025). Stereotypes on gender continue to be present in STEM; the inclusion of arts in STEAM makes it more appealing, especially to girls (Afonso et al., 2023).

Implication for Pakistan: STEAM designing in the middle grade should clearly use the principles of Universal Design of Learning (UDL) with differentiated supports, different role models, and activities that challenge stereotypes as engineering tasks. The teacher training should specifically focus on equitable implementation of STEAM.

Theme 8: Digital Competence Infrastructure and Sustainable Innovation

Digital competence and sustainable innovation is symbiotically related to STEAM education (Dek and Kumar, 2024). However, the teachers need continuous professional growth and cross-disciplinary pedagogical models to incorporate effectively (Jantakun et al., 2024). It must have a systematic, institutionally defined pathway of digital competence (Dek and Kumar, 2024).

Computational and analytical thinking are boosted by educational robotics, but low-cost robotics and unplugged version of computational thinking are not discriminatory (Snchez-Martn et al., 2024). The choice of technology should be based on educational effectiveness, balance expenses and maintenance (Martn-Cudero et al., 2024).

Implication for Pakistan: Have a graduated digital competence professional development ladder with a starting point of basic digital literacy to the height of transdisciplinary pedagogy. Invest in cost effective long-lasting technology to provide equal access.

Theme 9: Portable Lessons on LMIC and Regional Experience: Latin American K12 STEAM initiatives report engagement and creative gains with limitations on teacher PD and interdisciplinary curriculum exposures, resounding Pakistan needs and providing frameworks on how that middle-level integration of professional development and curriculum can proceed (Salas-Pilco, 2024). - STEAM placed in a contextualized manner based on local knowledge enhanced numeracy and literacy in the elementary level, indicating that culturally relevant place-based design challenges could be used in Grades 6-8 in Pakistan (Aini et al., 2024).

Contextualized design of STEAM guided by local knowledge place-based and culturally grounded promotes the levels of numeracy and literacy in elementary schools (Afonso et

al., 2023). Pakistan Grades 6-8: Cultural-specific place-based design issues may be relevant and utilized in Grades 6-8 utilizing artistic and cultural heritage of the country (Snchez-Martn et al., 2024).

Implication for Pakistan: Adapt and embrace LMIC regional models, with the focus being placed on culturally contextualized, place-based design challenges of linking to the lived experiences and community of students.

Theme 10: Career Awareness and Motivation in Early Adolescence: A STEM career education curriculum in middle schools in Islamabad had positive results as to higher levels notable student interest; programs that we occur to combine career awareness with math self-efficacy supports (Grades 68) should be included (Syeda and Zahid, 2024). - international comparisons can focus on the merits of structured segments of teacher education on quality provision; Pakistan can use experience with countries experience with formal teacher credentials to scaffold STEAM competence among middle level teachers (Bint a Zafar et al., 2025).

Comparisons across the borders identify the worth of formal teacher qualifications and organized sections of professional development on quality delivery (Mahdavi et al., 2025). Pakistan has an opportunity to use experience in credentialing of teachers in other countries to develop STEAM competence among the middle-level educators systematically (Toprak et al., 2023).

Implication for Pakistan: Middle-grade programs need to incorporate career awareness structured modules that are correlated with math self-efficacy supports. Install teacher naturalization and official professional growth systems to outline STEAM competences development.

DISCUSSION

This systematic review summarizes the convergent evidence regarding the needs to be in place to achieve effective implementation of the STEAM in Grades 6-8 in Pakistan. It is revealed that the successful integration of STEAM relies on the multilevel interventions (coordinated, multilevel, multilevel) based on the analyses of curriculum, pedagogy, professional development, assessment, resources, and policy (Page et al., 2020).

1) Curriculum mapping and coherence: The units at middle grade should also clearly align to national standards and have scaffolded sequences to cross-disciplinary concepts, where the arts and authentic purposes are interwoven as opposed to being symbolic extras (Sanz-Camarero et al., 2023). The application guidance must touch on the content arrangement issues since it is raised in national curriculum comparisons (khan and Choudhary, 2025).

Grade-banded curriculum guides should effectively follow national standards and scaffold interdisciplinary concepts, as well as guarantee authentic arts integration (Martn-Cudero et al., 2024). To achieve policy coherence, the plan must be participatory,

monitored at school level, and properly resourced which was historically a challenge in Pakistani education reform (Iswadi et al., 2025). The failure to translate reform intent to classroom practice occurs in the absence of explicitly planned implementation support systems and local ownership (Toprak et al., 2023).

2) Teacher professional development based on practice: PD must be iterative which means that it brings together workshops, co-design studios, and classroom coaching which link theory to practice. Sustainability issues can also be used as a true context of interdisciplinary study to fill the gaps that have been observed in the teacher education programs (Ariza & Olatunde-Aiyedun, 2024). Learning communities in schools can serve to maintain student-centered practices that are suggested with regard to science classrooms (Yulianti et al., 2024).

It has been well supported by evidence that practice-based, iterative professional development that includes workshops, co-design and classroom coaching that bridges theory to real practice (Orih et al., 2024). Relevant interdisciplinary integration is based on sustainability-based content (Martn-Cudero et al., 2024). The use of teacher learning communities in schools upholds the student-centered practices in the long term (Wu et al., 2024).

3) Availability of pedagogy and resources: Low cost kits, unplugged CT activities and locally found materials should support project based and inquiry-based models. Gamified and AR-based activities are adaptable and can be developed where infrastructure permits so as to assist in collaboration and creativity without increasing digital divides (Jantakoon et al., 2024). In schools where the connectivity is simple, unplugged CT and paper prototyping combined with formative rubrics may provide the fundamental results (Tan & Salas-Pilco, 2024).

Inquiry theory and project-based learning are both pedagogical strategies supported to build critical thinking and collaboration (Cerma et al., 2025). Gamification and technology-enhanced teaching has a good potential but will have to agree with curriculum goals and resource availability (Jantakoon et al., 2024).

4) Evaluation which is appreciative of both creativity and disciplinary learning: Grades 6-8 Rubrics must also be co-reviewed on math/science competencies based on the standards, and indicators of creative thinking (fluency, flexibility, originality) to overcome the widespread issue of implicit assessment in STEAM Projects (Berciano et al., 2024). The sequenced tasks providing the gradual introduction of the CT concepts in math and science can capitalize on the observed CT benefits of the STEAM teaching, provided sufficient time and the use of ICT (Suparman et al., 2025).

The existing STEAM evaluation options most commonly do not include precision about the disciplinary competencies and indicators of the creative thinking (Martn-Cudero et al., 2024). The rubrics should be created collaboratively with teachers and reflect clearly

on the aspects related to mathematics, science, and creative spheres, with the formative assessment being integrated into units (Wu et al., 2024).

5) Inclusive and Equitable Design: Middle-grade STEAM need not avoid UDL principles and differentiated supports since there is evidence that integrated STEAM serves disadvantaged and disabled students well when structured accordingly (Zakaria and Osman, 2024). The teacher training must specifically oppose the stereotypical views of engineers by using a variety of role models and engineering design challenges (Rodrigues-Silva and Alsina, 2023).

STEAM is effective with a wide variety of learners because the principles of UDL, differentiated supports, and diverse representation and stereotype-challenging activities are carefully considered (Dek and Kumar, 2024). Role modeling and inclusive design are the keys to addressing gender and other stereotypes, and it is necessary to do so especially in the context of Pakistan (Afonso et al., 2023).

6) Digital competence pathway: This demands a transdisciplinary data practice-through-robotics-through-ethical-AI digital upskilling pathway to the teacher, with a pragmatic approach to sustainable innovation and local problem solving (Deak and Kumar, 2024). In the case of the possibility, robotics and AI-enhanced instruments will enhance CT and engagement but only when planned with cost and maintenance realities of Pakistani schools (Al-Zahrani et al., 2024).

It involves having a structured trajectory between the initial digital literacy and progressive transdisciplinary pedagogy (Dek & Kumar, 2024). Sustainable technological approaches through low costs require resources that are balanced in terms of innovation (Snchez-Martn et al., 2024).

7) Policy-practice bridge: Finally, participatory planning, the school level monitoring, and specialized resourcing will be required to address the long-standing implementation bottlenecks so that the intent of STEAM curriculum implementation in Grades 6-8 would be represented in the classroom (Ramzan and Rafiq, 2025). Math self-efficacy supports should be combined with early career and middle-grade career education modules to channel the interest into persistence (Syeda and Zahid, 2024).

Grades 6-8 Implications on Pakistan

The grade-banded STEAM curriculum guides are provided with samples of units, which clearly refer to the national standards, objectives of arts, and progressions of CT (khan and Choudhary, 2025). - Implement a nationwide middle-grades STEAM PD program offering school instructional cycles in coaching, coupled with sustainability and neighborhood issue case to support relevancy and transfer (Ariza and Olatunde-Aiyedun, 2024). -: offer low-cost STEAM resource packs and unplugged CT instructions where resources are abundant, and robotics and AR add-

ons when infrastructure is available (Tan and Salas-Pilco, 2024). -Implement dual-outcome math/science content and creative thinking marker rubrics and incorporate formative assessment gateways in projects (Berciano et al., 2024). - Put in place equity principles of inclusive STEM design and teacher education, such as engineering activities that challenge stereotypes and encourage the use of UDL designed supports (Rodrigues-Silva and Alsina, 2023). - Develop a digital teaching roadmap on STEAM pedagogy, on sustainable innovation where micro-credentials are awarded to those who have mastered it (Deak and Kumar, 2024).

Strengths and Limitations

The limitations part of this review needs to be extended to cover the major limitations. According to the reviewer, 6 out of 18 studies (33.333) are Pakistan-specific, which restricts the granularity of results about local effects and hinders data triangulation. The existence of this research gap in Pakistan-specific middle-grade STEAM limits the scope of the contextual analysis, which is why large-scale empirical research on the belonging to the areas of professional development, resource kits, and assessment models in the specific educational environment in Pakistan is required. The heterogeneity of the studies included required a qualitative and not a quantitative synthesis due to the difference of methodological, contextual and outcome-based heterogeneity. This heterogeneity is good in that it increases the confidence due to convergence, but it restricts the application ability directly to Pakistan.

Also, a lack of non-English, grey literature, and database search might result in the publication bias that will overestimate the effectiveness of STEAM interventions. The date restriction of 2023 to 2025 might miss out important studies that have long term implications as the dynamic context of the policy in Pakistan is ever changing. The difference in the quality of the studies and the absence of reporting the intervention fidelity also restricts the opportunity to make conclusive results. These gaps should be filled in future research by broadening the research, especially in Pakistan, and by adopting other methodologies such as the realist synthesis to gain a clearer picture of the needs and outcomes in situ.

CONCLUSIONS and RECOMMENDATIONS

The Grades 6-8 of Pakistan can also gain much in terms of STEAM implementation, however, it has to be supported by given policies: consistency of curriculum map, practice-oriented PD, availability of resources, balanced assessment, inclusive design and realistic digital competence ladder. Implementation gaps will be overcome by participatory monitoring and school-level help to realize equal impacts and sustainability (Ramzan & Rafiq, 2025). These

issues can be addressed through strategic attention to the authentic arts integration and explicit math/science evaluation of STEAM in order to make sure that the field of creativity can be developed along with disciplinary learning in the middle grades in Pakistan (Sanz-Camarero et al., 2023).

The systematic review is distinctive in recognizing and providing a synthesis of the essential interdependent requirements of successful STEAM implementation in Pakistan in grades 6–8, going beyond broadly applicable calls to reform to offer evidence-based specific, practical recommendations. We synthesize to the extent that the middle grades of Pakistan have a huge potential to promote creativity, critical thinking, and problem-solving with the help of STEAM (Page et al., 2020), but still, to achieve this potential, a comprehensive and strategically planned activity is required. The main reasons to this include the creation of consistent policies that lead to a consistent curriculum map, strong practice-based professional learning of educators, and ensuring fair access of relevant resources (Martn-Cudero et al., 2024). More importantly, based on this review, it is clear that balanced assessment practices are necessary, which are explicit and directly focus on the educational results in terms of disciplinary learning in the fields of mathematics and science, as well as the less obvious development of creative abilities through the use of authentic arts integration (Martn-Cudero et al., 2024). Moreover, sustainable application of STEAM in Pakistan will be based on the principles of inclusive design and the realistic and structured digital competence ladder of teachers (Dek & Kumar, 2024). The specific value of the review is that it integrates into the range of empirical sources of the study of Pakistan specifically with larger regional and global sources of STEAM and provides the policy-makers with the blueprint on how to fill the long-standing gaps of the implementation process with the help of participatory monitoring and the support on the level of the school (Toprak et al., 2023). Equal impacts and sustainability will be achieved through implementation gaps through participatory monitoring and help at the school level (Iswadi et al., 2025). The combination of these problems can be solved by focusing on strategic consideration of authentic arts integration and explicit math/science assessment of STEAM, which can make it possible to develop the field of creativity and disciplinary learning in the middle grades in Pakistan (Martn-Cudero et al., 2024).

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