

Integrating STEAM in Early Childhood Education Classrooms: A Reflexive Content Analysis of Teachers' Experiences

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Abstract

Early childhood education plays a crucial role in fostering children's curiosity, creativity, and foundational competences in science, technology, engineering, arts, and mathematics (STEAM). However, European policies promoting STEAM and digital literacy from preschool onwards have not yet been fully translated into classroom practices that are developmentally appropriate for preschool children. This study explored preschool teachers' experiences integrating STEAM and digital technologies to identify pedagogical and didactic elements that can inform the design of an assessment tool for educators. Using a reflexive content analysis of six teacher interviews conducted in Spain and Germany, five analytical categories were established: pedagogical elements, teacher education, STEAM materials, educational technology, and evaluation processes. Results showed that teachers emphasized child-centred, hands-on approaches, cautious and purposeful use of digital tools, and predominantly observational assessment methods. They also reported fragmented professional training and a lack of structured evaluation instruments. Unlike previous studies that mainly describe barriers to STEAM implementation, this work contributes by identifying teacher-derived pedagogical indicators that can guide the development of a STEAM assessment framework based on Montessori pedagogy and aligned with European early education objectives.

Keywords

STEAM, early childhood education, preschool educators, reflexive content analysis

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Integración de STEAM en las Aulas de Educación Infantil: Análisis Reflexivo del Contenido de Experiencias Docentes

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Resumen

La educación infantil desempeña un papel crucial en el desarrollo de la curiosidad, la creatividad y las competencias básicas en ciencia, tecnología, ingeniería, artes y matemáticas (STEAM). Sin embargo, las políticas europeas que promueven las competencias STEAM y la alfabetización digital desde el preescolar aún no se han traducido plenamente en prácticas docentes adecuadas. Este estudio exploró experiencias de docentes de preescolar en la integración de las competencias STEAM y tecnologías digitales, identificando elementos pedagógicos y didácticos para diseñar una herramienta de evaluación. Mediante un análisis reflexivo de seis entrevistas a docentes realizadas en España y Alemania, se establecieron categorías analíticas: elementos pedagógicos, formación docente, materiales STEAM, tecnología educativa y procesos evaluativos. Los resultados mostraron el hincapié docente en enfoques prácticos y centrados en la infancia, usos cautelosos y deliberados de herramientas digitales y métodos de evaluación predominantemente observacionales. También señalaron fragmentación en la formación profesional y falta de instrumentos de evaluación estructurados. A diferencia de estudios anteriores enfocados en barreras para la implementación de STEAM, este trabajo identifica indicadores pedagógicos derivados de los docentes que pueden guiar el desarrollo de un marco de evaluación STEAM basado en la pedagogía Montessori y alineado con los objetivos europeos de educación temprana.

Palabras clave

STEAM, educación infantil, educadores preescolares, análisis reflexivo de contenidos

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Educational frameworks across European Union (EU) member states are shaped by directives from the European Council, which align with the broader economic and social objectives of the bloc (OECD, 2024). Global policy instruments such as the UNESCO Framework for Culture and Arts Education (UNESCO, 2024) have further established a foundation for educational reforms aimed at integrating creativity, cultural diversity, and sustainability into STEAM learning frameworks at all educational levels. In this context, the EU has progressively issued legislation and recommendations to promote competence-based education, highlighting the importance of STEAM (Science, Technology, Engineering, Arts, and Mathematics) and Digital Education (DE) learning from Early Childhood (EC) onward (Council of the European Union, 2019; European Commission, 2024; Spyropoulou & Kameas, 2024). Addressing this gap requires developmentally appropriate pedagogical strategies and reliable assessment tools to guide teachers' practice. Grounded in the Montessori approach and European educational objectives, this study explores preschool teachers' experiences integrating STEAM and DE to identify key elements that will inform the design of a contextually valid STEAM materials assessment tool for EC educators.

State of the Art

Despite significant policy efforts, research indicates that several European countries continue to face challenges in translating STEAM-related policies into practice across educational levels (Seery et al., 2022; Tönnsen, 2022). Existing initiatives and training programs have largely focused on primary and secondary education (Belbase et al., 2021; Tasiopoulou et al., 2022; Sakellaropoulou et al., 2024), leaving Early Childhood Education (ECE) comparatively underdeveloped in terms of STEAM integration.

This gap is particularly relevant given that European policy frameworks consistently emphasize both the development of educators' digital competence and the promotion of STEAM-related skills (Redecker & Punie, 2017), as well as the need for assessment and monitoring tools adapted to ECE (European Commission, 2020). However, EC educators often face lower qualification requirements and more limited access to continuous professional development compared to teachers at higher educational levels (Council of the European Union, 2020). Furthermore, European policy documents still provide limited guidance on age-appropriate strategies for introducing STEAM concepts in preschool settings (Council of the European Union, 2015; Council of the European Union, 2022). This lack of guidance is concerning, as early exposure to STEAM-related experiences has been shown to foster long-term engagement and academic development (Master et al., 2017).

Despite growing recognition of STEAM in early childhood, research on its implementation remains limited. Studies highlight challenges related to teachers' limited knowledge, low confidence, and difficulties designing STEAM activities, compounded by restricted training, resources, and institutional support (Sawangmek, 2019; Núñez et al., 2025; Ng et al., 2022). Teachers also struggle to achieve meaningful interdisciplinary integration, often relying on fragmented practices due to the lack of clear pedagogical guidance (Ng et al., 2022; Muhammad Rafiq-uz-Zaman, 2025). In addition, traditional assessment methods fail to capture

the process-oriented nature of STEAM learning. These limitations point to the need for structured frameworks, targeted training, and context-appropriate assessment tools in ECE.

In this context, it is necessary to incorporate pedagogical frameworks that respond to young children's developmental stages and learning processes (Council of the European Union, 2019). The Montessori Method offers a relevant approach, providing a structured yet flexible environment that supports autonomy, exploration, and hands-on learning, all of which align with key principles of STEAM education (Çakir & Yalçın, 2022). Core Montessori principles—such as the adaptation of materials to developmental stages and the emphasis on self-directed learning—enable the design of high-quality, developmentally appropriate STEAM experiences (Lillard & McHugh, 2019).

At the same time, teacher training emerges as a critical factor in bridging the gap between policy and practice. Integrating STEAM education, Digital Technology (DT), and Montessori pedagogy within professional development can support the creation of holistic and future-oriented learning environments (Bush & Cook, 2019; Yakman & Lee, 2012). Such integration has been associated with enhanced learning experiences, increased gender inclusivity, and the promotion of creativity and interdisciplinary thinking in EC contexts (Ching et al., 2019; Gibert & Valls, 2022; Sullivan & Strawhacker, 2021). Moreover, comprehensive professional development benefits not only teachers' professional growth but also children's social and cognitive development (García-Peñalvo, 2022; Bush & Cook, 2019).

The role of DT within STEAM education requires careful consideration. Digital literacy is not intrinsic to STEAM education; rather, it functions as a pedagogical enabler when meaningfully integrated by teachers. According to the European DigCompEdu framework, educators' digital competence involves the ability to select, adapt, and critically use technologies to enhance learning processes (Redecker & Punie, 2017). In ECE, this competence is particularly relevant, as teachers must balance the use of digital tools with hands-on, experiential learning.

Research on technology integration in Montessori and EC contexts highlights the importance of maintaining this balance, ensuring that digital tools complement rather than replace sensory and exploratory experiences (Owen & Davies, 2020; Vataavu et al., 2015). In addition, digital tools can support assessment practices by facilitating documentation, observation, and communication with families. For example, Şimşek and Tuğluk (2021) demonstrate how digital platforms such as SAP Fiori and Transparent Classroom can support Montessori educators in aligning assessment practices with pedagogical principles.

Nevertheless, assessing children's learning and development in STEAM contexts remains a significant challenge. There is a need for assessment tools and methodologies that are aligned with the foundational principles of ECE, particularly those emphasizing observation, process-oriented learning, and developmental appropriateness (Şimşek & Tuğluk, 2021; Silvis et al., 2022). Current approaches often lack structure or fail to capture the complexity of interdisciplinary learning processes characteristic of STEAM education.

Drawing on European policy analysis, existing literature, and field observations conducted in Spain, this study addresses this gap by identifying key pedagogical and didactic elements that can inform the development of an assessment tool for preschool teachers. Such a tool has the potential to support reflective practice, improve pedagogical decision-making, and align classroom practices with broader educational frameworks.

This study explores preschool teachers' experiences in implementing STEAM education, with a particular focus on how pedagogical practices, material selection, digital competence, and evaluation processes are enacted in EC settings. The aim is to identify key elements that inform the design of a context-sensitive assessment tool for preschool educators in European contexts.

To achieve this aim, the study addresses the following research questions:

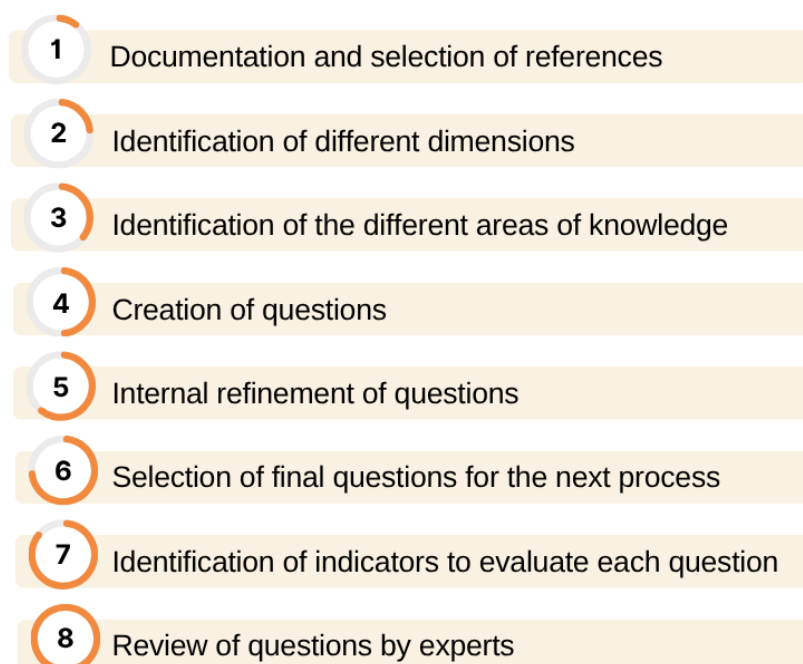
1. Which pedagogical elements work best when working with STEAM materials-activities in preschool?
2. How are teachers trained to improve their teaching practices?
3. What are the most suitable STEAM materials to offer in preschool groups?
4. How is Digital Education adopted in preschool teachers' daily bases?
5. Which evaluation process and assessment tools are implemented in preschool?

Method

This article forms part of a wider study on the integration of STEAM Education and the Montessori Method in ECE. Drawing on a qualitative exploratory study (Robson & McCartan, 2016), reflexive content analytic design (Nicmanis, 2024), it focuses on identifying the specific elements derived from teachers' experiences that can inform the construction of an assessment tool designed to evaluate pedagogical materials and practices within this framework.

Interview Construct

The interview protocol was developed based on three complementary sources: (1) a systematic literature review of how STEAM education is implemented through the Montessori Method for children aged 3 to 6 (Köchig et al., 2025); (2) analysis of EU policy documents related to ECE, STEAM, and teachers' digital competence; and (3) field observations conducted at Escola Montessori de Rubí (Spain) (Köchig, in press). These observations focused on how pedagogical practices, materials, and learning environments supported the integration of STEAM-related experiences in EC classrooms. Insights derived from this observational phase informed the identification of key dimensions and the formulation of the interview questions. The structure of the interview was adapted from Lázaro-Cantabrana and Gisbert-Cervera (2015) (Figure 1).

Figure 1*Systematic Process to Construct Validation*

Note. List modified from Lázaro-Cantabrana and Gisbert-Cervera (2015).

To ensure content validity, an international expert panel was convened. A purposive snowball sampling (Robson & McCartan, 2016) strategy was used to recruit five experts with relevant experience: two preschool teachers, two university teacher educators and researchers, and one educational technology researcher, representing Spain, Argentina, and Italy. The expert panel evaluated the interview instrument using an adapted version of Fernández-Gómez et al. (2020), assessing sufficiency, clarity, coherence, and relevance.

The evaluation was conducted via an online form (Microsoft Forms), consisting of 15 questions grouped by dimension (Appendix A). Each item was assessed as null, low, high, or optimum according to the following criteria:

- Sufficiency: the item adequately measures the corresponding dimension.
- Clarity: the item is easily understood; syntax and semantics are appropriate.
- Coherence: the item is logically related to the dimension or indicator it measures.
- Relevance: the item is essential or important and should therefore be included.

When participants selected null or low, they were asked to provide comments explaining their choice. Based on this feedback, the interview protocol was refined, ensuring a more coherent structure aligned with interview dynamics (Patton, 2002), resulting in a final set of nine questions organized across key dimensions (Figure 2).

Figure 2*Questions by Dimensions for the Interview*

School Setting	1. Which places in the school do you use for STEAM activities, and which are the materials do you have access to work STEAM in your group?
Educational System	2. How can you describe your training experience about STEAM areas and your training about child-centred pedagogies?
Digital Education	3. Do you integrate digital tools in your teaching practices? How do you do it?
STEAM Integration	4. How do you design or adapt your classes to promote STEAM education? 5. How do you currently integrate STEAM activities in your classroom and what are the main difficulties or challenges? 6. Which aspects do you consider when selecting STEAM materials for your classroom?
Children Development	7. When planning STEAM activities, which children's developmental aspects do you consider important?
Evaluation	8. While working with STEAM activities, how do you monitor and evaluate children's learning outcomes? Which indicators do you consider when determining the success of their work with the materials?
Early Childhood Education	9. What do you believe are the most essential key competences and basic skills for preschool children

Note. Created based on the review process for the interview questions.

Teachers Selection for Interviews

The sample was selected using convenience (or affinity) sampling (Robson & McCartan, 2016), a typical strategy in qualitative research that enables the identification and inclusion of participants with relevant expertise and direct experience in the phenomenon under study.

Participation was voluntary; the six educators received comprehensive information about the study and provided informed consent. Participants were selected based on their preschool teaching experience, which was considered relevant for identifying elements to be incorporated into the subsequent development of the evaluation tool (Table 1).

Table 1*Table of Interviewed Teachers Sample*

Code	Country	Context	Highlighted Training
Teacher 1	Spain	STEAM project	Tinker, Maker, STEAM
Teacher 2	Spain	STEAM project	STEAM training, Bibliotech, Magnet, AUNA & FACH projects
Teacher 3	Spain	STEAM project	STEAM-Magnet & FACH project
Teacher 4	Germany	Montessori setting	Nursery School Program - Montessori
Teacher 5	Germany	Montessori setting	Montessori- different workshops, refresher courses
Teacher 5	Germany	Montessori setting	Montessori - STEAM

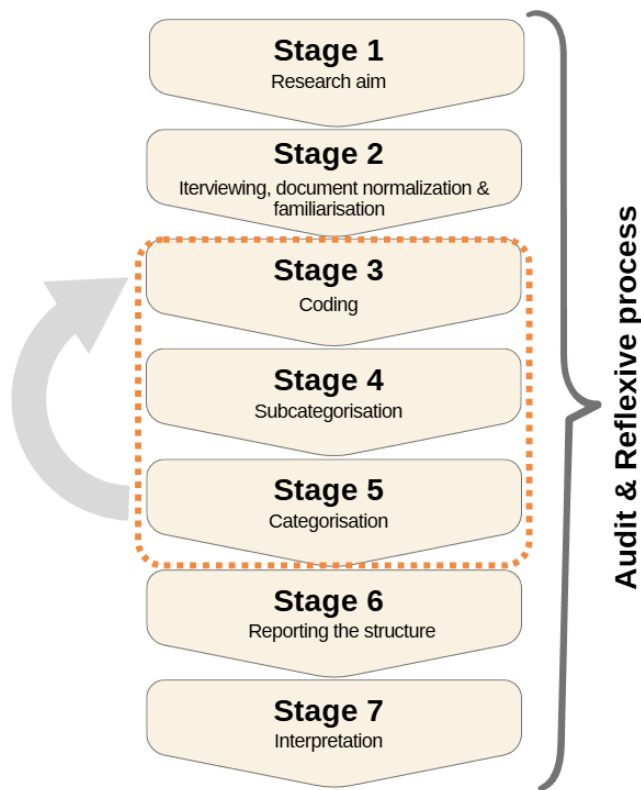
The inclusion of participants from two countries aimed to capture variability in educational settings and pedagogical approaches within a broader European framework. The selection of both expert panel members and interviewed teachers was informed by the prior analysis of EU policy documents, ensuring alignment between the study sample and the policy context under investigation. In this sense, the European dimension of the study is not limited to geographical diversity but is conceptually grounded in the policy frameworks that shape ECE, STEAM implementation, and digital competence across EU member states. Although cross-country comparison was not the primary objective, this design provides a broader perspective on how STEAM is interpreted and enacted across different European educational contexts.

Data Collection

Data were collected in June, 2025, the duration of the interviews ranged from approximately 25 to 45 minutes. Of the six teachers interviewed using the structured interview questions, five responded to all questions. Within the final sample, four interviews were conducted online (video-call), recording only audio; one teacher submitted pre-recorded answers, and one provided written responses. All audio recordings were transcribed verbatim using digital transcription software Microsoft Clipchamp (2025).

Data Analysis

Following Nicmanis (2024), Reflexive Content Analysis (RCA) was employed to systematically classify the textual data from the collected posts into codes, subcategories, and categories (Figure3). The unit of analysis was defined as meaningful segments of text representing complete ideas expressed by participants. The analysis focused on identifying which codes were mentioned most frequently and which were consistently reported by teachers, highlighting recurring patterns in their experiences and reflections. The study was guided by the research questions.

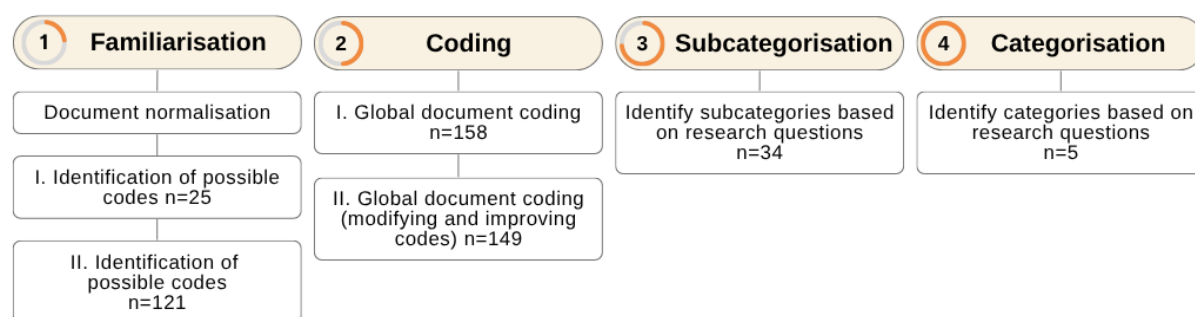
Figure 3*Seven Stages in Reflexive Content Analysis*

Source. Workflow inspired by *The seven stages of the CA process and reflexive practices*, created by Nicmanis (2024), source <https://doi.org/10.1177/1609406924123660>

The analysis followed an iterative process consisting of multiple stages: (1) familiarization with the data, (2) initial code generation, (3) refinement and consolidation of codes, and (4) grouping into subcategories and overarching categories aligned with the research questions. QualCoder (2025) software (version 3.7, IA disabled) was used to support coding during the familiarization process and data organization, while Microsoft Excel (2025) was used to maintain the codebook and document coding decisions. Additionally, data were quantified to support the identification of frequently mentioned codes and recurring patterns among teachers (Vaismoradi & Snelgrove, 2019). Typographical errors produced by the transcription software were corrected in all reported quotations.

Analysis Structure: Categories, Subcategories, and Codes

Each interview was organized in an individual Excel sheet, and a parallel codebook was maintained. The process started with an initial familiarization, followed by refining of the list, which was used for two coding iterations, keeping records of all changes and additions in the codebook (Figure4).

Figure 4*Reflexive Process from Familiarisation to Categorisation*

Note. Figure elaborated based on the *Codes by tagging process* data from the CORA dataset *Preschool Teacher's Experiences when Integrating STEAM: Reflexive Content Analysis Process* (Köchig, et al., 2026), <https://doi.org/10.34810/DATA2705>

To ensure trustworthiness despite the use of a single coder, several strategies were employed. First, an iterative coding process with multiple rounds of refinement was conducted, maintaining a detailed audit trail of all coding decisions (Tracy, 2018). Second, reflexive iteration practice was implemented to enhance the quality, consistency of the results and to critically examine potential researcher bias (Nicmanis, 2024).

For subcategorization, the codes were grouped by comparing each code with its corresponding text unit. The categories were derived from the five initial research questions. A subsequent review of the subcategories and categories was conducted among the research team, examining how certain transversal codes—related to child development, individual learning processes, and challenges—were best integrated (Appendix B).

Sample and Analytic Overview

For the presentation of the data, two analytical factors were considered: (1) the frequency of code occurrences within each category, and (2) the number of teachers who mentioned a particular code in response to the same question. The analysis therefore focused on identifying the most frequent codes within each category and those most commonly mentioned across participants (Table 2).

Table 2*Presentation of Findings by Category*

Category	Most frequent ¹		Most mentioned ²	
	Subcategory	Code	Subcategory	Code
Educational technology	Screens in the classroom from teacher's point of view	Screen tool in the classroom (access and use) n=16	Screens in the classroom from teacher's point of view	Screen tool in the classroom (individual tablets) n=4

Category	Most frequent ₁		Most mentioned ₂	
	Subcategory	Code	Subcategory	Code
Evaluation process	Evaluation in practice	Evaluation process (monitoring and tracking tools) n=32	Evaluation tools	Evaluation process (specific objectives to observe during the evaluation process) n=6
Pedagogical elements when working STEAM	Pedagogical practices about the planning	Pedagogical elements/practices (activity planning) n=81	Evaluation in practice	Evaluation process (global process) n=6
			Children	Children
			cognitive development	development (skills) n=6
			Pedagogical practices about the planning	Pedagogical elements/practices (project base activity plan) n=6
			Pedagogical practices about the planning	Pedagogical elements/practices (activity planning) n=6
			Pedagogical practice for the activities	Pedagogical elements/practices (activity content) n=6
			Children	Children
			cognitive development	development (will and interests) n=6
			School infrastructure building	School infrastructure and materials (classrooms) n=6
			Pedagogical practice for the activities	Pedagogical elements/practices (type of activity) n=6
STEAM material	Material attributes	Material in general (type) n=29	Pedagogical practice in connection to the materials	Pedagogical elements/practices (material selection) n=6
			Material attributes	Material in general (type) n=5
Teachers' education	Teachers' ongoing training	Teachers' training and education	Teachers' training experiences	Teachers' training and education (types of training) n=5

Category	Most frequent ₁		Most mentioned ₂	
	Subcategory	Code	Subcategory	Code
(content)				
n=13				

Note. *Most frequent* refers to the co-occurrence of the tagged code, while *Most mentioned* refers to the amount of teachers talking about the same code Table elaborated based on the *Frequency* data from the CORA dataset *Preschool Teacher’s Experiences when Integrating STEAM: Reflexive Content Analysis Process* (Köchig, et al., 2026), <https://doi.org/10.34810/DATA2705>

Ethical Considerations

This research was conducted in compliance with the ethical principles set out in the Declaration of Helsinki. All participants were informed of the purpose of this study and participated voluntarily, having signed an informed consent form. The knowledge and approval by management of Comité Ético de Investigación en Personas, Sociedad y Medio Ambiente (CEIPSA) from Rovira i Virgili University with the registered CEIPSA-2025-TDO-0019.

Results

Pedagogical Elements when Working STEAM

Teachers’ responses under this category clustered around operational subthemes, among them, pedagogical approaches in practice (scaffolding and didactic competence), material-related practice (selection and presentation), activity-level practice (content design and repetition), environment management (preparation and maintenance), planning interdisciplinary learning experiences (adaptation, routines, objectives) and contextual elements (difficulties and school setting).

Across interviews, the dominant emphasis was on the selection and planning of activities (Activity planning n=81), child-centred, hands-on approaches and scaffolding. Most teachers described STEAM activities or projects as emerging from children’s interests. As Teacher 5 explained, these involved ‘things that arose within the group activity and then being able to follow up and respond to them through small projects.’ Teacher 6 noted, ‘I believe that the idea for the activities comes from the children themselves, that is, they are designed with the interests, curiosity and flexibility of the group in mind.’

One common formulation was the use of brief teacher-led introductions followed by extended child-led exploration, the meticulous plan from the presentation of the material to the free exploration as key for a successful implementation. Teacher 1 commented, ‘once I have gone through two rounds with all the pupils using that robot, I can let them be on their own, because by then they will know the basic operation and will be able to explore other things.’

Participants consistently framed scaffolding as a flexible, moment-to-moment pedagogical decision, tied to the child’s current developmental needs. Codes grouped under “children cognitive development” were the second most frequent in this category (children development — skills: n = 80), indicating teachers repeatedly located pedagogical choices in developmental

observables (attention, fine motor skill, language). Teacher 6 mentioned that ‘the progressive development of language, in accordance with each child's individual pace, should also be taken into account when planning activities. ... Depending on each need and interest, fine and gross motor skills should also be present.’

Material-related practices were discussed in practical terms: teachers described organizing materials by accessibility, labelling, and updating of the offers according to children development while supporting independence. Presentation technique was emphasised as critical: whether to present a material individually, in small groups, or as a whole-class demonstration depended on the intended learning goal and the group's dynamics. A representative comment from Teacher 4 illustrates this approach, ‘I made a plan with the objectives, the materials, and the stages of how it will be done.’

Activity design reflected a preference for project-based or open-ended formats. Repetition and routine were described as features that enable consolidation (e.g. repeating an activity across days to deepen understanding). When asked about planning, teachers reported that they build flexibility into routines and set broad objectives rather than rigid, step-by-step plans. Teacher 5 explained that ‘workshops, activities, and anything else prepared for children must be followed up on and become a permanent part of the children's routine, part of their daily learning within the context of preschool and the environment...’

Teachers also described the classroom environment as a pedagogical resource: intentional arrangement of materials, defined zones for exploration, and orderly storage were all cited as supporting children's autonomous engagement with STEAM offers. A short quotation illustrating these themes includes, Teacher 1 stated that they have labelled and classified material for the offers, which are in furniture only accessible to teachers.

Collectively, the data for this category show teachers blending Montessori-compatible child-centred principles (independence, prepared environment, development, material presentation) with explicit scaffolding and planning strategies adapted to the preschool context (*Pedagogical elements when working STEAM* in Appendix C).

Teachers' Education

This category grouped codes about initial teacher education (pedagogical foundations), ongoing professional development (STEAM content and child-centred pedagogies), and the character of training experiences (types, adaptation and adoption).

One participant reported pre-service STEAM experiences while the main STEAM training was in-service. In addition, ongoing training was also self-directed (personal study, trial-and-error) or locally organised (school workshops). Teacher 1 explained ‘... a little bit, well, searching the Internet, a little more than you can do as an individual.’

Codes clustered under “teachers' ongoing training — content” were moderately frequent ($n = 13$), indicating that training for STEAM-specific content was present but not dominant across participants. A representative comment from Teacher 3 explained that ‘an initial part of training and then, if you want to do more training, you do it on a more personal level.’ In addition, Teacher 6 mentioned ‘this motivates me to keep searching for more information and better and new tools to design activities where I can combine these activities.’

Teachers described various training modalities: periods length, short workshops, peer-led exchanges, online courses, and learning by trial within their own classrooms. A recurring point was that training often lacked alignment with EC developmental specifics; several teachers expressed practical experiences, classroom-ready modules rather than theoretical overviews. An illustrative expression from Teacher 1 explained: ‘... in terms of teaching methods, it is true that this comes more from what you study at university than from your training once you become a teacher, unless you do a specific master's degree in a particular teaching method.’

Overall, participants positioned their professional learning as patchwork: pockets of useful training but gaps in systematic, developmentally informed STEAM education for preschool teachers, gaps that individually or, in some cases, schools provide training for (*Teachers' education* in Appendix C).

STEAM Material

Responses about materials split into four sub-topics: types of STEAM materials (kits, manipulatives, software), material attributes (contextualization, quality, safety), materials with a technological aspect (non-screen tech), and the role of purchased kits versus self-made resources.

Material-type codes were prominent (material in general — type: $n = 29$). Across interviews, teachers showed a clear preference for tactile, manipulable materials that encouraged sensorimotor exploration, consistent with the Montessori approach. Many teachers described using low-tech, mechanical objects (pulleys, gears, simple circuits without screens) and repurposed everyday materials. Teacher 1 stated that they used ‘... pompoms, different types of balls, and some felt so that they can hook the curlers onto the felt and make a marble run.’ In the case of Teacher 3: ‘you bring pine-cones, or leaves, or wood, or shells or things that they can then see in their reality and that make playing more relatable.’ And Teacher 4 mentioned: ‘our apprentice made a bench in the garden. ... where the children could use tools such as sanders and screwdrivers’

Key selection criteria reported by teachers included: safety, durability, contextual relevance to the children's lives, and potential for multiple levels of use (open-ended affordances). Several teachers expressed caution about commercial kits that were overly directive or developmentally mismatched. A representative comments from Teacher 1 explained:

you get the whole box [such] as electricity, so then you have all the material and everything. ... if there is someone who has already thought about it and everything is designed, then sometimes these practices are more to be discovered than connected... this would be a practice, a proposal that I could put there for more exploration, more freedom to say, well, look, I'll put some LEDs and some batteries in and see what happens.

Moreover, Teacher 3 mentioned ‘in other words, anything that is experiential and close to them will be closer to good learning. ... It depends on what you want to work on, whether you use a more open material or a more structured material.’ in addition Teacher 6 indicated that ‘the materials should be easy and varied to handle, safe, and in appropriate proportions for small hands.’

There was also discussion of technological materials that avoid screens (e.g., programmable floor robots with tangible interfaces). As is the case of Teacher 1 explanation: ‘I try to use mice, which are robots that are quite easy to program, which is basically code. ... You have to make the robot tell me the correct order of the butterfly cycle with the programming.’ These were valued for introducing computational thinking without relying on tablets or individual screens (*STEAM material* in Appendix C).

Educational Technology

Educational-technology codes bifurcated into (a) screens in the classroom (access, use, teacher attitudes) and (b) digital tools as pedagogical/administrative allies.

The most frequent technology code related to teachers’ perceptions of screens (screen tool in the classroom — access and use: $n = 16$). Teachers tended to draw a distinction between group-level use of screens (projector, shared display) and individual touchscreen devices. Group presentations and teacher-led searching were acceptable to many; individual tablet work was much less common and sometimes resisted for developmental or policy reasons. On the one hand, examples such as Teacher 1 illustrate this: ‘I do use the tablet for projects sometimes, not for them to search because they’re not at that level yet, but I prepare things for them.’ Similarly, Teacher 3 stated: ‘I think that there are students who, if you project an image with an oral explanation, will understand much more than if you are simply talking.’ On the other hand, Teacher 5 explained: ‘... the use of tablets or any other extra technology in children’s daily lives or routines is not part of our preschool or our institution.’

Teachers also described using digital tools outside direct child engagement: preparing material, documenting learning, and administrative tasks (planning, communication with families). When used pedagogically, digital tools tended to support teacher facilitation (e.g., using a laptop to show a short video that introduces a concept) rather than replace hands-on work. Representative statements include that of Teacher 6: ‘But I would very much like to be able to present “Peep and the Big Wide World” on the iPad soon. ... I think it’s a series that combines STEAM activities very well.’ Similarly, Teacher 5 explained: ‘I have increasingly used them to prepare my work during times when I am not in front of the group.’

Concerns raised included screen time, unequal access among families, and the need for teacher competence in selecting age-appropriate digital offers (*Educational technology* in Appendix C).

Evaluation Process

The Evaluation category comprised three main sub-topics: evaluation techniques (reflexive questioning, self-assessment), evaluation tools (scales, monitoring and tracking), and evaluation in practice (how evaluation is enacted day-to-day).

A clearly recurrent finding was that teachers predominantly relied on observational, formative assessment practices. The code “evaluation process (monitoring and tracking tools)” was the most frequent single evaluation code ($n = 32$), suggesting that participants repeatedly discussed their need for structured monitoring tools. Teacher 6 explained that ‘observing and

documenting experiences during the activity and teamwork can show us how the process unfolded and what the outcome was.’ Teacher 3 mentioned:

It is clear that you have to be very clear about your objectives and assess them, and I think the good thing is that you can keep track of them. It's not a yes or no, but rather how close you are to that goal. ... assessing the pupils, assessing the activity itself and then ourselves.

Current practices included anecdotal notes, photographic documentation, simple checklists, and narrative records. Formalized rubrics or validated scales tailored to STEAM-in-ECE contexts were largely absent. Teacher 4 mentioned:

What we have tried to do among ourselves is to have a list of all the materials separated by area, and we have the list of children above, and the child who has a presentation goes through it and crosses it off.

Teachers described evaluation as integrated into everyday practice (observing during free work, noting emergent skills) rather than a separate summative exercise. Several participants called for clearer, practical indicators that would help them identify and document children’s progression in STEAM competence. Among the quotations exemplifying this need are Teacher 1, who referred to how ‘right and wrong become more diluted, because in the end, if I manage to achieve that, there is nothing right or wrong in the process... . Incorrect could be a misuse of the material.’ Teacher 5 also referred to the need to ‘ensure consistency and record-keeping, and have the appropriate tools to also record observations relating to each child and the group as a whole.’

In practice, evaluation was used both to inform immediate scaffolding and adaptation as well as to communicate progress to families or school leadership, and teachers reported their main objectives are for children to be able to develop as individuals while working with the material, while teachers could track children's individual progress and, when possible, their social skills (*Evaluation process* in Appendix C).

Discussion

The aim of this study was to identify key pedagogical, material, technological, and evaluative elements derived from preschool teachers’ experiences that can inform the design of an assessment tool for STEAM education in EC settings. By integrating insights from teacher interviews, European policy frameworks, and prior observational data, the findings provide a coherent picture of how STEAM education is interpreted and enacted in practice.

Consistent with previous research highlighting the limited development of STEAM in ECE compared to other educational levels (Belbase et al., 2021; Tasiopoulou et al., 2022; Sakellaropoulou et al., 2024), teachers in this study did not approach STEAM as a distinct curricular domain. Instead, STEAM emerged as a pedagogical approach embedded in everyday classroom practices, grounded in hands-on, inquiry-based learning. This finding aligns with the need for developmentally appropriate strategies emphasized in European policy

frameworks (Council of the European Union, 2019) and with research on early STEAM experiences (Master et al., 2017).

The findings confirm that teacher preparation remains a central challenge in STEAM implementation. Participants reported fragmented training pathways, which align with existing evidence highlighting limited pedagogical knowledge, and insufficient preparation among early childhood educators (Núñez et al., 2025; Sawangmek, 2019; Council of the European Union, 2022). These constraints are compounded by restricted access to professional development, as well as limited resources and institutional support, which hinder teachers' ability to design and implement integrated STEAM practices (Ng et al., 2022).

Moreover, as identified in the literature, these limitations affect teachers' capacity to move beyond fragmented activities and engage in meaningful interdisciplinary approaches (Ng et al., 2022; Muhammad Rafiq-uz-Zaman, 2025). Together, these findings reinforce the need for structured, practice-oriented teacher training that supports both pedagogical understanding and the implementation of STEAM in early childhood contexts.

In terms of pedagogy, the emphasis on autonomy, hands-on learning, and adaptation to developmental stages strongly aligns with Montessori principles (Lillard & McHugh, 2019) and supports their relevance as a framework for STEAM integration (Çakir & Yalçın, 2022). This connection reinforces the argument that pedagogical approaches, rather than disciplinary content alone, are central to STEAM education in early childhood contexts.

The role of digital technologies observed in this study further supports the conceptual distinction outlined in the framework. Teachers used digital tools selectively and primarily as pedagogical supports, confirming that digital literacy is not intrinsic to STEAM but functions as an enabling competence when meaningfully integrated (Redecker & Punie, 2017). This finding is consistent with research emphasizing the need to balance digital and experiential learning in early childhood settings (Owen & Davies, 2020; Vatavu et al., 2015).

Regarding materials, teachers' preference for open-ended and adaptable resources reflects the importance of developmentally appropriate practices highlighted in both policy and research. This supports the idea that STEAM implementation in preschool should focus on the pedagogical use of materials rather than their technological sophistication.

Finally, the findings related to evaluation processes confirm a key gap identified in the literature: the lack of structured assessment tools adapted to early childhood STEAM contexts (European Commission, 2020; Silvis et al., 2022). While teachers rely on observational assessment, they report difficulties in documenting and systematizing these processes. This reinforces the need for tools that align with early childhood principles while supporting reflective and consistent evaluation practices.

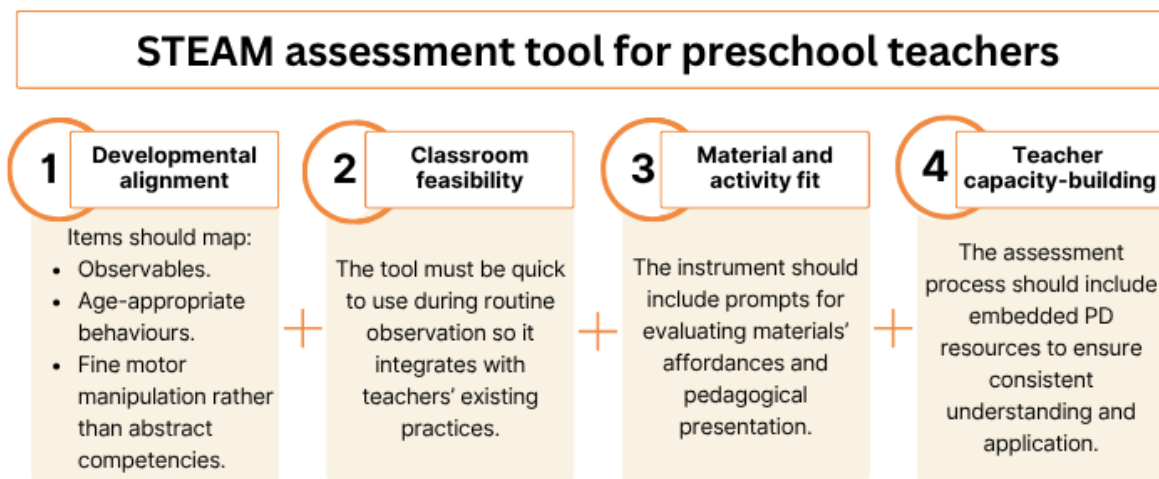
Taken together, these findings demonstrate that STEAM implementation in ECE is shaped by the interaction between pedagogical approaches, teacher competence, material selection, digital mediation, and assessment practices. These dimensions, identified both in the framework and in the empirical data, provide a coherent basis for the development of a context-sensitive assessment tool.

This study contributes to the field by (1) empirically characterizing how preschool teachers implement STEAM within everyday practice, (2) clarifying the role of digital competence as a pedagogical enabler rather than a defining component of STEAM, and (3) identifying practice-based indicators that can inform the design of an assessment tool aligned with European

educational frameworks and Montessori pedagogy. The conceptual model presented (Figure 5) synthesizes these elements, providing a foundation for the design of an assessment instrument that is both pedagogically meaningful and practically applicable in preschool contexts.

Figure 5

Conceptual Framework for the STEAM Assessment Tool



Note. Framework elaborated based on the data from the CORA dataset *Preschool Teacher's Experiences when Integrating STEAM: Reflexive Content Analysis Process* (Köchig, et al., 2026), <https://doi.org/10.34810/DATA2705>

Conclusion

This study explored preschool teachers' experiences with STEAM education through five guiding questions addressing pedagogy, training, materials, digital practices, and evaluation. The findings show that teachers enact STEAM through child-centered, exploratory methods grounded in the prepared environment and guided scaffolding. They favour tactile and adaptable materials, approach technology with pedagogical caution, and rely primarily on observational assessment.

Preschool STEAM practice in different environments emerges as developmentally coherent but structurally constrained. Teachers' narratives reveal pedagogical alignment — child-centred exploration, tactile learning, reflective technology use — alongside systemic gaps in training, materials, and assessment infrastructure. By capturing these elements, this study provides the empirical foundation for a validated, observation-based assessment tool and professional e-certificate program that bridges European policy objectives and everyday preschool realities.

Teachers in this study enact STEAM learning through child-centred, hands-on practices that foreground exploration, scaffolding, and well-prepared environments. They prefer tactile, adaptable materials and use technology cautiously, reserving screens largely for short, teacher-mediated activities while employing digital tools for planning and documentation. Professional learning is fragmented and often self-directed; evaluation is predominantly observational and would benefit from structured, feasible tools.

An effective STEAM assessment tool for preschool contexts should therefore be developmentally aligned, classroom-feasible, materials-sensitive, and accompanied by concise professional development resources. Priorities for implementation include co-design with teachers, piloting in diverse settings, and ensuring the instrument supports both formative classroom decisions and communication with families and school leadership. These steps will maximize the tool's utility and contribute to closing the gap between policy aspirations for early STEAM and everyday classroom practice.

Moreover, despite EU policy emphasis on early digital literacy and high-quality ECEC, participants' accounts reveal persistent implementation gaps: limited STEAM-specific training, variable access to context-appropriate materials, and the absence of standardized evaluation tools. These gaps reflect earlier analyses of uneven European uptake of STEAM objectives and point to the need for policies that fund practical teacher supports (materials, PD, validated assessment instruments) rather than only high-level recommendations.

The reflexive content analysis approach allowed an iterative, context-sensitive coding process that generated a rich codebook and frequency counts; using QualCoder and Excel facilitated audit trails and transparent code refinement. As a qualitative study, the small convenience/snowball sample (N = 6) aimed to provide depth and contextual richness rather than generalization, allowing detailed insights into teachers' experiences with STEAM and Montessori practices. Future research should pilot the proposed assessment tool in a larger, stratified sample and include classroom observations to triangulate self-reported practice.

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Conceptualization, E.P. Köchig, B. Lores-Gómez and M. Usart-Rodríguez; methodology, E.P. Köchig, B. Lores-Gómez and M. Usart-Rodríguez; validation, E.P. Köchig, B. Lores-Gómez

and M. Usart-Rodríguez; formal analysis, E.P. Köchig; investigation, E.P. Köchig, B. Lores-Gómez and M. Usart-Rodríguez; data curation, E.P. Köchig; writing—original draft preparation, Erica Pamela Köchig; writing—review and editing, E.P. Köchig, B. Lores-Gómez and M. Usart-Rodríguez; visualization, E.P. Köchig. All authors have read and agreed to the published version of the manuscript.

References

- Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2021). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology*, 53(11), 2919-2955. <https://doi.org/10.1080/0020739X.2021.1922943>
- Bush, S. B., & Cook, K. L. (2019). Structuring STEAM Inquiries: Lessons Learned from Practice. In: Khine, M.S., Areepattamannil, S. (Eds.), *STEAM Education* (pp.19-35). Springer, Cham. https://doi.org/10.1007/978-3-030-04003-1_2
- Çakir, Z., & Yalçın, S. A. (2022). The effect of Montessori approach-based STEM education on pre-service pre-school teachers' self-directed learning. *e-International Journal of Educational Research*, 13(2), 142-162. <https://doi.org/10.19160/e-ijer.1038793>
- Ching, Y., Yang, D., Wang, S., Baek, Y., Swanson, S., & Chittoori, B. (2019). Elementary School Student Development of STEM Attitudes and Perceived Learning in a STEM Integrated Robotics Curriculum. *TechTrends*, 63(5), 590-601. <https://doi.org/10.1007/s11528-019-00388-0>
- Council of the European Union. (2015). *Council conclusions on the role of early childhood education and primary education in fostering creativity, innovation, and digital competence*. Official Journal of the European Union. [https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015XG0527\(04\)](https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015XG0527(04)). Accessed 18 March 2025.
- Council of the European Union. (2019). *Council recommendation of 22 May 2019 on high-quality early childhood education and care systems*. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=oj:JOC_2019_189_R_0002. Accessed 18 March 2025.
- Council of the European Union. (2020). *Council conclusions on European teachers and trainers for the future*. Official Journal of the European Union. [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020XG0609\(02\)](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020XG0609(02)). Accessed 18 March 2025.
- Council of the European Union. (2022). *Council recommendation of 16 June 2022 on learning for the green transition and sustainable development*. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=oj:JOC_2022_243_R_0001. Accessed 18 March 2025.
- European Commission. (2020). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions: Digital education action plan 2021-2027-Resetting education and training for the digital age*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0624>. Accessed 18 March 2025.
- European Commission. (2024). Opinion of the European Economic and Social Committee on the proposal for a Council Recommendation on the key enabling factors for successful digital education and training. <https://eur-lex.europa.eu/eli/C/2024/885/oj/eng>. Accessed 21 March 2026.

- Fernández-Gómez, E., Martín-Salvador, A., Luque-Vara, T., Sánchez-Ojeda, M. A., Navarro-Prado, S., & Enrique-Mirón, C. (2020). Content Validation through Expert Judgement of an Instrument on the Nutritional Knowledge, Beliefs, and Habits of Pregnant Women. *Nutrients*, 12(4), 1136. <https://doi.org/10.3390/nu12041136>
- Fernandez-Oliveras, A. F., Correa, V. M., & Oliveras, M. (2016). Estudio de una propuesta lúdica para la educación científica y matemática globalizada en infantil. *Revista Eureka Sobre Enseñanza Y Divulgación De Las Ciencias*, 13(2), 373-383. <https://tinyurl.com/3atjdj9>
https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2016.v13.i2.10
- García-Peñalvo, F. J. (2022). Desarrollo de estados de la cuestión robustos: Revisiones Sistemáticas de Literatura. *Education in the Knowledge Society*, 23, 1-23. <https://doi.org/10.14201/eks.28600>
- Gibert, K., & Valls, A. (2022). Building a territorial working group to reduce gender gap in the field of artificial intelligence. *Applied Sciences*, 12(6), 3129. <https://doi.org/10.3390/app12063129>
- Köchig, E. P. (in press). Experiencias STEAM en educación infantil en escola Montessori de Rubí, Barcelona-España. XIII Congreso Internacional Multidisciplinar de Investigación Educativa CIMIE25. Donostia, Spain. <https://doi.org/10.62701/revedu.v13.5470>
- Köchig, E. P., Lores-Gómez, B., & Usart-Rodriguez, M. (2025). Integración de Montessori en STEAM en Educación Infantil: Una revisión sistemática. *EDU REVIEW. International Education and Learning Review Revista Internacional De Educación Y Aprendizaje*, 13(2), 1-21.
- Lázaro Cantabrana, J. L., & Gisbert Cervera, M. (2015). Elaboració d'una rúbrica per avaluar la competència digital del docent. *UTE Teaching & Technology (Universitat Tarraconensis)*, 1(1), 48-63. <https://revistes.urv.cat/index.php/ute/article/view/648>
<https://doi.org/10.17345/ute.2015.1.648>
- Lillard, A. S., & McHugh, V. (2019). Authentic Montessori: The Dottoressa's View at the End of Her Life Part I: The Environment. *Journal of Montessori Research*, 5(1), 1-18. <https://doi.org/10.17161/jomr.v5i1.9753>
- Master, A., Cheryan, S., & Meltzoff, A. N. (2017). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, 109(6), 912-920.
- Muhammad Rafiq-uz-Zaman. (2025). STEAM: A contemporary concept and a set of early childhood education. *Journal of Childhood Literacy and Societal Issues*, 4(1), 122-140. <https://doi.org/10.71085/joclsi.04.01.77>
- Ng, A., Kewalramani, S., & Kidman, G. (2022). Integrating and navigating STEAM (inSTEAM) in early childhood education: An integrative review and in STEAM conceptual framework. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(7), em2133. <https://doi.org/10.29333/ejmste/12174>
- Nicmanis, M. (2024). Reflexive Content analysis: an approach to qualitative data analysis, reduction, and description. *International Journal of Qualitative Methods*, 23. <https://doi.org/10.1177/16094069241236603>

- Núñez, R. P., Tarazona, M. E. P. ., & Moreno, F. J. R. . (2025). The Steam Educational Approach in the Pedagogical Practice of Early Childhood Teachers: Reality or Utopia?. *Journal of Ecohumanism*, 4(1), 4593-4607. <https://doi.org/10.62754/joe.v4i1.6358>
- OECD. (2024). Education at a Glance 2024: OECD Indicators. Paris: OECD Publishing. <https://doi.org/10.1787/c00cad36-en>. Accessed 18 March 2025. <https://doi.org/10.1787/c00cad36-en>
- Owen, S., & Davies, S. (2020). Maintaining an empowered school community: Introducing digital technologies by building digital literacies at Beehive Montessori School. *London Review of Education*, 18(3). <https://doi.org/10.14324/LRE.18.3.03>
- Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods* (3rd ed.). Sage Publications, Inc.
- Redecker, C. & Punie, Y. (2017). *European Framework for the Digital Competence of Educators: DIGCOMPEDU*. Publications Office of the European Union.
- Robson, C., & McCartan, K. (2016). *Real World Research: A Resource for Users of Social Research Methods in Applied Settings* (4th ed.). Wiley
- Sakellaropoulou, G., Spyropoulou, N., Agaliotis, I., Kartasidou, L., Kameas, A. (2024). Navigating STEAM education and inclusive practices: A needs analysis of primary educators in Greece. In 11th International conference on software development and technologies for enhancing accessibility and fighting Info-exclusion (DSAI 2024) (pp.82-90). <https://doi.org/10.1145/3696593.3696643>
- Sakellaropoulou, G., Spyropoulou, N., & Kameas, A. (2025). Exploring Greek Primary Teachers' Perspectives in Inclusive Education for Special Educational Needs (SEN) Students and Related Research Trends: A Systematic Literature Review. *Education Sciences*, 15(7), 920. <https://doi.org/10.3390/educsci15070920>
- Sawangmek, S. (2019). Trends and Issues on STEM and STEAM Education in Early Childhood. *Training and Practice : Journal of Educational Sciences*, 17(3-4), 97-106. <https://doi.org/10.17165/TP.2019.3-4.8>
- Seery, N., Dunbar, R., & Reid, C. (2022). Status and Trends of STEM Education in Ireland. *Technological and Vocational Education Research Center*, 207-258. <https://files.eric.ed.gov/fulltext/ED623352.pdf>
- Silvis, D., Clarke-Midura, J., Shumway, J. F., Lee, V. R., & Lewis, S. (2022). Children caring for robots: Expanding computational thinking frameworks to include a technological ethic of care. *International Journal of Child-Computer Interaction*, 33, 100491. <https://doi.org/10.1016/j.ijcci.2022.100491>
- Şimşek, M., & Tuğluk, M. N. (2021). Making learning visible in the 21st Century: Examining the use of digital assessment tools in Montessori education. *Pegem Journal of Education and Instruction*, 11(2), 72-86.
- Spyropoulou, N., & Kameas, A. (2024). Augmenting the impact of STEAM education by developing a competence framework for STEAM educators for effective teaching and learning. *Education Sciences*, 14(1), 25. <https://doi.org/10.3390/educsci14010025>
- Sullivan, A., & Strawhacker, A. (2021). Screen-Free STEAM: Low-Cost and hands-on approaches to teaching coding and engineering to young children. *Springer*, 87-113. https://doi.org/10.1007/978-3-030-65624-9_5

- Tasiopoulou, E., Gori, J. N., Grand-Meyer, E., Myrtsioti, E., Xenofontos, N., Chovardas, A., Cinganotto, L., Garista, P., Jakić, I., Kralj, L., Dasović, D., Grgec, K., Apa, M., Ljubek, A., Krikovic, N., Castro, S., Ramos, C., Cândido, E., Francone, A.,...Gras-Velazquez, A. (2022). European Integrated STEM Teaching Framework. Brussels: European Schoolnet. [https://ricerca.unistrapg.it/retrieve/f3e19608-a5eb-4c4f-b119-e2487d1de894/STE\(A\)M-IT-Framework-Digital.pdf](https://ricerca.unistrapg.it/retrieve/f3e19608-a5eb-4c4f-b119-e2487d1de894/STE(A)M-IT-Framework-Digital.pdf)
- Tönnsen, K.C. (2022). Status and Trends of STEM Education in Germany. *Technological and Vocational Education Research Center*, 97-140. <https://files.eric.ed.gov/fulltext/ED623352.pdf>
- Tracy, S. J. (2018). A phronetic iterative approach to data analysis in qualitative research. *Qualitative Research*, 18(3), 281–300.
- UNESCO. (2024). UNESCO Framework for Culture and Arts Education. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000390135.locale=en>
- Vaismoradi, M., & Snelgrove, S. (2019). Theme in qualitative content analysis and thematic analysis. *Forum: Qualitative Social Research*, 20(3). 23.
- Vatavu, R., Cramariuc, G., & Schipor, D. M. (2015). Touch interaction for children aged 3 to 6 years: Experimental findings and relationship to motor skills. *International Journal of Human-Computer Studies*, 74, 54-76. <https://doi.org/10.1016/j.ijhcs.2014.10.007>
- Yakman, G., & Lee, H. (2012). Exploring the Exemplary STEAM Education in the U.S. as a Practical Educational Framework for Korea. *Journal of the Korean Association for Science Education*, 32(6), 1072-1086. <https://doi.org/10.14697/jkase.2012.32.6.1072>

Appendix A

Interview Questions Validation

Figure A1

Example from the Form Sent to the Experts

7. (1/15) **Dimension1: Children Development QA. Which developmental aspects do you consider are important when working with STEAM activities?** We would like to know how the question posed meet the following criteria: *

	Null	Low	High	Optimum
Sufficiency: the item is sufficient to measure this dimension.	☐	☐	☐	☐
Clarity: the item can be understood easily, i.e., syntax and semantics are appropriate.	☐	☐	☐	☐
Coherence: the item is logically related to the dimension or indicator it is measuring.	☐	☐	☐	☐
Relevance: the item is essential or important, i.e., it must be included.	☐	☐	☐	☐

8. Observations (explain when a category is assessed as **null or low**)

Enter your answer

Appendix B

Categories, Subcategories and Codes

Table elaborated based on the *Subcategories by categories* data from the dataset *Preschool Teacher’s Experiences when Integrating STEAM: Reflexive Content Analysis Process* (Köchig et al., 2026).
Refer to *Subcategories grouped by categories with code examples* (Köchig et al., 2026).
CORA. <https://doi.org/10.34810/DATA2705>

Appendix C

Dataset of the Reflexive Content Analysis

Files with the interview transcriptions grouped by category and subcategory.

Table C1*Files from the Dataset with Links*

Files	Links
Educational technology	https://dataverse.csuc.cat/file.xhtml?fileId=429861&version=1.0
Pedagogical elements when working STEAM	https://dataverse.csuc.cat/file.xhtml?fileId=429863&version=1.0
STEAM material	https://dataverse.csuc.cat/file.xhtml?fileId=429864&version=1.0
Teachers' education	https://dataverse.csuc.cat/file.xhtml?fileId=429865&version=1.0
Evaluation process	https://dataverse.csuc.cat/file.xhtml?fileId=429862&version=1.0

Source. Table with links from Köchig, E. P., Lores-Gómez, B., & Usart-Rodriguez, M. (2026). Preschool Teacher's Experiences when Integrating STEAM: Reflexive Content Analysis Process, CORA.Repositori de Dades de Recerca, V1. <https://doi.org/10.34810/DATA2705>