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Designing a Model for Enhancing the Skills of Primary School Principals with an Emphasis on STEAM Education

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A B S T R A C T

Objective: This study aimed to design a comprehensive model for enhancing the professional and managerial skills of primary school principals with an emphasis on the implementation of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education.

Methods and Materials: This qualitative study employed a thematic analysis design. The study population consisted of primary school principals, experts in school management and STEAM education, university faculty members, educational administrators, and specialists working in the 22 education districts of Tehran, Iran. Fifteen participants were selected through purposive sampling, and recruitment continued until theoretical data saturation was achieved. Data were collected through in-depth, semi-structured interviews designed to explore participants' experiences, perceptions, and recommendations regarding the competencies required by primary school principals for the successful implementation of STEAM education. The interview data were transcribed, coded, categorized, and analyzed using thematic network analysis. The credibility and consistency of the findings were supported through systematic coding, continuous comparison of the extracted concepts, expert review, and revision of the thematic structure.

Findings: The thematic network analysis identified 155 initial codes, which were classified into 28 organizing themes and six global themes. The six principal dimensions of the proposed model were strategic and transformational leadership of primary school principals in implementing STEAM education; development of the professional and managerial competencies of school human resources; establishment of a participatory, innovative, and learning-oriented organizational culture; management of resources, processes, and the quality of STEAM program implementation; enhancement of managerial communication, collaboration, and networking skills; and sustainability, alignment, institutionalization, and inclusive implementation of STEAM programs in primary schools. These interconnected dimensions constituted the main structural components of the proposed skill-enhancement model.

Conclusion: The proposed model indicates that successful STEAM implementation requires primary school principals to possess integrated leadership, professional, communicative, organizational, and resource-management competencies.

Keywords: *Principals' Skills, STEAM Education, Primary Schools, Educational Administration, Tehran*

1 Introduction

The accelerating transformation of educational systems has intensified the need for schools to prepare learners for complex, technology-rich, interdisciplinary, and rapidly changing social and occupational environments. Contemporary education is no longer expected merely to transmit disciplinary knowledge; rather, it must cultivate creativity, critical thinking, problem-solving, collaboration, technological literacy, adaptability, and the capacity to apply knowledge in authentic contexts. Within this transformation, Science, Technology, Engineering, Arts, and Mathematics education, commonly referred to as STEAM education, has emerged as an integrated instructional approach intended to reduce disciplinary fragmentation and connect scientific and technical learning with artistic creativity, design thinking, communication, and human-centered problem-solving. STEAM education therefore represents more than the simultaneous teaching of several subjects. It involves establishing meaningful relationships among disciplines, designing inquiry-oriented learning experiences, and encouraging learners to generate innovative solutions to multidimensional problems. Research synthesis has shown that integrated STEAM education depends on teaching–learning strategies that facilitate interdisciplinary connections, active participation, inquiry, collaboration, project development, and the practical application of concepts (Akrami et al., 2026). Similarly, investigations of the interconnection among STEAM domains indicate that integrated learning can create coherent conceptual relationships and enable students to understand how knowledge from multiple fields contributes to the analysis of real-world phenomena (Viseu et al., 2025).

The significance of STEAM education is particularly evident at the primary school level. Primary education is the foundational stage during which students develop their initial attitudes toward learning, science, technology, creativity, social participation, and problem-solving. Educational experiences provided at this stage can influence students' subsequent academic trajectories, self-efficacy, intellectual curiosity, and willingness to engage with complex learning tasks. Accordingly, the implementation of STEAM in primary schools can provide children with early opportunities to explore, construct, design, experiment, collaborate, and communicate. An optimal primary education model based on the integrated STEAM approach requires alignment among curriculum objectives, learning activities, instructional strategies, assessment procedures, school resources, and the developmental characteristics of students (Eskandari et al., 2024). STEAM-oriented teaching also emphasizes experiential, interdisciplinary, and learner-centered processes through which abstract knowledge is transformed into meaningful and applicable understanding (Badreh & Savaedi, 2024). Therefore, successful STEAM implementation at the primary level requires not only curricular innovation but also a school-level management system capable of supporting instructional change.

Empirical evidence indicates that STEAM-based educational methods can improve the quality of learning by engaging students in practical and creative activities. For example, STEAM-based instruction in programming through Scratch software provides a context in which learners can integrate computational thinking, problem-solving, design, creativity, and technological application (Abtahi & Fathali Beigi, 2024). Comparative research on STEM and STEAM teaching methods has also highlighted the potential contribution of the arts component to students' creativity and problem-solving abilities, because artistic processes can strengthen imagination, flexibility, communication, and the generation of alternative solutions (Rahmati Nejad, 2025). Furthermore, the incorporation of artificial intelligence into the STEAM curriculum creates new possibilities for personalized learning, data-informed instruction, adaptive educational environments, and the development of advanced digital competencies (Pourjamshidi & Mozaffari, 2024). These developments indicate that STEAM implementation is not limited to the adoption of a particular teaching technique; it requires continuous decisions regarding technologies, instructional resources, learning spaces, staff development, ethical considerations, assessment practices, and curricular coherence.

Despite its educational potential, the transition from conventional subject-based instruction to integrated STEAM education is a complex organizational change. Comparative analysis of STEAM curricula in different countries indicates that translating policy aspirations into school practices requires contextual adaptation, institutional support, appropriate teacher preparation, suitable learning materials, interdisciplinary planning, and systematic evaluation (Shahbazi Dastjerdeh et al., 2024). Educational systems may formally acknowledge the value of STEAM while schools continue to face practical barriers such as insufficient resources, limited teacher competencies, fragmented curricula, inadequate technological infrastructure, resistance to change, weak collaboration, and a lack of clear

implementation standards. Evidence concerning preschool teachers' implementation of STEAM activities similarly suggests that implementation is affected by multiple professional and organizational factors rather than by teachers' individual willingness alone (Nguyen et al., 2025). Thus, the institutionalization of STEAM education depends on the interaction of leadership, human resources, organizational culture, planning, technology, finance, assessment, and stakeholder engagement.

Within this process, school principals occupy a central position because they connect educational policy with school-level practice. Principals are responsible for interpreting reforms, communicating organizational priorities, allocating resources, developing staff capabilities, supervising instructional processes, creating collaborative structures, managing resistance, and evaluating implementation outcomes. Their decisions can determine whether an innovation becomes embedded in the school's routines or remains a temporary and fragmented initiative. At the primary school level, the principal must simultaneously address instructional leadership, administrative coordination, teacher development, student needs, family expectations, resource constraints, and regulatory requirements. Research has demonstrated that primary school principals' skills are associated with the quality of organizational and educational performance, emphasizing that effective school management depends on a combination of technical, human, conceptual, and leadership competencies (Manti et al., 2023). Moreover, the relationship between principals' managerial skills and teachers' performance quality indicates that managerial competence can influence instructional effectiveness indirectly through the conditions, guidance, support, and professional environment provided for teachers (Undiadi & Muhammad, 2025).

In a STEAM-oriented school, the principal's role extends beyond routine administration. The principal must serve as a strategic leader who develops a shared vision of integrated education and translates that vision into long-term plans, measurable objectives, operational priorities, and coordinated activities. Strategic leadership is necessary to align school programs with STEAM-related policies while ensuring that reform efforts remain responsive to local needs. Transformational leadership is likewise important because STEAM implementation frequently requires changes in teachers' beliefs, professional roles, instructional routines, collaboration patterns, and approaches to assessment. Principals must communicate the value of change, inspire commitment, encourage experimentation, reduce uncertainty, and establish psychological safety for innovation. The development of educational managers' skills in the era of the Fourth Industrial Revolution further demonstrates that contemporary managers require advanced competencies in strategic thinking, technological understanding, innovation, change management, learning leadership, and data-based decision-making (Darini & Vafaei Yeganeh, 2024). These competencies are particularly relevant to STEAM education because its implementation occurs within the broader digital and technological transformation of schooling.

Evidence-based decision-making constitutes another essential managerial competency. Principals must use information about student learning, teacher performance, program quality, resource utilization, stakeholder expectations, and implementation barriers to guide school improvement. The growing digitalization of management processes has increased the availability of organizational data while simultaneously creating new demands for data literacy, information security, digital judgment, and responsible decision-making. Research on the digitalization of financial management skills illustrates how technological change can alter the competencies required to manage resources, make decisions, and support individuals in complex service contexts (Gbebel et al., 2023). Although such findings arise from a different organizational setting, they underscore a broader principle relevant to educational management: digital transformation changes not only the tools used by managers but also the nature of managerial competence. In STEAM schools, principals must therefore be capable of managing digital information, evaluating technological investments, supporting appropriate technology integration, and using data to monitor implementation quality.

Human resource management is equally important because teachers are the primary agents through whom STEAM curricula are enacted. Principals must assess teachers' professional needs, organize targeted professional development, facilitate interdisciplinary teamwork, provide constructive feedback, recognize effective practice, and motivate staff to adopt new instructional approaches. Teachers may possess strong expertise in individual subjects but lack experience in interdisciplinary planning, project-based instruction, technology integration, collaborative assessment, or the incorporation of artistic and design processes. Consequently, professional development must be continuous, practice-oriented, collaborative, and aligned

with the school's STEAM objectives. Research concerning teachers' work engagement and professional performance has highlighted the mediating importance of communication skills, suggesting that the quality of professional interaction can influence the translation of engagement into effective performance (Ahmadi et al., 2023). For principals, this finding reinforces the importance of clear communication, active listening, professional feedback, conflict management, and relational leadership when developing teachers' capacity for STEAM implementation.

The psychological and interpersonal dimensions of leadership should also be considered. Educational change often generates anxiety, uncertainty, role ambiguity, and concerns about competence. Principals need emotional awareness and relational sensitivity to recognize staff concerns, regulate their own responses, maintain constructive interactions, and provide appropriate support. Research on emotional intelligence and parent–child relationships, although focused on adolescents and family relationships, emphasizes the broader relevance of emotional processes to the quality of interpersonal relationships (Shee et al., 2025). In school management, emotional intelligence can facilitate empathy, trust, communication, negotiation, and the management of resistance. These capacities are important when principals coordinate teachers from different disciplinary backgrounds, engage families in unfamiliar instructional practices, and encourage staff members to experiment with innovative methods.

The successful implementation of STEAM also depends on the creation of a participatory, innovative, and learning-oriented organizational culture. An innovative school culture encourages inquiry, reflection, knowledge sharing, interdisciplinary collaboration, and responsible experimentation. In such a culture, unsuccessful attempts are treated as opportunities for learning rather than as reasons to avoid innovation. Principals must establish formal and informal structures that enable teachers to jointly plan lessons, observe practices, evaluate student work, discuss implementation problems, and develop context-sensitive solutions. Systems thinking is especially important because STEAM programs involve interdependencies among curriculum, personnel, technology, scheduling, finance, assessment, facilities, and community partnerships. A principal who approaches each component in isolation may overlook how changes in one area affect the entire school system. A learning-oriented principal, in contrast, continually reviews evidence, reflects on outcomes, invites feedback, and adjusts implementation strategies.

Resource and process management are additional requirements for sustainable STEAM education. Practical and project-based learning may require specialized materials, digital devices, flexible spaces, safety procedures, external expertise, and additional planning time. Principals must therefore prioritize activities, secure financial resources, allocate budgets transparently, redesign learning environments, manage operational risks, and ensure the quality of program delivery. Studies of skill development in other sectors demonstrate that management-related learning is most effective when it is context-sensitive and linked to authentic problems. For instance, learning models designed to enhance farmers' water-management skills emphasize the importance of practical needs, local conditions, participatory learning, and the application of knowledge to real challenges (Ragique et al., 2025). This principle is relevant to school leadership development because principals' STEAM-related competencies should likewise be cultivated through authentic planning, budgeting, problem-solving, and implementation tasks rather than through abstract training alone.

STEAM education may also connect schools with wider economic, cultural, and community capacities. Research has suggested that school-based STEAM education can contribute to the revival of skill-based commercial capacities in tourism areas by linking education with local knowledge, creativity, entrepreneurship, and occupational opportunities (Ghouti & Sadoughi, 2025). This perspective expands the role of STEAM beyond classroom achievement and positions schools as contributors to community development. Primary school principals must therefore develop networking skills to establish relationships with universities, cultural institutions, technology centers, local businesses, municipal organizations, parents, and other schools. External partnerships can provide expertise, materials, mentoring, field experiences, and authentic project contexts. However, networking requires communication, negotiation, partnership governance, accountability, and the ability to align external contributions with educational priorities.

The relationship between competence and performance is also relevant to the design of a managerial skill-development model. Research among management students has emphasized the importance of employability skills from teachers' perspectives, indicating that technical knowledge must be complemented by communication, teamwork,

problem-solving, adaptability, and other transferable competencies (Singh & Bala, 2023). Similarly, research has shown that psychological empowerment may mediate the relationship between digital competencies and job performance, suggesting that possessing digital skills does not automatically produce improved performance unless individuals also experience autonomy, competence, meaning, and influence in their work (Pacheco & Coello-Montecel, 2023). Applied to school leadership, these findings imply that STEAM-related managerial development should not be reduced to the acquisition of isolated technical skills. Principals need opportunities to exercise judgment, lead change, participate in decision-making, experience professional agency, and perceive the meaningfulness of STEAM implementation.

A comprehensive model must further address sustainability, alignment, inclusion, and educational equity. Short-term STEAM projects may produce temporary enthusiasm without generating lasting organizational change. Sustainability requires the integration of STEAM objectives into school development plans, professional learning systems, resource-allocation procedures, assessment frameworks, and routine decision-making processes. Alignment is required among national policies, district expectations, school objectives, teacher practices, and student assessment. Inclusion requires attention to students with different abilities, socioeconomic backgrounds, learning needs, cultural experiences, and levels of access to technology. Without explicit attention to equity, STEAM programs may disproportionately benefit students who already possess greater educational and technological opportunities. Principals must consequently monitor participation patterns, identify barriers, allocate support, and ensure that STEAM learning opportunities are accessible to all students.

The literature therefore provides substantial evidence regarding STEAM teaching, interdisciplinary curriculum design, technological integration, creativity, teacher implementation, managerial competence, communication, digital skills, human resource development, and organizational performance. Nevertheless, these strands of knowledge are often examined separately. Studies commonly focus on student outcomes, teachers' instructional practices, curriculum characteristics, or general managerial skills, while less attention is given to the integrated set of competencies that primary school principals require to institutionalize STEAM education. The absence of a contextually grounded framework can make professional development fragmented and prevent educational authorities from determining which competencies should be prioritized, how they are interrelated, and how they can be evaluated. A model developed from the perspectives of educational administrators, university faculty members, and management-skills specialists can provide a more comprehensive representation of the strategic, professional, cultural, operational, communicative, and sustainability-related dimensions of STEAM leadership.

Accordingly, the aim of the present study was to design a model for enhancing primary school principals' skills with an emphasis on STEAM education.

2 Methods and Materials

This study was applied in terms of its purpose and was conducted using a qualitative research approach. The research strategy was exploratory, and thematic analysis was employed as the primary analytical method. The study population consisted of 15 primary school administrators and experts in the field of primary school principals' skills, with an emphasis on STEAM education, as well as university faculty members, administrators, and educational specialists from the 22 education districts of Tehran.

In accordance with the research objectives, data were collected through in-depth, semi-structured interviews and a review of relevant literature and documents. Concurrent note-taking was used to document the interviews. An effort was made to complete the written documentation immediately after each interview. To ensure the accurate transcription and transfer of information, the interview content was reviewed repeatedly, allowing for a more detailed examination and analysis of the participants' perspectives.

Nonprobability purposive sampling was used to select relevant documents and participants for the semi-structured interviews. Sampling and data collection continued until theoretical saturation was achieved.

The criteria proposed by Guba and Lincoln (1980) were used to establish the trustworthiness of the study. These scholars introduced four criteria—credibility, transferability, dependability, and confirmability—for evaluating the scientific rigor of qualitative research.

Credibility was established through member checking. To ensure transferability, the findings were presented to specialists and experts for evaluation. Dependability was assessed using inter-coder agreement, while confirmability was strengthened through peer review and peer feedback.

To verify the consistency of the coding process, four independent evaluators were asked to recode the findings. Scott's pi coefficient was used to assess inter-rater agreement. The inter-rater agreement coefficient obtained in this study was 81.11%, indicating an approximately 81% level of agreement among the evaluators regarding the coding decisions.

The research data were analyzed using NVivo, Version 11, and MAXQDA 2020.

3 Findings and Results

First, the demographic and professional characteristics of the participants are presented in Table 1.

Table 1

Demographic and Professional Characteristics of the Interview Participants

No.	Participant Category	Gender	Age	Work Experience (Years)	Educational Level	Area of Expertise/Main Position
1	Senior educational administrator	Male	52	26	PhD	Director General of Primary Education
2	Senior educational administrator	Female	49	23	Master's degree	Deputy Director for Educational Affairs of an Education District
3	Senior educational administrator	Male	53	28	PhD	Director of a District Department of Education
4	Senior educational administrator	Female	54	21	Master's degree	Senior Management Development Specialist
5	Senior educational administrator	Male	48	24	PhD	Head of the Primary Schools Department
6	University faculty member	Male	43	18	PhD	Assistant Professor of Educational Administration
7	University faculty member	Female	49	14	PhD	Associate Professor of Curriculum Planning
8	University faculty member	Male	41	20	PhD	Associate Professor of Educational Leadership
9	University faculty member	Female	43	16	PhD	Assistant Professor of Educational Psychology
10	University faculty member	Male	46	22	PhD	Full Professor of Educational Administration and Policy
11	Management skills expert	Female	39	12	Master's degree	Instructor and Consultant in Management Skills Development
12	Management skills expert	Male	50	19	PhD	Senior Educational Consultant
13	Management skills expert	Female	44	15	Master's degree	Senior Specialist in Administrators' Performance Evaluation
14	Management skills expert	Male	39	13	PhD	Modeling Consultant
15	Management skills expert	Female	42	17	Master's degree	Instructor of In-Service Training Courses for School Principals

In response to the research question, six global themes, 28 organizing themes, and 155 initial codes were identified. The results are presented in Table 2.

Table 2

Three-Level Thematic Analysis of the Model for Enhancing Primary School Principals' Skills with an Emphasis on STEAM Education

No.	Global Themes	Organizing Themes
1	Strategic and transformational leadership of primary school principals in the implementation of STEAM education	Strengthening principals' strategic leadership skills in implementing STEAM education
2		Developing long-term planning skills based on the STEAM approach
3		Enhancing evidence-based decision-making skills in primary school administration
4		Strengthening educational change and transformation management skills with a focus on STEAM
5		Developing principals' clinical supervision and instructional leadership skills

6	Development of the professional and managerial competencies of school human resources	Enhancing human resource management skills for STEAM teams
7		Strengthening skills in evaluating and improving teachers' performance in STEAM education
8		Strengthening skills in encouraging and motivating staff to adopt the STEAM approach
9		Developing skills in leading the professional learning of primary school teachers
10		Enhancing professional feedback skills for teachers and staff
11	Creation of a participatory, innovative, and learning-oriented organizational culture	Developing skills for creating a participatory and innovative organizational culture
12		Enhancing school principals' reflective practice and organizational learning skills
13		Strengthening school principals' systems-thinking and interdisciplinary skills
14		Enhancing managerial adaptability and flexibility in emerging educational environments
15	Management of resources, processes, and the quality of STEAM program implementation	Enhancing time-management and prioritization skills for STEAM activities
16		Strengthening skills in securing and allocating financial resources for STEAM programs
17		Developing skills in designing and managing active STEAM learning environments
18		Strengthening risk and safety management skills in practical school activities
19		Developing skills in evaluating the quality of STEAM-based curricula
20		Strengthening data and information management skills for STEAM-related decision-making
21	Strengthening managerial communication, collaboration, and networking skills	Strengthening effective communication skills with educational stakeholders in STEAM projects
22		Enhancing skills in establishing interschool and external organizational collaborations
23		Developing technology-integration skills in educational administration
24		Developing managerial problem-solving skills for challenges associated with STEAM implementation
25		Developing crisis-management skills for challenges associated with STEAM implementation
26	Sustainability, alignment, and inclusive implementation of STEAM programs in primary schools	Strengthening planning skills for inclusion and educational equity in STEAM education
27		Enhancing skills in monitoring and evaluating students' progress in STEAM education
28		Strengthening skills in aligning school programs with STEAM policies

The thematic analysis process involved several stages. First, initial codes were assigned to meaningful excerpts from the participants' statements. The initial codes extracted from these excerpts were subsequently reviewed, compared, and consolidated to generate basic themes. The basic themes were then categorized into organizing themes, and the organizing themes were classified under broader global themes.

Following the initial development of the thematic structure, the themes were finalized and presented to the participants for feedback. The researcher subsequently reviewed the findings, reflected on the analytical position adopted throughout the study, and revised the thematic structure where necessary.

The final thematic network was then developed and is presented in Figures 1 and 2. The results demonstrated that the model for enhancing primary school principals' skills with an emphasis on STEAM education consisted of 155 initial codes, 28 organizing themes, and six global themes.

Figure 1

Final Research Model Extracted Using MAXQDA

4 Discussion

The present study aimed to design a model for enhancing primary school principals' skills with an emphasis on STEAM education. The thematic analysis generated 155 initial codes, which were organized into 28 organizing themes and six global themes: strategic and transformational leadership in implementing STEAM education; development of the professional and managerial competencies of school human resources; creation of a participatory, innovative, and learning-oriented organizational culture; management of resources, processes, and the quality of STEAM program implementation; strengthening managerial communication, collaboration, and networking skills; and sustainability, alignment, and inclusive implementation of STEAM programs in primary schools. Taken together, these dimensions demonstrate that the effective implementation of STEAM education is not dependent on a single administrative capability. Instead, it

requires an integrated configuration of strategic, instructional, technological, interpersonal, organizational, and evaluative competencies through which principals can translate STEAM policies and curricular expectations into sustainable school-level practices.

The first global theme concerned the strategic and transformational leadership of primary school principals in establishing STEAM education. This theme included strategic leadership, long-term planning, evidence-based decision-making, change management, and instructional supervision. The emergence of this theme indicates that STEAM implementation must be treated as a school-wide transformation rather than as an isolated instructional project. Principals need to define a clear vision, align organizational priorities with the STEAM approach, identify implementation stages, anticipate resistance, and continuously monitor the instructional consequences of managerial decisions. This finding is consistent with research showing that educational managers in the Fourth Industrial Revolution require competencies in strategic thinking, technological awareness, innovation management, and organizational transformation (Darini & Vafaei Yeganeh, 2024). It also aligns with evidence that principals' managerial skills are significantly related to teachers' performance quality and the overall effectiveness of educational processes (Manti et al., 2023; Undiadi & Muhammad, 2025).

The importance of strategic leadership can also be explained by the interdisciplinary character of STEAM education. STEAM requires coordination across science, technology, engineering, arts, and mathematics rather than the continuation of fragmented, discipline-specific teaching. Research on the interconnection of STEAM areas has demonstrated that meaningful learning occurs when disciplinary knowledge is deliberately linked through coherent tasks and shared conceptual structures (Viseu et al., 2025). Similarly, research synthesis on integrated STEAM education has identified inquiry-based learning, project-based learning, collaborative problem-solving, design activities, and interdisciplinary teaching as central instructional strategies (Akrami et al., 2026). Such practices cannot be institutionalized without principals who understand their pedagogical foundations and can organize schedules, staff collaboration, professional development, and assessment systems around them. Therefore, the strategic and transformational leadership dimension reflects the need for principals to serve not merely as administrative coordinators but as instructional leaders of interdisciplinary reform.

The second global theme was the development of the professional and managerial competencies of school human resources. This dimension encompassed human resource management for STEAM teams, evaluation and improvement of teachers' performance, motivation of staff, leadership of professional learning, and provision of professional feedback. The finding suggests that the success of STEAM education depends substantially on teachers' readiness and the principal's ability to develop that readiness systematically. Teachers may be proficient in their own disciplines yet lack the knowledge, confidence, or collaborative experience required to design integrated STEAM activities. Principals must therefore identify competency gaps, establish professional learning communities, facilitate peer learning, support experimentation, and provide feedback based on instructional evidence.

This result is supported by Nguyen et al., who showed that the implementation of STEAM activities by educators is affected by a combination of professional, organizational, and contextual factors (Nguyen et al., 2025). It is also consistent with findings that teachers' work engagement and professional performance are connected through the quality of their communication skills (Ahmadi et al., 2023). In the context of the present study, these findings imply that principals cannot improve STEAM implementation solely by issuing formal instructions. They need to build trust, communicate expectations clearly, recognize staff efforts, address concerns, and establish a supportive climate for professional learning. The identified theme of professional feedback is especially important because feedback allows teachers to evaluate the degree to which their instructional practices reflect interdisciplinary integration, student engagement, creativity, technological application, and authentic problem-solving.

The findings further suggest that professional competence should be accompanied by psychological empowerment. Research has shown that psychological empowerment can mediate the relationship between digital competencies and job performance, indicating that technical capability produces stronger outcomes when individuals experience autonomy, competence, meaning, and influence in their work (Pacheco & Coello-Montecel, 2023). Applied to STEAM implementation, this means that teachers should not be treated merely as recipients of predetermined programs. Principals should involve them in curriculum

planning, project design, resource selection, and assessment decisions. The development of management-related skills similarly requires opportunities for applied learning, collaboration, and decision-making rather than reliance on theoretical training alone (Singh & Bala, 2023). Therefore, the human resource dimension of the proposed model emphasizes both competence development and the creation of conditions in which teachers can exercise professional agency.

The third global theme was the creation of a participatory, innovative, and learning-oriented organizational culture. Its organizing themes included participatory and innovative culture, reflective practice, organizational learning, systems thinking, interdisciplinarity, adaptability, and managerial flexibility. This finding indicates that STEAM education requires a cultural foundation that supports collaboration, experimentation, critical reflection, and continuous improvement. Traditional school cultures characterized by rigid role boundaries, hierarchical communication, and fear of failure may inhibit interdisciplinary work. By contrast, a learning-oriented culture encourages teachers to share experiences, evaluate unsuccessful practices, and collaboratively redesign activities.

This interpretation is consistent with research describing STEAM teaching as an active, integrated, and creative approach that requires flexibility in instructional design and the meaningful connection of different knowledge domains (Badreh & Savaedi, 2024). It also corresponds with the optimal primary education model developed on the basis of integrated STEAM, in which curriculum, teaching strategies, learning environments, assessment, and organizational support were conceptualized as interrelated components (Eskandari et al., 2024). Systems thinking is therefore essential because changes in one element, such as technology or curriculum, affect teacher workload, budgeting, assessment, scheduling, and student participation. The principal must recognize these interdependencies and prevent the implementation process from becoming fragmented.

The cultural dimension may also be interpreted through the role of emotional and interpersonal competencies in organizational relationships. Although Shee et al. examined emotional intelligence in a different relational context, their findings reinforce the broader relevance of emotional awareness and relationship quality to effective interpersonal functioning (Shee et al., 2025). Within schools, emotionally intelligent leadership can enable principals to respond constructively to resistance, manage conflict, build trust, and sustain staff motivation during change. Thus, a participatory and innovative culture is not created solely through structural arrangements; it is also shaped by the principal's capacity to understand and manage the emotional dynamics of organizational transformation.

The fourth global theme concerned the management of resources, processes, and the quality of STEAM program implementation. This dimension included time management, prioritization, budget acquisition and allocation, management of active learning spaces, risk and safety management, curriculum-quality evaluation, and data and information management. The identification of this theme shows that STEAM implementation requires substantial operational capacity. Integrated projects may involve digital devices, laboratory tools, artistic materials, flexible spaces, external facilitators, and additional planning time. Without careful resource allocation, even well-designed programs may remain inaccessible or unsustainable.

The finding is consistent with studies demonstrating that STEAM-based learning often depends on appropriate technologies and practical learning environments. For instance, STEAM-based programming instruction through Scratch integrates computational, creative, and problem-solving activities and therefore requires access to technological tools and competent instructional support (Abtahi & Fathali Beigi, 2024). The application of artificial intelligence technologies in STEAM curricula similarly creates opportunities for personalized learning and advanced digital instruction, while simultaneously increasing the need for infrastructure, ethical oversight, data literacy, and managerial planning (Pourjamshidi & Mozaffari, 2024). Therefore, principals must be capable of evaluating technological options, managing implementation costs, monitoring use, and ensuring that technological integration remains pedagogically purposeful.

The importance of data and financial management can also be understood in light of broader digitalization processes. Research on the digitalization of financial management skills has shown that technological change can transform decision-making requirements and increase the need for new forms of digital and organizational competence (Gbebel et al., 2023). Although the context of that study differed from school management, the underlying implication is relevant: managers operating in digitally transformed environments need more than traditional administrative skills. Primary school principals must be able to interpret data, assess program performance, manage digital records, protect information, and make transparent

financial decisions regarding STEAM resources. The management dimension identified in the present study therefore reflects the operational infrastructure required to convert educational intentions into reliable implementation.

The fifth global theme was the strengthening of managerial communication, collaboration, and networking skills. This dimension included communication with educational stakeholders, interschool and external collaboration, technology integration in educational management, managerial problem-solving, and crisis management. This result demonstrates that STEAM education extends beyond the boundaries of individual classrooms and requires sustained interaction among teachers, families, district administrators, universities, technology centers, cultural institutions, businesses, and community organizations. Principals must establish common expectations among these stakeholders and coordinate their contributions to school objectives.

This finding is consistent with research suggesting that STEAM-based school education can connect learning with local skill-based and commercial capacities, particularly when educational activities are linked to community resources and authentic occupational contexts (Ghouti & Sadoughi, 2025). It is also supported by the demonstrated importance of communication skills in teachers' professional performance (Ahmadi et al., 2023). Effective communication allows principals to explain the purposes of STEAM, reduce misunderstandings, mobilize support, negotiate access to external resources, and maintain accountability across partnerships. Networking further enables schools with limited resources to share expertise, equipment, and successful practices.

The problem-solving and crisis-management components of this theme indicate that implementation is likely to involve unpredictable challenges. These may include budget restrictions, technological failures, teacher resistance, safety concerns, insufficient parental understanding, or inconsistencies between curricular requirements and project-based learning. Research on skill-development models in other applied contexts has shown that effective learning is strengthened when it is grounded in authentic problems, local needs, and participatory processes (Ragique et al., 2025). This principle applies to principals' professional development as well: managerial training should involve realistic STEAM implementation scenarios and opportunities to practice negotiation, resource allocation, conflict resolution, and crisis response.

The sixth global theme addressed the sustainability, alignment, and inclusive implementation of STEAM programs. It included planning for educational inclusion and equity, monitoring students' progress, and aligning school programs with STEAM policies. This finding indicates that STEAM initiatives should not be evaluated only by their initial attractiveness or innovation. Sustainable implementation requires institutionalization within school plans, professional development systems, assessment frameworks, resource-allocation procedures, and policy structures. Comparative research on STEAM curricula has shown that successful implementation differs across countries and depends on the alignment of policy, curriculum, teacher preparation, and practical school conditions (Shahbazi Dastjerdeh et al., 2024). Consequently, principals must interpret broad STEAM policies in relation to their own school contexts while preserving the central principles of interdisciplinary and learner-centered education.

The emphasis on inclusion and equity is also significant. STEAM programs may unintentionally reproduce inequality when access to devices, materials, extracurricular opportunities, or family support differs among students. Principals must therefore monitor participation, identify barriers, and ensure that students with diverse abilities and socioeconomic backgrounds benefit from STEAM learning. The comparison of STEM and STEAM teaching methods has shown that the integration of artistic and creative processes can enhance creativity and problem-solving (Rahmati Nejad, 2025). However, such benefits can only be generalized when programs are accessible and responsive to different learning needs. Monitoring student progress should therefore include not only academic achievement but also creativity, collaboration, design competence, technological literacy, and problem-solving.

5 Conclusion

Overall, the proposed model demonstrates that the enhancement of primary school principals' skills for STEAM education is a multidimensional process. The six global themes are mutually reinforcing: strategic leadership provides direction; human resource development builds professional capacity; organizational culture supports innovation; resource and process management makes implementation feasible; communication and networking expand collaboration; and sustainability and alignment institutionalize the program. The model therefore advances

a systemic understanding of STEAM leadership and suggests that fragmented managerial training is unlikely to produce lasting reform.

This study was subject to several limitations. First, the findings were derived from interviews with 15 participants selected purposively from educational administrators, faculty members, and management-skills specialists in Tehran; consequently, the perspectives of principals, teachers, parents, and students in other provinces or educational systems may not be fully represented. Second, the qualitative design provided an in-depth understanding of the dimensions of the model but did not statistically test the relationships among the identified components. Third, although member checking, peer review, and inter-coder agreement were used to strengthen trustworthiness, qualitative interpretation may still have been influenced by the researchers' analytical perspectives. Finally, the proposed model was developed at the conceptual level and was not implemented longitudinally in primary schools to evaluate its practical effectiveness.

Future studies should quantitatively validate the proposed model using exploratory and confirmatory factor analysis and structural equation modeling with larger and more diverse samples of primary school principals. Comparative research should examine whether the model remains stable across public and private schools, different geographical regions, and schools with varying levels of technological infrastructure. Longitudinal and experimental studies are also recommended to assess whether training based on the six dimensions improves principals' competencies, teachers' implementation of STEAM, organizational culture, and student outcomes. Future researchers should additionally incorporate the perspectives of teachers, students, parents, and community partners and examine potential mediating variables such as psychological empowerment, digital readiness, organizational support, and resistance to change.

Educational authorities should use the proposed model as a framework for designing competency-based professional development programs for primary school principals. Training should combine strategic planning, instructional leadership, human resource development, digital and data management, budgeting, communication, networking, inclusion, and program evaluation rather than addressing these competencies separately. School districts should provide principals with practical workshops, mentoring, collaborative learning networks, and implementation toolkits tailored to actual STEAM challenges. Principals should also establish interdisciplinary teacher teams, allocate regular time for collaborative planning, develop partnerships with universities and community organizations, and create monitoring systems that evaluate both implementation quality and equitable student participation.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were observed.

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