

A Historical Analysis of Science, Technology, Engineering, Arts, and Mathematics (STEAM) Education Initiatives and Policies in Balochistan

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Abstract

The teaching or learning of Science, Technology, Engineering, Arts and Mathematics (STEAM) has grown in popularity and been advocated internationally as an integrated subject that encourages creativity, problem solving, technological literacy, a scientific mindset, team work and innovation. But STEAM education was not a momentous or singular process in Balochistan; it did not materialize as a provincial policy at one time. Instead, it has been built over time and come from previous reforms in science and mathematics education, curriculum development, TVE, information and communication technology (ICT), teacher professional development, assessment, federally-funded STEM programs and more recently, explicit STEAM programming. This study aims at studying the history and development of STEAM education programs and policies in Balochistan. The qualitative historical content-analysis design was used to analyze provincial education sector plans, education statistics, curriculum and assessment documents, legislative and institutional records, federal STEM and STEAM program documents, implementation reports, and scholarly literature. It brings into focus 5 general phases over the course of the evolution of STEAM related education in the province: pre-STEAM, policy consolidation post devolution of education, learning driven phase, digital readiness, explicitly named STEM programming by the Pakistan Science Foundation and finally the shift toward STEAM as a result of federal initiatives focusing on interdisciplinary learning, creativity, girls inclusion in learning and school based programming. The results indicate significant policy change, as well as differences in the extent of provincial planning and federally-initiated programming, limited technological infrastructure, a lack of specialized teachers, uneven geographical access, weak integration of the arts, and little evidence of the integration of the arts at the system level. The study highlights that in Balochistan, the status of individual subjects related to STEAM has shifted to an interdisciplinary approach but the shift to the interdisciplinary model is incomplete. To help the transition from individual initiatives towards sustainable system-wide implementation, a province owned STEAM approach and an equity-scaled approach is recommended.

Keywords: STEAM; STEM; education; historical analysis; policies; reforms; Balochistan

I. Introduction

The educational systems of today are increasingly challenged with preparing students for social, technological, environmental and economic circumstances that can only be met by a more integrated and coordinated engagement of the learner's abilities. As a result, fundamental concepts like scientific understanding and digital competence, mathematical reasoning, engineering design, creativity, communication, and the interdisciplinary view of complex problems are now central to today's educational agenda. This has led to the development of a STEAM approach which tries to weave disciplinary learning into a whole, instead of learning each discipline separately.

The concept of STEAM learning has developed from previously STEM learning that focused on the integration of science, technology, engineering and mathematics. Integrated STEM scholarship states that a "meaningful" STEM education can't simply be the co-existence of several school subjects. It is purposeful relationships between the concepts of a discipline, often created through inquiry, engineering design, technological problem solving, mathematical reasoning and meaningful, real-world contexts (Kelley & Knowles, 2016). The subsequent expansion of arts included the arts as a broad field of understanding and study, encompassing creativity, design, communication, aesthetics, social interpretation, and human-centered problem solving, topics previously in the realm of the sciences and technologies.

The inclusion of the "A" has brought a lot of discussion to the academic world, however. There is no universal definition of STEAM and there are significant variations in how widely the arts are infused in the studies. In some programs, arts and design are integral to interdisciplinary inquiry and in others, the role of arts is to make science or mathematics "more interesting. An examination of STEAM research, therefore, suggests that not all creative STEM activities are necessarily substantive STEAM integration (Colucci-Gray et al., 2019; Perignat & Katz-Buonincontro, 2019).

This conceptual difference is especially significant in terms of history of STEAM education in Balochistan. All of the science and math, computer, technical or creative education programs that came before it should not be considered "STEAM." These domains have been treated as distinct fields or units of education policy in the province for much of its education-policy history. However, the modern teaching and learning language for interdisciplinary STEAM did not enter into the policy and implementation arena until much later. However, the previous reforms laid the institutional and pedagogical groundwork for further explicit STEM and STEAM programs.

Balochistan is a particular area of interest in this developing trend. The province is the largest in terms of geographical area and the population is very spread out which poses unique challenges in terms of access to education, deployment of teachers, infrastructure, technological connectivity and institutional support. After the Eighteenth Constitutional Amendment, education was significantly devolved to the provinces, which gives increased powers to Balochistan in terms of curriculum, planning, execution, staff development, assessment and governance of the education sector. The post-devolution period has produced the province's first ever comprehensive Balochistan Education Sector Plan (BESP) 2013-2018 which aimed to build a coordinated system in Balochistan with regards to curriculum, textbooks, assessment, teacher training, governance, information systems, literacy and technical and vocational education (T&V) (Government of Balochistan, 2013).

The 2013-2018 plan did not make any specific STEAM strategy; however, some of the concerns mentioned in the plan have been developed into major concerns for STEAM development. The plan highlighted learning outcomes in science and mathematics, identified shortcomings in conceptual learning, expressed concern about examination and textbook focusing on rote memorization, emphasized the role of ICT to address geographical barriers in Balochistan and identified the need for building capacity of teachers in research. The priorities were an early move away from access to the question of what and how students learn.

This educational structure was reinforced by institutional changes over the next few years. The province enacted compulsory education laws, instituted curriculum and textbook reviews, and formalized an assessment system. The Balochistan Assessment and Examination Commission Act, 2018 established the Balochistan Assessment and Examination Commission at the provincial level to conduct large scale assessment and standardized tests at the elementary level. These were not STEAM policies per se, but they created pathways for future STEAM related curriculum, teaching and assessment changes to be implemented in the public education system.

Another crucial step was the Balochistan Education Sector Plan 2020-2025. The plan gave greater emphasis to learning in education reform, and pointed out the deficiencies in the curriculum design, teaching practice, assessment, teacher availability, and specialized subject teaching. It highlighted the dearth of science and mathematical teachers and the importance of reading, numeracy, analytical skills and preparation for life and livelihood. It also encouraged more contextually relevant learning material that would help in the development of more creative and analytical skills instead of rote learning (Government of Balochistan, 2020).

Meanwhile, the pandemic COVID-19 caused a surge in the focus on educational technology. Having children receive education from a distance, through television, radio, digital communications, and other alternative delivery methods became policy issues. However, there was a high level of inequity in the digital infrastructure in Balochistan. In 2016-2017, education statistics showed that there were only 1.3% of all schools with a computer laboratory.

Nevertheless, later figures reported that some improvement was achieved, and the education census of 2022–2023 still revealed huge gaps in the infrastructures like limited electricity and computer lab at schools (Government of Balochistan, 2017, 2023).

Federal involvement began to establish a more explicit STEM phase. In August 2021, the Pakistan Science Foundation approved its project titled “Launching of STEM in Pakistan, Phase-I” and implemented various STEM laboratories, teacher training, questions solving activities, fabrication lab, and interdisciplinary learning in selected schools across the country. Participating schools and fabrication laboratory sites included ten institutions in Balochistan; creating an identifiable footprint of school-level STEM in Balochistan (Pakistan Science Foundation [PSF], 2021).

The shift towards explicit STEAM terminology became evident starting from 2022 and onwards, via STEAM Pakistan in the Ministry of Federal Education and Professional Training (MoFEPT). The program aims to increase access of secondary school-aged girls to STEM, and to encourage interdisciplinary and hands-on learning in public schools, specifically. It launched activities such as STEAM clubs, storytelling, teacher hubs, mentors, competitions and university-school partnerships, and is working to integrate program learning into government policies.

The integration of Balochistan in this national STEAM is relatively slow, however. An official Senate report dated March 20th, 2025, showed that there were just 9 STEAM Pakistan partner schools in Balochistan, while there were several thousand in the province of Punjab and Sindh and that there was a plan to establish a provincial STEAM Policy Unit in Balochistan during the year 2025. This is an indication of the difference between having STEAM activities in Balochistan and a province owned STEAM policy.

By 2025-2026, the province of Balochistan participated in yet another round of education sector planning with the Balochistan Education Sector Plan 2025-2030, and continued with the increased focus on digital teacher development programs such as the Virtual Academy for Teacher Training (VATT) at the Provincial Institute for Teacher Education (PITE). This existing education system includes 14,700+ public schools with almost 1.2 million students, and represents the scope of transitioning from isolated STEM or STEAM pilots to province-wide education changes.

Although this has occurred, there has been little systematic research to reconstruct the history of the policies and initiatives related to STEAM specifically in Balochistan. Current literature covers the STEAM concept in a general way, reviews nationally-based initiatives or takes individual approaches to curriculum, ICT, science education, teacher education or access to education. A historical examination is therefore essential to understand how these strands came together, when the explicit integration of STEM and STEAM approaches came about, who was influential in shaping the process and what the areas of disconnect are between the policy intention and systemic application of the approach.

I.I. Objective of the Study

This study aims to explore the past and the development of STEAM education schemes and policies in Balochistan province. The study investigates how earlier science, mathematics, technical, creative and ICT reforms evolved to explicit STEM and STEAM approaches and the factors that shape policy continuity, institutional development, patterns of implementation, equity, teacher capacity, technological infrastructure and provincial ownership.

2. Literature Review

2.I. The Journey from STEM to STEAM Education

The need for STEM education arose from the recognition that traditional education often divorced scientific and technical fields, and in practice these fields are often interdependent in solving the problems faced by science and technology workers. Integrated STEM does not simply add time to the STEM disciplines, but rather looks to meaningful connections between science, technology, engineering and math. Kelley and Knowles (2016) define integrated STEM as a "way of connecting scientific inquiry, technological literacy, engineering design, and mathematical thinking in meaningful contexts".

This separation in the focus of strengthening STEM subjects as opposed to integration is very important. All four STEM domains can be taught in a school that has mathematics/science teachers, a computer laboratory, and is still using disciplinary silos. The learner needs to transfer the knowledge between STEM fields as integrated STEM. For instance, to design a water-conservation system, one might need to learn about scientific characteristics of water, perform mathematical calculations to determine volume, incorporate engineering design, and utilize technology to model or monitor water-conservation system performance.

The integrative principle is expanded upon in STEAM, which adds arts to the mix. The principles are more involved than the addition of "drawing or decoration" to scientific activities. Arts can bring design thinking, communication and visualization techniques, creativity, cultural knowledge, ethical reflection, aesthetic judgment, storytelling and human-centered perspectives. This much broader idea is especially important in education, where the goal is to cultivate socially responsible students who not only create technically viable solutions, but can also comprehend the social and cultural contexts they are applied to.

The STEAM literature cautions about conceptual ambiguity. Perignat and Katz-Buonincontro (2019) conducted an integrative literature review that revealed wide differences among the definitions, combinations of disciplines, pedagogies and outcomes of STEAM. Similarly Colucci-Gray et al (2019) stress that with the introduction of the arts, the uses and purposes of STEM education expand and can go beyond pure economic and economic-productivity ones to include creativity, participation, environmental concerns and social significance.

Another is the prospect of the use of art as a means to an end. Some systematic reviews have reported that arts are sometimes added to enrich STEM content, but without artistic forms of knowledge and inquiry being considered, in their own right (Sanz-Camarero et al., 2023). The Balochistan case is particularly important in this regard as over the years, provincial school policy has seen "arts" and "science" as two distinct educational paths. So the later use of the term STEAM is not necessarily an indicator of deep arts integration, nor is it a requirement for a province to do.

2.2. STEAM Education Proper Policy or Single Goal Oriented Program

Just throwing a science fair, robotics event or even a technology lab won't cut it for a strong STEAM education system. It takes alignment when the curricula, pedagogy, teacher education, learning resources, assessment, school leadership, infrastructure, and institutional governance are aligned. Innovative activities can be introduced into a few schools in a program, but sustainable policy change takes place when these activities become part of the main lines of the state system.

The separation of initiative and policy is very important in historical analysis. Initiatives are typically limited interventions, having specific activities, partners, schools, and funding durations. Policies are systemic and establish standards, institutional roles, resource allocation, curriculum expectations and responsibility. The documented STEM and STEAM activities are mostly through national projects or development partnerships in Balochistan. The question of whether or not STEAM activities happened is not enough; it has to be whether they were institutionalized in the provincial education governance.

2.3. Education as Provincial Subject and the Balochistan Education Policy Context

The world is currently witnessing a series of shifts in education. Nowadays the world is seeing a slew of transformations in education that are being called provincialization of education.

The Eighteenth Constitutional Amendment (ECA) has changed the governance of education system in Pakistan radically through increasing the responsibility of provinces. Balochistan thus got more autonomy for planning educational programs, actualizing the curriculum, training of teachers, textbooks, assessments, and service provision. The post-devolution period is thus the most appropriate time frame for examining current provincial STEAM development.

Balochistan Education Sector Plan 2013- 2018 was the first comprehensive plan of the sector in Balochistan after devolution. The plan was developed by the Policy Planning and Implementation Unit and aimed to shift the focus from ad hoc interventions to coordinated reform in the education sector. It was prepared based on Provincial analysis and through support of the development partners; however, the institutional mandate was to facilitate the government ownership of planning (Government of Balochistan, 2013).

The plan is significant on a STEAM-history level because it is a pre-cursor to other plans. The learning areas most important for students' education were identified as science and mathematics, and the weaknesses of the concepts' explanations in curriculum and textbooks were criticized; the assessment practices were linked to rote learning, ICT was seen as a means to involve geographically dispersed communities and external expertise, and technical and vocational education was taken up as part of the broader sector architecture. However, these strands continued to be relatively distinct. Only limited evidence for 2013 plan that it planned for science, mathematics, technology, engineering, and arts through integrated pedagogical model now known as STEAM. The distinction is of analytical value. Looking back on history is easy to make contemporary terms apply to the past policies. Such a thing would make the universe's seemingly

longer history of STEAM than it actually is. Instead of thinking of 2013 as a year of STEAM, it would be more fitting to view it as the building of STEAM related foundations.

2.4. Reforms in Curriculum, Assessment, and Learning Outcomes

The curriculum and assessment structures impact on the possibility of learning that is integrated across disciplines. With a system of examinations that emphasizes recall of facts and textbooks that present knowledge in distinct modules, teachers are not strongly encouraged to use inquiry, design, experimentation, and/or interdisciplinary projects. This was exactly the issue that was identified in the initial sector analysis of Balochistan. The 2013 plan identified deficiencies in textbooks, teaching, assessment and implementation of the 2006 curriculum and identified that rote learning was a problem. The curriculum and textbook procedures were initiated in 2014 and Balochistan Assessment and Examination Commission (B.A.E.C) was established making the environment more formal for quality assurance.

The BESP 2020 – 2025 took this conversation forward by emphasizing learning design as the focus of reform. It saw curriculum frameworks, schemes of work, textbooks, teachers, teaching, assessment and learners as inter-related aspects of quality in education. The focus on numeracy, reading, analytical skill and preparing for life and livelihood in its stated goals shifted policy discourse to the focus on skills and competencies, not just memorization (Government of Balochistan, 2020). Though the plan was not inherently STEAM, it is very compatible with STEAM pedagogy. The interdisciplinary project-based learning relies on analytical ability, creativity, subject-specialist capacity and contextualized learning. The 2020-2025 years then could be considered as a time of building up STEAM readiness.

2.5. Capacity Building and Specialized Skill Development of Teachers

As interdisciplinary education places higher requirements on subject teachers, teachers are the key to the realization of STEAM. Disciplinary confidence and the ability to plan for students' learning in an inquiry-based way across multiple knowledge areas are needed for teachers. This is one of the significant issues in Balochistan. The BESP 2020-2025 noted a shortage of teachers as a problem in districts, especially in the areas of science and math. It also highlighted the inadequacies in the pre-service teacher training and the importance of CPD in PITE as the major institution.

An issue with sequence is that there is a lack of subject experts. We have struggled with effective interdisciplinary integration when we don't have teachers with adequate disciplinary content in the first place. Therefore, in strengthening mathematics, science, IT, and language instruction it is not a replacement for STEAM but a necessary component of the capacity needed for successful interdisciplinary work before it can become sustainable. Gender is also a crucial aspect. The provincial planning has identified lack of female science and maths teachers and a need to increase female involvement. This is also a priority that resonates with the goal of STEAM Pakistan to enhance the participation of girls in STEAM disciplines.

2.6. Digital Infrastructure and Technology-Facilitated Learning

Technology has a unique role in STEAM as it is a discipline, a tool for other disciplines and a conduit for accessing education. Balochistan's geographical context could be very useful in utilizing digital learning to link teachers and students in remote areas with resources which are mostly available to the students in cities. But the same geography poses electricity and connectivity challenges. The facts of history indicate that there is a problem. A computer laboratory was reported in only 1.3% of Schools in Balochistan in 2016–2017, the highest proportion of which was 8% in Quetta District. Access to education is also limited in the high and higher secondary schools (Government of Balochistan, 2017).

Provincial statistics indicated improvement by 2022-2023 but highlighted poor infrastructure: at schools overall 20.9% had electricity and there was 6.9% reporting on computer laboratories. There is a need to adapt technology-rich models developed in well-resourced urban schools for implementation in Balochistan schools because of such conditions. In a review of technology facilitated learning in Pakistan, Wilson et al. (2022) also found that the Balochistan Education Sector Plan acknowledged the limited internet connectivity and limited extent of use of distance education in rural areas. Their broader analysis highlights the critical role of teachers, infrastructure, family support, and the right pedagogy, along with ongoing institutional engagement – all of which contribute to the effectiveness of EdTech as a process that enhances learning. This argument has implications directly to STEAM: Fab equipments or computers can not directly create interdisciplinary learning.

2.7. Explicit STEM and STEAM Initiatives in Pakistan

The most visible shift from precursor-like reforms to a specific branding of STEM education was in the context of the national project by the Pakistan Science Foundation. On 4th August 2021, the launching of STEM in Pakistan, Phase-I was approved on the rate of about Rs. 993.784 million. It aimed at the grade 9–12 students and aimed to create the conditions for STEM learning in certain higher-secondary schools and cadet colleges including areas of gender balance and non-represented areas. The project included teacher training, the integration of technologies like 3D printing and digital fabrication, inquiry-based learning, and selected laboratories that were converted into mini STEM fabrication laboratories, and practical activities. Ten institutions were mentioned on the official list in Balochistan which were spread across Quetta, Kachhi, Turbat, Hub, Loralai, Ziarat, Killa Saifullah, Chagai and Sui. This marked a key historical shift in emphasis, from a theoretical possibility of integration (as a corollary of provincial reform) to a program goal.

The next STEAM Pakistan project added the arts and added more weight to the school culture, the communities of teachers, mentorship, storytelling, hands-on activity and policy reform. The program defines STEAM as a "multidisciplinary approach placing science, technology, engineering, arts, and mathematics together for collaborative problem solving and real world learning. It is not just limited to schools, as it has a partnership model that goes beyond that. A growing idea was to link school students to universities, laboratories, faculty knowledge, mathematics circles, STEAM clubs, guest speakers, competitions, and visits to the university campuses, which is what MoFEPT did in its partnerships with the universities, as opposed to merely providing a laboratory.

However, certain provinces have been more successful than others in implementing this. According to an official record in Senate, 7,229 partner schools were there country wide but only 9 in Balochistan till January 13, 2025. There was no dedicated policy unit for the STEAM Policy for Balochistan yet and was to be put in place in 2025. This imbalance is one of the main outstanding issues in Balochistan's STEAM journey: national innovation has come to the province but yet institutionalization and scaling up are lacking.

2.8. Research Gap and Analytical Framework

Few elements have been identified in the literature to support STEAM development in Balochistan, these are: curriculum reform, science and mathematics education, teacher shortage, limitations of ICT, assessment reform, national STEM laboratories and national STEAM programming. Their historical relationship has yet to be explored. The majority of documents available are reports of interventions at one moment rather than an analysis of how one reform led to the other. As a result, little is known about the nature of current STEAM projects: whether it is a policy shift or an extension of past policies under new labels or a new layer on top of an education system that remains largely content-driven. This gap is filled in the present study, which uses systematic historical content analysis.

A historical-institutional and policy-layering view is used for the study. Historical institutionalism takes as its starting point that new educational reform does not come about on a blank institutional ground. Prior reforms can affect what can be accomplished by subsequent reform initiatives, including existing curriculum, teacher corps, assessment measures, administration, buildings, and past policy decisions. Previous decisions are thus capacities and constraints. Policy layering is a significant issue in Balochistan. The successive projects have not been about creating a new STEAM school building but about building upon previous school buildings. Then came the curriculum and assessment change, followed by the addition of digital and ICT policies and priorities in the existing school systems, the introduction of federally supported STEM laboratories in selected schools, and later the incorporation of the arts, teacher networks and policy-integration aspirations in the framework of STEAM Pakistan.

The analysis focuses thus on four interconnected aspects of STEAM development: evolution of the conceptual framework (from disciplinary subjects, to interdisciplinary learning); evolution of the institutional framework (from individual pilot STEAM schools to STEAM scale-up governance); evolution of the implementation framework (from individual STEAM schools and pilots to potential scale-up); and evolution in terms of equity (gender, geography, school resources). The historical question does not simply concern when the word "STEAM" came into use, but how the province came about to create or not create the systemic conditions conducive to STEAM education.

3. Materials and Methods

The study used qualitative historical content analysis design to examine the development of the STEAM related education programs and policies in Balochistan. Since the focus of the research was to examine the policy texts,

institutional records, education plans, administrative documents, statistical reports, program descriptions, and scholarly literature in a systemic way, but not to collect primary interview data, a content analysis approach was chosen. The document corpus was purposively developed towards materials that regulated education in Balochistan or materials that were directly related to science, technology, engineering, arts, mathematics, curriculum, assessment, teacher development or interdisciplinary learning. These core documents included the Balochistan Education Sector Plans for 2013–2018, 2020–2025, and 2025–2030 (the present planning cycle); education statistics at Province level; booklets related to curriculum and textbooks policy; assessment legislation; documents of Pakistan Science Foundation STEM program; records of MoFEPT and STEAM Pakistan documents; documents of Parliament; teacher-development materials; and relevant peer-reviewed literature. The time frame covered in the historical analysis was 2011–2026, with previous national curriculum changes included as appropriate to help illuminate previous provincial changes. The documents were read in a chronological order and both deductive and inductive categories were used to code them. The categories used were deductive and comprised of curriculum orientation, teaching pedagogy, science and mathematics provision, ICT and technology, teacher capacity, assessment, gender equity, infrastructure, institutional ownership, arts integration, partnerships, and implementation scale. The patterns that emerged from the inductive coding were Policy layering, External partnerships, Rote learning to analytical learning, and pilot innovation to system-wide institutionalization. The triangulation of evidence included provincial documents, federal program records, parliamentary reports, education statistics and academic literature. The analysis made clear a difference between policy intent and documented implementation – just because a policy was mentioned in a statement did not mean it had an impact in the classroom. Likewise, some of the earlier science and/or ICT reforms were not considered STEAM until they were added in after the fact. No personal data were collected as only publicly available documentary evidence was used in the study. One caveat to this is that documentary analysis can be used with greater confidence to reconstruct formal policy development as compared with the day-to-day enactment of policy in classrooms, especially when program evaluations are limited.

4. Data Analysis and Findings

4.1. Pre-STEAM Foundation: Technical Education, and Rote-Learning Challenges

The first step found in the analysis can be described as a phase for disciplinary foundations. There was a presence of science, mathematics, technical education, information and communication technology (ICT) and arts in the education system, but mostly in the form of separate curricular or institutional units. This stage was then marked by not the integration of STEAM, but the creation and the (failed attempt) to improve the individual STEAM disciplines. National Curriculum 2006 had a legacy during this time. Balochistan later implemented curriculum arrangements based on standards, inspired by this national framework but the implementation was faced with challenges. Analysis related to the development of the next sector plans highlighted the mismatch between the intent of curriculum being learner-centred and classroom practice.

Education system also continued to have the traditional dichotomy of science and arts streams in Secondary Level. These buildings embodied the traditional disciplinary structure of the school and its prevailing culture of students pursuing subject strands instead of integrating scientific, technologic, mathematical and artistic/design approaches to shared issues. This historic organization is of significance because it paved the way for STEAM to emerge in a system set up around specialization and examination subjects. The integrated STEAM policy thus appears to have been absent from the context of Balochistan during this earlier period of time. However, the problems of weak science and mathematics learning, technical skills, creativity, ICT and pedagogy that focus on learners gradually gave rise to the policy environment out of which STEAM could later grow.

4.2. The 2011–2013 Devolution of Education and Building up of Policy Capacity in Province

The first big turning point is after the Eighteenth Constitutional Amendment. Balochistan needed more robust planning, curriculum, implementation, research, assessment and coordination mechanisms in the sector as the responsibility for education was delegated to the provinces. This institutional change is reflected in the Balochistan Action Plan of 2011 and the formulation of the BEP 2013–2018. However, the provincial EMIS repository remains as two key parts of the provincial policy history. The BEP 2013–2018 was an important step forward in that it tried to combine several aspects of education in a single national strategy sector by sector. The curriculum, books, evaluation, teacher training, educational management, literacy, ICT, technical and vocational education were not viewed as separate administrative initiatives, but as part of a bi-directional system.

One of the key aspects of the plan from a STEAM perspective was an understanding that the quality of education was not about what could be seen in the textbooks, it was about concept creation and understanding. A review of the plan led to the identification of gaps in science and mathematics textbooks, poor implementation of the standards, and the assessment practices which encouraged memorization. The plan also took into account geographical conditions in Balochistan as an excuse for the investigation of ICT. Information technologies were rationalized as a solution for linking educators and educational institutions not only due to the long distances but also because of large distances, dispersed settlements, inadequate communication system and the inability to get specialized expertise. This was not digital STEAM education, but it was a big shift in policy as it began to recognize that technology could be used as a tool to support the educational process rather than as a computer course.

Another observation of particular significance, is the plan's understanding of the lack of a strong research culture and reliance on ideas brought in by the development partners. This observation is a pertinent one to connect with subsequent development of STEAM. Innovation can be introduced into an education system from outside, with the help of experts and money, but it needs to be owned by local institutions, have research capacity and adapt. It was therefore not surprising to see the seeds of another governance challenge in the first sector plan. Thus, the time period 2011–2013 should be considered as the construction phase of STEAM history, rather than the implementation phase. It established provincial organizations in which further interdisciplinary changes might be incorporated.

4.3. The Curriculum, Assessment and Institutional Consolidation (2014-2018)

The next period was a time of institutional consolidation. Balochistan Compulsory Education Act 2014 provided a stronger legal framework for educational access and the curriculum and textbook development procedures were at the provincial level intended to formalize quality assurance. Provision of assessment institutions in provinces and strengthening of these institutions by law further added to the government's capacity to monitor learning. While these may seem to be only tangentially connected to STEAM, these are historically relevant. Integrated education cannot be maintained just by the implementation of extra-curricular activities if there is no change to the curricular standards, text books, assessment and teacher expectations, which continue to focus on memorizing subjects. Thus, institutional reform during this time contributed some of the governance structure needed for implementation of future competency based approaches.

The content analysis shows, however, that hardly any evidence exists of the actual nature of the fundamental changes in disciplinary boundaries. There was little integration of these courses with the others, and they were mostly kept in isolation, especially the subjects of science, mathematics, IT, vocational subjects and arts. There was little evidence of engineering design being firmly established as a regular school-learning process and the arts were still predominantly linked to the traditional, or curriculum-driven, categories of learning and not seen as a collaborator in scientific and technological problem solving. The importance of this time is not conceptually in terms of STEAM adoption, but rather in the readiness of systems. Mechanisms in place to support implementation of a future STEAM policy were being reinforced in the province, but an interdisciplinary approach was not to be seen.

4.4. Learning Centered Reform and Building of STEAM Education

The second was the BESP 2020 - 2025. It was more focused on the process of learning, than the earlier plan. The elements of curriculum frameworks, schemes of work, texts, teacher ability, classroom practice, assessment, child welfare and context of the school were considered as interacting elements. The plan clearly stated the objective of the development of reading, numeracy, analytical skills, preparation for life and livelihood. This was a significant paradigm shift in thinking to competencies that are aligned with STEM and STEAM learning. Students have to analyse, not reproduce information in interdisciplinary problem solving. The iterative thinking is required to engineering design. Questions are a part of science inquiry and so are evidences. Space for other solutions is needed for creativity. The BESP challenged learning designs which focused on rote learning and promoted analytical skills, bringing the province closer to the pedagogical priorities of today's STEAM. Another key focus was on teacher specialization. The plan noted lack of science and mathematics educators at the district level, and deep science teacher preparation and professional development shortcomings. The results reveal an underlying issue: good interdisciplinary teaching cannot offset the lack of knowledge in a particular subject. To be able to relate mathematics to engineering, or science to technological design, there needs to be a certain level of expertise in the science, engineering or mathematical areas.

Gender became more apparent within this challenge as it was found that remote girls' schools tended to be more at an impasse in finding specialist teachers. Thus, the attention of national STEAM initiatives to girls did not simply spring into existence, but emerged in line with a preexisting provincial interest in the issue of the access of girls to

STEM and maths teaching. Digital education is another element of STEAM readiness that was quickened by the COVID-19 pandemic. Given that schooling had been disrupted, BESP 2020–2025 was aware of the possibilities of alternative delivery via television, radio and digital platforms. But at the same time the sector plan also recognized that distance-learning opportunities were “clumped” in urban areas, and that connectivity was also limited to urban areas. The conflict between the potential and availability of educational technology was an integral part of the province's next wave of innovation.

This is supported by infrastructure statistics. Only 1.3% of schools had a computer laboratory in 2016–2017. Availability of computer-labs was not greatly improved and only approximately one-fifth of schools had electricity by 2022–2023. The progression over time then shows improvement in technology without technological readiness. Thus, the 2020-2021 becomes an understanding of learning reform as the way to STEM-readiness. Analytical learning, specialized STEM teachers, ICT and teacher development were highlighted as priorities in the province and an explicitly integrated STEAM approach had not yet emerged as the framework for the provincial education policy.

4.5. Explicit STEM Education in Balochistan and Pakistan Science Foundation

With the launch of the national STEM project by Pakistan Science Foundation, the journey started in a qualitatively different way. The specific focus of “Launching of STEM in Pakistan, Phase-I” was to motivate students in Grades 9-12 for STEM education and to build the capacity of students in interdisciplinary and hands-on skills. Selected higher secondary schools and cadet colleges were the focus of the national project, which included gender equity and concerns for underserved areas. This measure is historically important as it was no longer assumed that the reforms in science, mathematics and ICT will lead to STEM. It was made a program identity.

The project aimed to convert the existing laboratories into mini STEM fabrication laboratories, and integrate theory with practical experience. The model included teacher training, inquiry-based activity, fabrication, problem solving and modern equipments. This is an ongoing initiative of the Pakistan Science Foundation to create a manpower base for the new technological and knowledge-based economies in Pakistan by means of its annual reporting. A direct representation of Balochistan was taken care of. There are 10 institutions in the province on the official list of fabrication laboratories (girls' and boys' schools, and institutions in Quetta, Kachhi, Turbat, Hub, Loralai, Ziarat, Killa Saifullah, Chagai and Sui). Of particular interest is this geographical distribution, which included institutional facilities for girls, in addition to Quetta.

The project also transformed the material notion of science & technology learning. Lab-oriented STEMs focused on the notion of inputs, such as laboratories, whereas fabrication-oriented STEMs highlighted making, designing, experimenting and linking knowledge to outputs. This was an approach that was more closely aligned with international conceptions of integrated STEM. But there were certain shortcomings in the program in the history of provincial policy. Prior to this, it was a Federal project, not a complete Provincial STEM policy for Balochistan. Second, it had very limited school coverage as compared to the provincial system. Thirdly, its acronym didn't change to STEAM — the arts were not given a seat at the table. Lastly, the introduction of advanced equipment can not necessarily solve pre-existing problems that include the shortage of teachers, electricity, connectivity, assessment, and curriculum alignment. Thus, the explicit STEM implementation phase in Balochistan for 2021-2022 is the first explicitly documented explicit phase of STEM implementation and was pilot and externally initiated.

4.6. The Transition from STEM to Explicit STEAM in 2022-2025

In 2022, STEAM Pakistan was launched and started to grow as the third turning point. This initiative was not only the introduction of the letter “A” but had a broader vision of school transformation as compared to the previous project of the Pakistan Science Foundation. According to STEAM Pakistan, STEAM is interdisciplinary education that combines science, technology, engineering, arts and mathematics in an experiential manner that involves problem solving in real-world contexts. It is aimed at students, teachers, government institutions and policy makers and its objective is information for policy in sustainable impact.

In April 2022, MoFEPT started the process of formalizing university partnerships for it. The partnership idea was grounded in the idea that there are faculty, labs, maker spaces, studios, and academic networks within universities that can be tapped by school systems. Later agreements included using mathematics circles, STEAM clubs, professional speakers, competitions, visits to universities, and teacher activities. This was a much bigger conceptual leap than a hardware approach to STEM. STEAM clubs facilitated reoccurring school programs, STEAM Safeers made links

between students and professionals, Teachers' Hubs fostered professional communities, and STEAM Storytelling utilized storytelling to make complex ideas easily understood.

The increased accentuation of access to education for female students also reflected the longstanding concerns of Balochistan regarding educational access for women and lack of female specialists in science and math. The STEAM Pakistan model, in principle, thus touched two important aspects; interdisciplinary pedagogy and an equity aspect. However, institutionalization uptake was limited in Balochistan. The January 20, 2025, Senate record is key. It said that the national STEAM Policy Unit was set up in March 2022 in MoFEPT, while two other units were established in Sindh, Gilgit-Baltistan and Punjab and another in Khyber Pakhtunkhwa. Some of the STEAM Policy Units in Balochistan remained identified as “to be set up in 2025.” There were 9 partner schools in Balochistan while 4,176 and 2,538 schools were partner schools in Punjab and Sindh, respectively, as of January 13, 2025.

The above figures show that the transition process towards STEAM in Pakistan was not uniform. Institutionalization in Balochistan was lagging behind the other better-established institutionalization programmes in the country, despite the inclusion of Balochistan in the national programme. This distinction is important because if a school with federal or federally affiliated schools has a small number of activities that are transformed, this cannot be considered a transformation of STEAM across the province. The evidence, however, suggests a picture of early adoption, but shallow institutionalization.

The arts dimension also was relatively undeveloped. While STEAM Pakistan's storytelling, design, communication and creative activities offer real opportunities for arts integration, the overall education-policy structure of Balochistan persisted with the separation of arts and science from its curriculum. With this, the introduction of the “A” in program terminology signals an important conceptual shift but not yet clear evidence of systematic incorporation of artistic inquiry in the curricula of all provinces, teacher preparation programs, and assessment.

4.7. The Future Direction and Institutionalization of STEAM Education

This phase is not a STEAM consolidation phase but a transition phase. Balochistan Education Sector Plan 2025–2030 is the current 5-year strategic plan in the School Education Department's official document centre which was published in November 2025. It has been designed to inform access, quality, governance, funding and implementation of sectors in the new planning cycle. Meanwhile, the growth of teacher professional development has been greatly enhanced by digitization. Government teachers benefit from online professional-development opportunities through PITE's Virtual Academy for Teacher Training that is available in remote districts, even in areas with limited connectivity. The platform is oriented around the subject content, classroom management, child development, and the use of up-to-date approaches to teaching and learning and is designed to meet provincial education priorities and national curriculum requirements.

As per July 2026, records from VATT showed that the number of teachers participating in various large-scale training categories was beyond 11,000. VATT is not a STEAM program per se, but rather its relevance to STEAM history is that it is a platform that will support further large-scale teacher learning in STEAM. Such mechanisms are necessary in a province where teachers live in wide-spread and remote areas, to allow for interdisciplinary professional development to shift from face-to-face workshops limited to Quetta. Discussions regarding reforming the province have also been ongoing and continued to focus on specialist science and mathematics teachers, modern pedagogies, digital tools, and the strengthening of PITEs' capacity, along with better coordination of development partner support. These trends align with the circumstances needed for the institutionalization of STEAM.

The scale challenge, however, is too big. The School Education Department (SED) has 14,709 public schools, over 1.2 million public school students in attendance, and over 80,000 teachers and staff in 39 districts as of 30 July 2026. Ten schools in Balochistan, identified by the Pakistan Science Foundation's STEM fabrication program over the years, and nine schools as partners of STEAM Pakistan, have only a limited institutional presence in that system size. Based on the available evidence from the history up to 2026, it is not justifiable to say that the province of Balochistan has achieved a province-wide transition to STEAM education. Instead, it is a time of nascent institutional opportunity that is present in the province. It has better planning systems, digital teacher training systems, STEM laboratory experience, exposure to interdisciplinary STEAM programming and institutions that have established curriculum and assessment institutions. Lacking is a lack of systemization that is not adequately demonstrated so that these components can be aligned under one provincial STEAM framework.

5. Discussion

The history shows that the trajectory of the development of STEAM learning in Balochistan is not a simple case of adoption nor a linear series of programmes. It is more comprehensible as layering of policies over a period of nearly fifteen years of educational reform. The first was enhancing the traditional educational base – science, maths, curriculum, technical education, teacher development and ICT. The second enhanced provincial planning, curriculum, textbooks and assessment and quality assurance following devolution of education. The third turned policy dialogue further towards learning, analytical ability, creative thinking, specialized teachers and access to digital. The fourth explicitly brought in the concept of STEM education using a federal fabrication-laboratory and a hands-on learning model. The fifth introduced the integration of arts, storytelling, school clubs, networks of teachers and the partnership with the universities, and explicit policy integration plans under the name STEAM Pakistan.

This path shows a true progression in ideas. The primary educational issue has slowly moved from the provision of specific subjects and inputs in schools to linking content together, building analytical skills, relating to problems and learning skills for the modern world. In this context, STEAM is a component of a larger trend—content coverage to competency-based learning. But history also shows that conceptual change is outstripping institutional change. There's a big issue here about provincial ownership and federal innovation. While education is mostly done through a provincial system, the most explicit and clearly labeled STEM and STEAM initiatives arrived in Balochistan via national programs (e.g., Pakistan Science Foundation, MoFEPT). Federal involvement can offer resources, expertise, visibility, experimentation and cross-provincial learning. However, if provincial curriculum, teacher-development, assessment, budgeting and school-management systems do not then absorb these programs, they are still susceptible to fragmentation.

This can be seen from the fact that the establishment of a dedicated Balochistan STEAM Policy Unit is delayed and the number of partner schools in January 2025 is small. The main historical question now becomes, then, whether Balochistan has experienced STEAM? So the big question in the eyes of the history is now: Has the province of Balochistan faced STEAM? It clearly has. The question is not whether STEAM is a capability of the government but whether it is not, and can't be, dependent on a few special projects, partnerships, and schools with the will to work for STEAM.

Another key constraint is infrastructure. While fabrication laboratories, digital resources and coding, design software, robotics and multimedia can enhance STEAM learning, the school system in Balochistan has been much more challenged by much more basic infrastructure constraints. Limited electricity and computer laboratory availability, as reflected in provincial statistics, testifies to the need to design a technology-driven model that has the potential to create unintended consequences of increasing educational disparity when it is concentrated in high-performing schools.

This is confirmed by the literature on EdTech. Technology solutions have the power to be of educational benefit only if they are part of a right pedagogical approach, teacher support, technology infrastructure, and institutional framework (Wilson et al., 2022). A room with 3D printers does not necessarily make a STEM room, and a computer lab does not necessarily demonstrate digital learning. What is the frequency of learners accessing resources to investigate, design, collaborate, create, test, revise and explain?

The third key issue is teacher capacity. Multiple times, the planning documents of Balochistan have also mentioned a deficit of science and mathematics teachers in Balochistan. The pedagogical requirement is a new one for STEAM: teachers should now work together with others and relate ideas about problems across fields. Hence the need for a dual strategy in order to succeed with STEAM reform. The province needs to further build knowledge in the disciplines of science and mathematics, as well as the capacity of teachers to include interdisciplinary approaches to science and math learning through projects and inquiry. Given the nature of VATT, it offers a critical institutional opportunity as opportunities for professional development can expand beyond urban areas. For an explicit interdisciplinary reform, however, an explicit STEAM professional-development pathway would be necessary if this infrastructure is to support this interdisciplinary reform.

The fourth discovery was in the field of the arts. A history of the development of science, mathematics, technology and analytical learning is way more obvious than in the substantive arts. This means the transition of the STEM to the STEAM concept was incomplete in Balochistan. Arts should not be just an accessory to a science project, or to act as entertainment around a maths project. The design, visual communication, local crafts, architecture, story telling, music, cultural heritage, indigenous ecological knowledge and regional art forms are some of the knowledge types that can be incorporated in the creation of meaningful Balochistan STEAM model that can enrich scientific and technological inquiry. This, especially, since the arts are often used as instruments, not as integral parts of STEAM

(Sanz-Camarero et al., 2023). A locally designed STEAM model is the ideal solution for Balochistan to avoid this issue and to focus on locally designed activity models instead of those imported from elsewhere.

The fifth, historical continuity is equity. Before STEAM's explicit appearance, these challenges of educational participation for girls, lack of women in science and mathematics, educational isolationism, and educational technological disadvantage were issues that were prevalent across the province. It is in this context that the national initiative for STEAM aims to strengthen girls' participation in STEAM, rather than establish a new need. It is important that in a future provincial model this emphasis is retained and that issues of rurality, poverty, disability, language and access to the remote districts are taken into account.

Lastly, there is a problem with the evaluation. The ability of official sources to record plans, numbers of partner schools, facilities, training activities and administrative structures is relatively good. While there is some evidence of sustained improvements in SRS, mathematical problem solving, creativity, collaboration, design ability, student aspirations, girls' participation in advanced study, and teacher classroom practice, there is significantly less in the public record, particularly in Balochistan, that STEAM interventions have led to sustained improvements in these areas. Lack of evidence does not indicate failure of programs. It illustrates how implementation evidence is not necessarily impact evidence. For a world-class STEAM strategy, the evaluation systems would need to be able to assess reach and quality of learning. In general, the historical evidence shows four general stages of conceptual development: stages of disciplinary strengthening, system readiness, explicit STEM experimentation, and emerging integration of STEAM. Clearly, Balochistan has gone through the first three stages and has reached the fourth and further, but not fully institutionalized.

6. Conclusions

A qualitative historical content analysis was used to explore the history and development of STEAM learning initiatives and policies in Balochistan. The results show that STEAM education in the province is not a policy package. It evolved over a period of time, as a result of more and more changes to the structure of education. At the initial levels, these aspects—namely science, mathematics, technical education, curriculum, textbooks, assessment, ICT, and teacher development—were reinforced as distinctly separate aspects. After the Eighteenth Constitutional Amendment, devolution of education allowed Balochistan to play a larger role in the organization of these through provincial bodies. The Balochistan Education Sector Plan 2013–2018 provided a critical framework on a systemic basis and highlighted the areas of conceptual learning, science and mathematics education, teacher preparation, assessment, research, and ICT as the areas of weakness.

Between 2014 and 2018, institutional reforms further reinforced the governance of curriculum and assessment; and the BESP 2020–25 shifted the policy focus toward learning, numeracy, analytical ability, contextualized materials, specialized science and mathematics teachers, teacher professional development and digital alternatives. While not a direct call for STEAM education, the education reform increased the province's readiness for STEAM education. A turning point was reached in 2021, by the explicit identification of STEM programmes in Pakistan, such as fabrication laboratories, and practical inter-disciplinary learning in selected schools of Balochistan, done by the Pakistan Science Foundation. The subsequent work of STEAM Pakistan (2022) broadened the vision to include arts, storytelling, creativity, teachers' communities, professional mentoring, university connections, girls' engagement, and policy changes.

But this historical analysis also shows the boundaries of this transformation. By the beginning of 2025, participation by Balochistan in the national STEAM programming was relatively low, and a provincial STEAM Policy Unit has not yet been developed. Old issues like school infrastructure, electricity, computer access, specialist teachers, geographical spread and institutional capacity remain key factors to consider when determining what can be realistically achieved. The most important finding is that the educational components in STEAM have shifted from mere mentioning to there being actual STEAM initiatives, but not yet a STEAM education system in the province.

This is a key distinction. Science lab isn't a science education lab. Technological literacy is not a computer! An activity that is creative does not necessarily qualify as an arts integration activity. A national project in a number of provincial schools is not a provincially institutionalized policy. Sustainable STEAM education is realized when the curriculum, teachers, assessment, resources, leadership, partnerships, and learning experiences all work together to help develop interdisciplinary problem solving. There is a great opportunity in the current period. Balochistan now has a new education-sector planning cycle, an increase in digital teacher development infrastructure, the development of curriculum and assessment institutions, experience with STEM fabrication labs, and a large public-school system in

which innovation could be scaled. Whether these distinct capacities will continue to be parallel ventures or are purposefully linked will be the next historical phase.

A provincial-based framework, coupled with an equity-based scaling model, would enable Balochistan to not only have episodic STEAM activities but also sustainable educational transformation. Such a model should not be mechanically reproduced in other settings lacking the resources of the others. It should be designed accordingly keeping its geographic, cultural, linguistic, environmental, economic, artistic and institutional realities in mind. The evolution of STEAM in Balochistan is an evolution of going from disciplinary separation to interdisciplinary possibilities. The province has established numerous institutional building blocks for the next steps. The next big policy hurdle is to transform those building blocks into a system where STEM is not just subjects that are delivered side-by-side in school, but a system of learning that allows young people to understand and respond to the challenges of their communities and their future.

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