

Applicability of STEAM+X Approach in Early Childhood Education: Teacher Needs Analysis

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Abstract: In this study, the needs of preschool teachers were analyzed to determine the applicability of STEAM+X approach in early childhood education. The study was conducted within the framework of the case study model, one of the qualitative research methods. The study group consisted of 16 preschool teachers working in independent preschools or kindergartens within primary schools affiliated to the Ministry of National Education in the 2024-2025 academic year. As a data collection tool, the "Applicability of STEAM+X Approach in Early Childhood Education: Teacher Needs Analysis SWOT Form" developed by the researchers was used. The data obtained were evaluated by content analysis method through MAXQDA program. The findings of the study revealed that teachers have a conceptual understanding of STEAM fields, use various methods and techniques effectively in educational processes, integrate technological tools in their classrooms, and are open to innovative approaches. However, it was determined that they lacked experience in implementing STEAM practices in the classroom, there was a lack of materials, the physical and infrastructural facilities of the school were limited, the administration and parental support were insufficient, guidance mechanisms were lacking, and mixed age groups made applicability difficult. Among the main threats preventing the adoption of the STEAM+X approach, teachers emphasized the need to raise awareness of parents, insufficient school resources, intense workload and time constraints, lack of access to technology, and lack of knowledge about the STEAM+X approach. On the other hand, within the scope of opportunities related to STEAM education, teachers stated that some STEAM materials are available at the institutional level and that they can benefit from online resources, in-service trainings and academic publications. However, it was also found that they did not have sufficient knowledge on how to effectively select and evaluate these resources. Accordingly, it was determined that teachers should be supported in integrating the STEAM+X approach into the preschool education program, developing applications with different methods and techniques, and using this approach as an effective tool. As a result, it was revealed that it is necessary to develop practice-based programs based on the STEAM+X approach to guide teachers and to expand teacher trainings.

Index Terms: STEAM+X Approach, Early Childhood, Needs Analysis.

1. Introduction

STEAM is an interdisciplinary educational approach that refers to the integration of the arts in science, technology, engineering and mathematics. This concept was first introduced to the literature by Georgette Yakman in 2008. According to [1], STEAM education is based on STEM and is defined as "science and technology are interpreted through engineering and art; all are expressed in the language of mathematics." STEAM not only provides knowledge of the disciplines of science, technology, engineering, art, and mathematics, but also integrates these disciplines with developmental domains such as language, literacy, social interaction, communication, and physical movement [2-5].

Studies define STEAM as a structure that supports interdisciplinary integration in solving students' daily life problems, while other studies argue that the combination of arts and STEM fields promotes innovative solutions to real-world problems [6,7].

STEAM education offers a transdisciplinary approach to learning based on creativity, problem solving, and inquiry by promoting hands-on learning processes involving aesthetic and design pedagogies [8]. This approach is considered as a paradigm that is not only limited to arts integration but also restructures teaching and learning processes by including cultural, architectural and environmental elements [9]. This idea is rooted in Dewey's approach that "the only way to unite the parts in education is to relate each of them to life" [9]. The STEAM+X model enables the inclusion of fields such as culture, architecture, and history in learning processes through the "X" variable based on disciplinary integration [10-12]. In this study, the X dimension of the STEAM+X framework refers specifically to culturally grounded components such as culture, architecture, and history, which aim to contextualize interdisciplinary learning within children's sociocultural environments. Recent theoretical contributions conceptualize STEAM+X as an expansion of traditional STEAM education that integrates culturally and contextually grounded dimensions into interdisciplinary learning processes [9]. Within this framework, architectural modelling and culturally embedded design tasks are proposed as pedagogical tools that connect disciplinary knowledge with authentic real-world contexts [13,14]. Rather than functioning merely as an additive component, the "X" dimension is positioned as a contextual layer that enriches disciplinary integration and supports culturally responsive learning environments. The role of culture in learning is not limited to content delivery; it also affects our expectations of learning and how we construct knowledge. Neuroscience studies show that cultural differences have profound effects on cognitive processes, such as attention, focus, choice, motivation, and perceptions of self and others [15]. In this context, it is understood that cultural values are determinant in learning processes beyond conscious awareness [16-19].

In this context, it is important to understand how the theoretical foundations of interdisciplinary learning processes overlap with classroom practices. Therefore, examining teachers' perspectives on how the STEAM+X approach is translated into preschool classroom practices becomes essential for identifying both its strengths and implementation challenges. Accordingly, the purpose of this study is to examine preschool teachers' views on the STEAM+X approach and the reflection of these views on classroom practices. To realize this aim, the research focuses on the following basic question: "What are teachers' views on STEAM+X approach in early childhood?"

2. Methodology

This research was conducted with the case study method, one of the qualitative research designs. A case study is an approach that aims to examine a specific phenomenon in-depth and in a multifaceted way under the current conditions [20]. According to Yin (2017), a case study design is particularly appropriate when the boundaries between the phenomenon and its context are not clearly evident and when the researcher seeks to investigate contemporary issues within real-life settings. In this study, the applicability of the STEAM+X approach was examined within its natural educational context, aligning with Yin's definition of a bounded case [21]. In this context, since it was aimed to comprehensively reveal the current needs of preschool teachers regarding the STEAM+X approach, the case study design was determined as an appropriate methodological choice for this research.

2.1. Research Design

In this study, the case was conceptually bounded rather than geographically or institutionally bounded. The bounded case was defined as the applicability of the STEAM+X approach within public preschool education in Türkiye as perceived by practicing preschool teachers. Although participants were employed in different provinces and schools, all teachers worked in public institutions affiliated with the Ministry of National Education and implemented the same national preschool curriculum under a shared regulatory framework. The 16 preschool teachers were treated as a single coherent case because they collectively represented a common pedagogical and institutional context. The purpose of the case study was not to compare schools or regions, but to explore teachers' perceived needs, strengths, weaknesses, opportunities, and threats regarding STEAM+X implementation within a standardized public preschool system. Thus, the study follows an embedded single-case design in which multiple teacher perspectives were analyzed within a unified institutional context.

2.2. Working Group

In determining the study group of the research, convenience sampling, a type of non-probability sampling, was used. This method is frequently used in field research by providing practicality in terms of time and access opportunities [22]. The study group consisted of 16 preschool teachers working as preschool teachers in public schools affiliated to the Ministry of National Education in the spring semester of the 2024-2025 academic year.

When the demographic characteristics of the 16 preschool teachers who participated in the study were analyzed, it was found that all participating teachers were female. There were no participants between the ages of 20 and 24. The age distribution of the participants was as follows: six teachers aged 25–29, seven aged 30–34, one aged 35–39, and one over 40. Regarding educational background, 11 participants held bachelor's degrees and 4 held master's degrees. In terms of their majors, 15 teachers graduated in Preschool Education, and 1 in Child Development. Regarding employment status, 10 teachers were permanent staff, and 6 were contractual employees. The number of teachers with STEAM training was quite limited (n=2), indicating a significant need for training in this field.

Although the sample size (n=16) is limited, qualitative case studies aim for analytical rather than statistical generalization. To support transferability, participants were described in detail in terms of institutional structure, professional background, and shared curricular conditions. All participants worked in public preschool settings operating under similar organizational and pedagogical frameworks.

All participating teachers were female. This gender distribution reflects the demographic reality of early childhood education in Türkiye, where the profession is predominantly female dominated, rather than indicating sampling bias. Nevertheless, potential influences of gender homogeneity on perceptions of STEAM+X implementation are acknowledged as a limitation.

2.3. Data Collection Tool

In this study, the "Applicability of STEAM+X Approach in Early Childhood Education: Teacher Needs Analysis SWOT Form" developed by the researchers was used. The main purpose of this form was to systematically reveal preschool teachers' views on the STEAM+X approach, their experiences regarding classroom practices, and the strengths, weaknesses, opportunities, and threats they encountered in this process. The full SWOT analysis form is provided in Appendix A.

2.3.1. Form Development Process and Theoretical Basis

In the process of developing the form, firstly, the relevant literature was extensively reviewed and national and international studies on STEAM, STEM, interdisciplinary teaching and design of learning environments in early childhood were analyzed. However, no original and comprehensive data collection tool that analyzes the applicability of STEAM+X approach in early childhood based on teachers' views was found.

In this context, an original SWOT analysis form was designed based on theoretical foundations (e.g. Yakman's definition of STEAM, culture-based learning, transdisciplinary design thinking) and findings in the literature. SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is a strategic analysis method that enables a holistic assessment of the internal and external situation of individuals, organizations or practices. For this reason, this structure was deemed appropriate to reveal teachers' experiences of STEAM+X practices in a multidimensional way.

2.3.2. Expert Opinions and Pilot Implementation Process

Field experts were consulted to evaluate the draft form in terms of content and construct relevance. The expert panel consisted of two early childhood education academics, two senior preschool teachers (with at least eight years of professional experience), and one overseas researcher specialized in the STEAM+X approach and program development.

Experts were asked to review the items in terms of clarity, relevance to the research aim, and comprehensibility. Based on their feedback, four minor wording revisions were made across four items to improve semantic clarity. No item was removed or conceptually altered.

It should be noted that a formal quantitative content validity index (CVI) was not calculated; instead, expert evaluation was conducted through qualitative review and consensus-based refinement.

To test the applicability of the form, a pilot study was conducted with four preschool teachers prior to final implementation. During the pilot phase, the clarity of questions, potential redundancy, and comprehensibility were evaluated. As a result, no structural modifications were required, and the form was finalized for data collection.

2.3.3. Structure of the Form

- The SWOT form developed consists of two main sections: Section One – Participant Information: This section contains eight closed-ended questions to determine the demographic and professional characteristics of the teachers. The questions cover variables such as gender, age, level of graduation, field of graduation, years of professional seniority, type of school, tenure status, and whether they have received STEAM training. This section is designed to ensure that teacher profiles are linked to SWOT assessments.
- Section Two – SWOT Analysis Open-Ended Questions: This section includes 13 open-ended questions for teachers to assess the strengths, weaknesses, opportunities, and threats related to the STEAM+X approach. These questions are structured in a way that allows teachers to provide comprehensive feedback, considering not only their pedagogical knowledge and skills, but also systemic, managerial, material and cultural factors.

2.4. Data Collection

Data were collected online using a Google Form developed by the researchers. Before the application, the participating teachers were informed in detail about the purpose, scope and process of the research; it was clearly stated that the data would be used only for scientific purposes and that participation was voluntary. The teachers who agreed to participate accessed the form via the online form link and submitted their responses digitally.

To protect the privacy of the participants, each teacher was assigned a code as P1, P2, ..., P16 and all responses were anonymously entered into the data set with these codes. The confidentiality of personal data was meticulously ensured, and no data was directly matched with identification information.

The study was conducted with a total of 16 preschool teachers working in public kindergartens affiliated with the Ministry of National Education and attached to primary schools during the spring semester of the 2024-2025 academic year. The participants' responses to the online form were transferred to the MAXQDA analysis program as raw data and the analysis process was initiated.

2.5. Ethical Principles

Ethical approval for this study was obtained from the Ethics Committee of Gazi University (Approval No:2024-1918, Date: 21.12.2024).

Prior to data collection, all participants were informed about the purpose and procedures of the study. Participation was voluntary, and informed consent was obtained from all preschool teachers. Confidentiality and anonymity were ensured throughout the research process.

2.6. Data Analysis

In this study, qualitative data were analyzed using the content analysis method with the support of MAXQDA 2022 software. Content analysis is a systematic analytical approach that aims to identify meaningful themes, concepts, and relationships within qualitative data [20, 23].

The analysis process was guided by a holistic perspective. Within this framework, a coding approach informed by predefined concepts was initially adopted based on the SWOT structure. This combined deductive–inductive approach is consistent with qualitative content analysis procedures, where initial categories may be theoretically informed and subsequently refined or expanded based on the data [24]. However, to allow themes to emerge directly from teachers' responses, inductive coding was also employed. This combined deductive–inductive approach helped minimize the risk of forcing data into predetermined categories and ensured that participants' authentic perspectives were adequately represented.

During the coding process, participant statements were grouped under representative concepts. Where necessary, conceptual structures supported by the literature were utilized, data were conceptualized, transformed into codes, and subsequently organized into thematic patterns. The analysis followed a three-stage structure:

1. Creation of initial codes
2. Organization of codes into categories
3. Development of overarching themes from categories

2.6.1. Coding Reliability Process

To enhance the scientific rigor and trustworthiness of the qualitative analysis, reliability over time was considered. According to [20], reliability over time is defined as the consistency of coding when the same researcher reanalyzes the data set at different points in time. Accordingly, after completing the initial coding, the researcher paused the analysis process for one week and then recoded the data set. In the second coding cycle, only the wording of one code was revised, while a high level of consistency was observed across the remaining codes, categories, and themes. This indicates that the reliability of the coding process over time was high.

Inter-coder reliability refers to the level of agreement between independent coders analyzing the same dataset, which is considered an important indicator of consistency in qualitative research [25]. In addition, to enhance the credibility of the analysis, the coding process was conducted collaboratively by the researchers. Initial codes were discussed, and differences in interpretation were resolved through consensus-based discussions. A shared coding framework was established, and the data were revisited to ensure consistency across categories. This iterative and reflective process contributed to the credibility and dependability of the findings. In qualitative research, particularly in interpretive content analysis, consensus-based coding and transparent analytic procedures are considered appropriate strategies for establishing reliability without relying on statistical agreement coefficients [26,27].

2.6.2. Analysis Themes and Categories

As a result of the data analysis, teachers' views were organized into four main themes in line with the SWOT framework. These themes reflect preschool teachers' perceptions and experiences regarding the implementation of the STEAM+X approach:

- Strengths: Participants' competencies, experiences, and positive attitudes toward STEAM+X practices.
- Weaknesses: Challenges encountered in the implementation process, including lack of experience, resource limitations, and structural constraints.
- Opportunities: Supportive conditions provided by the educational system, professional development opportunities, access to materials, and academic resources.
- Threats: Systemic barriers such as limited administrative and parental support, time constraints, inadequate technological infrastructure, and lack of awareness.

3. Findings

The data obtained were structured within the SWOT framework, and teacher opinions were analyzed under four main themes: "Strengths," "Weaknesses," "Opportunities," and "Threats." These themes reflect teachers' evaluations of the STEAM+X approach in a multidimensional way in both individual and structural dimensions.

Each theme was structured in line with the categories and sub-themes and supported by relevant teacher statements. Code frequencies and representation rates are presented in a table to show the centers of gravity of the findings.

The prominent findings related to these four themes are summarized below, with detailed content presented in Table 1.

- Under the Strengths theme, teachers demonstrated familiarity with STEAM+X concepts at a theoretical level, openness to innovative approaches, a tendency to experiment with diverse teaching methods, and positive attitudes toward technology integration.
- Weaknesses: The most frequently cited challenges included lack of experience, inadequate materials, limitations in physical infrastructure, and insufficient interdisciplinary planning skills.
- Opportunities: This theme included access to institutional STEAM resources, online training opportunities, academic publications, willingness to pursue professional development, and a school culture supportive of collective learning.
- Threats: The most emphasized systemic threats were intensive workload, time pressure, lack of managerial support, low parental awareness, and insufficient teacher knowledge regarding the STEAM+X approach.

Table 1. Data analysis matrix for teacher responses.

Strengths	f	Room for Improvement	f
Conceptual mastery of STEAM domains	11	Lack of experience	16
Use of different methods and techniques in educational processes	16	Inadequacy of materials	3
Integrating technological tools into the classroom	16	Limited physical and infrastructure facilities of the school	4
Openness to innovative approaches	15	Lack of administrative and parentalsupport	2
		Lack of guidance mechanisms	3
		Mixed age group	5
Opportunities	f	Threats	f
Some STEAM materials available at institutional level	3	The need to raise awareness of parents	13
Online resources	4	Inadequacy of available school resources	10
In-service training	4	Heavy workload and limited time	9
Academic publications	2	Lack of access to technology	6
		Lack of knowledge about the STEAM+X approach	6

Analysis of the Strengths theme in Table 1 reveals four main categories: conceptual mastery, diversity in teaching methods, integration of technological tools, and openness to innovative approaches.

- **Conceptual Mastery of STEAM Fields:** The majority of participants reported a basic understanding of the contextual and theoretical aspects of STEAM disciplines. In particular, it was observed that they had knowledge about STEAM's opening, its components, and its main purposes in the preschool context.
- "At a basic level, I know what it is and its aims in preschool. It is an abbreviation of the words science-technology-engineering-art-mathematics in English"(P13). This finding suggests that teachers have developed conceptual awareness, but other factors may be determinative in the transition to practice.
- **Use of Different Methods and Techniques in Educational Processes:** All participants (100%) stated that they used multiple teaching methods and were open to strategies compatible with the STEAM approach.
- "Educational games, brainstorming, drama, experimentation... I think I use these methods more often and I am more successful" (P13). This shows that teachers have the flexibility to think creatively and implement STEAM+X, which can be an advantage in the transition to STEAM+X.
- **Integrating Technological Tools into the Classroom:** All participants (100%) stated that they had basic knowledge and practical experience in using various technological tools and platforms in classroom activities.
- "I received STEAM training supported by robotic coding. I worked with coding at a basic level with Lego spike prime. I received basic training on Scratchjr, lego coding programs." (P8) This finding shows that the potential of technological integration, especially in early childhood, is recognized by teachers and these skills are reflected in learning processes.

- Openness to Innovative Approaches: Almost all participants (93%) stated that they were open to professional development, followed innovative educational approaches, and were willing to integrate them into their classroom environments.
- "I follow the developments and try to internalize and apply them" (P11). This finding shows that teachers tend to internalize individual learning and current educational approaches and can be considered as positive data in terms of the sustainability of STEAM+X practices.

Analysis of the Weaknesses theme in Table 1 groups the limitations faced by teachers into six main categories: lack of experience, material inadequacy, physical infrastructure limitations, lack of guidance, insufficient administrative/parental support, and difficulties with mixed-age group practices. These sub-themes point to important factors affecting the sustainability and efficiency of practices.

- Lack of Experience: All participants (100%) stated that their direct experience of STEAM+X practices was insufficient. Although they had theoretical knowledge, they expressed that they had difficulty in transferring this approach to the classroom environment in practice:
- "My knowledge and experience are always lacking in this field" (P7).
- "I need to be trained in all areas of STEAM and improve myself" (P13). This finding indicates that education policies should provide more hands-on support for teachers.
- Inadequacy of Materials: Some participants (19%) stated that materials required for STEAM+X activities were unavailable in their classrooms and that they lacked the skills to develop such materials:
- "I lack in material development" (P10).
- "I think that the lack of mastery of science fields and the lack of materials create deficiencies in our practice" (P6). This situation emphasizes the importance of structural measures, especially for the fair distribution of resources and the elimination of teachers' equipment deficiencies.
- Limited Physical and Infrastructural Facilities of the School: Some teachers (25%) stated that the physical spaces and technological infrastructure where they could carry out STEAM+X practices were not sufficient:
- "Technology-based education and the school not being physically technologically equipped" (P1).
- "There are limitations due to the lack of equipment in the classroom environment" (P6). These findings show that school buildings should be made ready for STEAM practices in terms of infrastructure.
- Lack of Guidance Mechanisms: Some participants (19%) stated that they needed guidance on planning STEAM+X practices, selecting appropriate activities, and choosing assessment tools. This lack of guidance makes teachers feel that they are left alone in the process.
- Insufficient Administrative and Parental Support: Some of the participants (13%) stated that they did not receive sufficient support from administrators and parents.
- "Time is insufficient because plans and programs are busy enough" (P9). In particular, time pressure and managerial expectations make it difficult to carry out a multidimensional approach such as STEAM+X in a healthy way.
- Implementation Difficulties of Mixed Age Groups: Some teachers (31%) stated that having multiple age groups in the same classroom made planning, implementation, and material preparation difficult. Managing different developmental levels at the same time can reduce the effectiveness of STEAM+X practices.
- In line with this analysis, the aspects most emphasized by the teachers were the lack of implementation experience and systemic support inadequacies.
- Teachers' structural limitations such as lack of practical experience and inadequate materials may make it difficult to implement the STEAM+X approach effectively in the classroom. This, coupled with the lack of guidance mechanisms, can negatively affect implementation confidence. If these areas for improvement are mitigated through systematic support, implementation capacity is likely to increase.

According to Table 1, the Opportunities theme identified four main categories: availability of institutional materials, access to online resources, in-service training opportunities, and access to academic publications.

- Availability of STEAM Materials at the Institutional Level: Some teachers (19%) stated that their institutions had limited materials suitable for STEAM practices. This was considered as a motivating factor for starting STEAM practices.
- "Although there is a lack of materials, I can access some tools at school." This statement shows that teachers' ability to evaluate these resources is as important as the availability of resources.
- Access to Online Resources: Some participants (25%) stated that they could access STEAM activity examples and teaching materials through digital platforms.

- "I use online resources, especially activity videos and PDFs, which give me ideas." This finding highlights teachers' potential to utilize and evaluate digital resources. However, the effective use of this potential depends on the level of digital literacy.
- In-Service Training Opportunities: Some of the participants (25%) stated that they had previously participated in various in-service training programs in the fields of STEAM or technology-assisted instruction.
- "Last year I took a short seminar on coding, which gave me an important perspective." This shows that teachers are willing and open to professional development and take advantage of the opportunities offered by the system.
- Accessibility to Academic Publications: Some teachers (13%) stated that they could access academic articles and theoretical resources related to STEAM+X.
- "I sometimes try to transfer what I read from articles to the classroom environment." This statement reveals teachers' interest in scientific sources in terms of using theoretical knowledge in practice. However, to promote widespread adoption, it is important to guide teachers and develop their skills in selecting relevant literature.
- In general, teachers recognized some of the opportunities offered by the current system and were open to developing these opportunities. However, the effective use of these opportunities is directly related to teacher competencies and structural supports.
- Research findings reveal that teachers' access to online resources and in-service training programs can provide opportunities for professional development. Providing these opportunities in a more structured way can enable teachers to use the STEAM+X approach more effectively. With appropriate guidance and access to resources, these opportunities can become effective support.

According to Table 1, the Threats Theme shows that teachers emphasized a number of external threats that limit the applicability of the STEAM+X approach. These threats were grouped into five main categories: parental awareness, insufficient school resources, time management issues, lack of access to technology, and lack of knowledge about the approach.

- The Need to Raise Awareness of Parents: The majority of teachers (81%) emphasized that in order for STEAM+X practices to be effective, parents' awareness of this approach should be raised.
- "Parents do not care enough about this process. When there is no support at home, children's interest decreases." (P6)
- This finding indicates that the STEAM+X approach should be supported not only in the classroom but also at home.
- Inadequacy of Existing School Resources: 63% of the participants stated that the materials, equipment, and infrastructure required for STEAM practices were lacking in their institutions.
- "The school facilities are not at a level to meet the needs of the program." (P9) This highlights the importance of infrastructure investments at the system level.
- Busy Workload and Limited Time: 56% of the participants stated that they could not allocate enough time for STEAM+X practices due to busy daily routines, planning load and curriculum pressure.
- "Time is insufficient because the schedule is already too packed." (P9) This finding suggests that teachers need a more flexible training program to allocate time for creative and innovative practices.
- Lack of Access to Technology: 38% of the teachers stated that there were limitations in their access to digital tools and software to be used in STEAM+X applications.
- "The fact that it is technology-based education and the school is not physically equipped with technology makes the process difficult." (P1) This finding shows that digital inequalities constitute a critical barrier not only for students but also for teachers.
- Lack of Knowledge about the STEAM+X Approach: 38% of the participants stated that they did not have enough information about the basic principles, planning and implementation of the STEAM+X approach.
- "I think I need to improve myself in this field. I lack knowledge." (P7) This emphasizes the need to update teacher education policies and to expand STEAM+X- specific in-service trainings.
- These findings reveal that not only individual competencies, but also systemic and structural conditions need to be improved to integrate the STEAM+X approach into the educational environment.
- Factors such as time pressure, lack of school resources and lack of parental support can threaten the sustainability of STEAM+X practices. This may reduce teachers' motivation and encouragement towards innovative practices. Unless the necessary structural and managerial measures are taken to mitigate these threats, there is a risk that the practices will not be sustained.

4. Discussion

The findings of this study indicate that preschool teachers possess a basic conceptual understanding of the STEAM+X approach; however, they struggle to translate this knowledge into effective classroom practices. Teachers frequently reported that the STEAM-related courses they had taken during their undergraduate education were insufficient in terms of practical implementation. This reflects a gap between theoretical preparation and classroom application. Similar findings have been reported in the literature, suggesting that limited pedagogical knowledge and practical experience may negatively influence children's learning processes [28-32]. Therefore, teacher education programs should provide structured and practice-oriented opportunities to facilitate the transfer of theoretical knowledge into instructional practice [33].

Although teachers' emphasis on the need for training and instructional resources may initially appear predictable, these findings point to broader structural issues in the integration of STEAM+X within early childhood education. Rather than solely indicating individual deficiencies, the results suggest a misalignment between curricular expectations and institutional support mechanisms. The perceived inadequacy should therefore be interpreted within a systemic framework, highlighting the importance of coordinated policy, administrative, and professional development support.

While the theoretical framework of STEAM+X emphasizes integrating cultural, architectural, and historical dimensions, teacher responses predominantly focused on core STEM components. While previous international studies have demonstrated structured implementations of culturally grounded architectural modelling and technology-supported design tasks within STEAM+X frameworks, the present findings suggest that such structured integration has not yet been systematically embedded within the Turkish early childhood context [9, 13, 14]. In these international studies, architectural and culturally situated modelling tasks were intentionally designed and supported through explicit pedagogical tools and structured lesson planning approaches. By contrast, teachers in the current study tended to interpret STEAM primarily through its core STEM components, with limited emphasis on cultural or architectural integration.

This pattern should not be interpreted as a conceptual deficiency among teachers; rather, it appears to reflect contextual differences in curriculum structure, institutional support mechanisms, and professional development opportunities. Accordingly, the operationalization of the "X" dimension in Türkiye may require context-sensitive adaptation and structured pedagogical guidance instead of direct replication of international models. Addressing this contextual dimension could contribute to strengthening STEAM+X implementation while simultaneously fostering culturally responsive pedagogical practices in early childhood education [34].

The findings further demonstrate that teachers are open to innovative pedagogical approaches and frequently employ diverse teaching strategies. This creates a favorable foundation for interdisciplinary and creativity-oriented approaches such as STEAM+X. Consistent with previous research, drama-based STEM activities and interdisciplinary integrations have been shown to enhance children's scientific process skills, creativity, and holistic development [31, 35-37]. However, sustainable implementation requires adequate material resources, time management structures, and administrative support.

Insufficient materials, inadequate physical infrastructure, and a lack of guidance support were repeatedly mentioned as major implementation challenges. Previous studies similarly emphasize that access to instructional materials and structured guidance significantly influences the effectiveness of STEM-based practices [38-41]. Supporting classroom environments with appropriate resources may therefore enhance both instructional quality and children's active engagement in learning processes.

Although teachers reported confidence in using technological tools, they indicated that the physical and digital infrastructure of schools was insufficient to fully support such practices. Research suggests that technology integration becomes meaningful not merely through access to tools but through systematic pedagogical guidance [42]. Individual teacher effort alone may not overcome structural limitations.

Under the theme of opportunities, some teachers reported benefiting from online resources, in-service training programs, and academic publications. Nevertheless, access to high-quality and practice-oriented content remains limited. Under the theme of threats, teachers emphasized parental awareness, workload intensity, limited administrative support, and planning challenges as major obstacles. Despite these constraints, all participants expressed willingness to receive further training, suggesting that institutional support mechanisms could significantly enhance the practical applicability of the STEAM+X approach. Future studies may strengthen these findings by triangulating teacher perceptions with classroom observations and child-level learning outcomes.

4.1. Limitations

The sample size of this study ($n = 16$) was limited and selected through convenience sampling. Although qualitative research does not aim for statistical generalization, this may restrict the transferability of findings to different educational contexts. Although all participants in this study were female, this reflects the demographic structure of early childhood education, where the teaching workforce is predominantly female. National education statistics indicate that preschool teaching in Türkiye is largely represented by female teachers [43]. Similarly, national statistics indicate that approximately 95% of teachers in pre-primary education in Türkiye are female [44]. Nevertheless, gender homogeneity

may influence perceptions of STEAM+X implementation and is therefore acknowledged as a contextual limitation of the study. Additionally, descriptive studies on preschool teacher profiles in Turkey similarly report that the majority of participants were female, supporting the representativeness of our sample in terms of gender composition [45].

A small number of participants had prior STEAM-related training, which did not allow for a comparative analysis between trained and untrained teachers. Future research with larger and more diverse samples may examine how professional training influences STEAM+X implementation.

This study relied solely on self-reported teacher perceptions and did not include classroom observations, document analysis, or child outcome data. The absence of methodological triangulation may limit the comprehensiveness of the findings.

5. Conclusion

This study explored preschool teachers' knowledge, implementation experiences, opportunities, and limitations regarding the STEAM+X approach and its potential for integration into early childhood education. The findings show that teachers generally have a positive attitude toward this approach and high pedagogical motivation; however, their knowledge levels are limited, their implementation experiences are insufficient, and structural supports are lacking. This situation clearly reveals that teachers should be supported in their professional development processes not only with conceptual content but also with practice-oriented experiences.

The findings of the research show that teachers are open to innovative teaching methods and use these methods in classroom activities. However, the inadequacy of classroom environments in terms of physical, technical and material resources makes it difficult for teachers to implement these approaches in a sustainable manner. In this context, the most basic elements that teachers need are access to quality materials, time management, professional guidance and institutional support.

One of the most striking findings of the research is the strong need for training programs to support teachers' professional development in STEAM+X. The desire of all participants to receive more training in this area indicates that there is a potential to increase the dissemination of this approach in the field. However, to realize this potential, structural, pedagogical, and managerial support for teachers must be addressed through a holistic approach.

In conclusion, the STEAM+X approach offers an important opportunity in preschool education to support teachers' professional development and to develop children's 21st-century skills. However, to realize this potential, teacher education programs need to be restructured, in-service training needs to be expanded, guidance systems for implementation need to be established, and learning environments need to be physically supported. In this context, it is of great importance that policy makers, program developers and academics work together to realize this transformation in a holistic and sustainable manner. The limited articulation of the "X" dimension in teacher responses highlights the need for professional development models that explicitly integrate culture, architecture, and history into early childhood STEAM practices.

All the Declarations and Statements

Author Contributions Statement

All authors contributed equally to all stages of the study, including conceptualization, methodology, data collection, data analysis, and manuscript preparation.

All authors have read and agreed to the published version of the manuscript.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding Declaration

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Data Availability Statement

The data supporting the findings of this study are not publicly available due to ethical restrictions, as they include qualitative data obtained from human participants. Data may be made available from the corresponding author upon reasonable request.

Ethical Declarations

Ethical approval for this study was obtained from the Gazi University Ethics Committee (Approval No:2024-1918, Date: 21.12.2024). Informed consent was obtained from all participants prior to data collection.

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Declaration of Generative AI in Scholarly Writing

The authors declare that no generative AI or AI-assisted technologies were used in the writing or preparation of this manuscript.

Abbreviations

The following abbreviations are used in this manuscript:

STEAM - Science, Technology, Engineering, Arts, and Mathematics

MEB - Ministry of National Education

APPENDIX

A SWOT Analysis Form

The SWOT analysis form developed for this study consists of 13 open-ended questions designed to explore preschool teachers' perceptions and needs regarding the implementation of the STEAM+X approach in early childhood education.

Strengths

1. What are your knowledge and skills in STEAM fields?
2. Which methods and strategies do you think have been successful in early childhood education?
3. How familiar are you with technology use and digital vehicles?
4. How would you rate yourself in terms of adapting to innovative educational programs and current approaches?

Weaknesses

5. Are there any areas in STEAM or other fields (art, engineering, etc.) where you feel you have a lack of knowledge and experience?
6. What are your limitations in developing materials or using technological tools?
7. Do you experience any significant difficulties in areas such as classroom management or increasing student motivation?

Opportunities

8. What resources, supporting educational materials or guidance services are available to you in the STEAM+X field?
9. Does your school or institution provide support for this program through partnerships or access to external resources?
10. Are there any training or certification programs available in STEAM fields where I can improve myself?

Threats

11. Does the school's current resource meet the program's requirements?
12. How would you assess the awareness of parents or the community regarding STEAM+X education?
13. During the implementation of the program, are you likely to encounter difficulties such as time constraints or curriculum intensity?

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