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Conceptions and Attitudes of Pre-School and Primary School Teachers towards STEAM Education in Spain

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Abstract: STEAM education postulates integrated problem-solving-based learning of its disciplines. Although positive results are being reported, there are some difficulties with its implementation. The purpose of this research is to analyze the conceptions and attitudes of Early Childhood and Primary School teachers in Spain towards this educational approach, as well as to determine the initial relationship with their training and experience. A multiple case study with 11 teachers was conducted using a reflection protocol, a photo-elicitation, and a semi-structured interview. All teachers presented an integrated profile. Although they explicitly acknowledged cognitive, affective, and logistical obstacles, a positive relationship was detected between their level of training, experience in STEAM education, and conception of STEAM. Based on this evidence, some recommendations are proposed to optimize the conceptions of the STEAM approach and the usual practices of the teaching staff.

Keywords: STEM; STEAM; conceptions; attitudes; training; case study; teachers; Early Childhood; Primary School; Spain

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1. Introduction

Our society is shaped by science and technology in complex ways, and everyone within it needs a basic level of understanding to remain active and engaged [1]. However, wide-ranging problems currently underlie science education that have not always been encouraging for achieving priority and quality science education [2]. In this sense, it has been suggested in several papers that there is a very notable turning point in early adolescence, in terms of students' experience of the scientific literacy process [3]. That age is around 12 years old, a stage that corresponds to the transitional stage between Primary and Secondary Education and, from an evolutionary perspective, to the beginning of adolescence when children's natural curiosity and interest in science begin to turn into disinterest, boredom, and generalized feelings of failure at school [4].

At the national level, the Confederation of Spanish Scientific Societies [5] states that Primary School pupils possess the necessary scientific knowledge but are unaware of how to apply it (even less so in new situations), their motivation is passive, and their understanding of how science works, very scant. That is, their scientific competence development lacks several dimensions, among them, procedural, attitudinal, and the nature of disciplinary knowledge [6].

In this context, a teaching approach emerged just over a decade ago to improve student learning abilities by bringing them closer to reality by integrating various disciplines: integrated education in Science, Technology, Engineering, Art, and Mathematics (hereinafter, STEAM). The approach is presented as one way to improve student literacy with positive results reported in various contexts [7–11] including disadvantaged contexts [12]. However, several implementation difficulties have been reported in the recent literature, related mainly to issues of curriculum organization and teacher training [13–15], for which some solutions have also been provided [16].

Given that teachers are fundamental to implementing any innovative proposal, the conceptions, and the attitudes towards STEAM of a group of practicing and trained teachers are presented. This group is associated with Early Childhood Education and Primary Education in Spain, a country where this approach is booming and whose law has recently been recommended. Their views are analyzed in this research, to advance understanding of potential needs.

2. Theoretical Framework

As shown in many research studies, the utility of disciplinary integration in curricula is extensive. Among other benefits, it provides students with a more relevant, less fragmented, and more stimulating experience [17]; it means that students can determine when to apply their knowledge, as well as to relate various concepts [18]; it helps to encourage more student-focused teachers [19]; and it helps to improve problem-solving skills [20].

It is along these lines that STEAM emerges. In our research, we define it as an approach that significantly integrates different school disciplines by enhancing the development of problem-solving, communication, and teamwork skills in real-world contexts and problems through the use of active student-focused methodologies, some especially recommended, such as inquiry teaching and engineering design methodologies [21–23].

The implementation of STEAM educational proposals is being promoted in various countries internationally [24–27] among others], producing a large number of practical proposals. Also, in Spain [28], even the acquisition of a specific competence in this area has been regulated from Primary Education [29]. However, the theoretical foundations for STEAM have been developed more for Secondary Education and beyond than for Primary Education, and much less for Early Childhood Education [30]. These teaching groups have a limited understanding of what STEM is and what it means for their everyday practice [14]; it is consistent to think that the situation for STEAM is similar. Perhaps this problem is due to the multitude of conceptions that exist [31], as the study of Martín-Páez et al. (2019) [32] on the theoretical inconsistency surrounding the definition of STEM education, STEAM's predecessor approach, might appear to indicate. However, authors such as Thibaut, Ceuppens, et al. (2018) [33] argue that, although there is no single way of conceiving STEM, there are several components that can be considered essential: integration, design-based learning, and cooperative learning. In fact, it should be noted that all conceptions revolve around the type of disciplinary integration that takes place. This aspect is in itself complex if we take into account the results of Gresnigt et al. (2014) [34], based on a systematic review of integrated proposals for Primary Education, which pointed to at least six levels of integration, ordered by complexity.

It seems clear that STEM and, therefore, STEAM are certainly difficult to conceptualize, and, as a result, many teachers hardly feel confident when implementing didactic proposals framed within these approaches [31,35]. It has been shown in previous research [36–38] that teachers' attitudes towards STEM are related to their classroom practices and that those with negative attitudes avoid using it. In this regard, DeCoito and Myzskal (2018) [39] indicated that "effective STEM teachers not only need deep content knowledge in STEM subjects, but they must also be confident in their ability to teach that content" (p. 498). Bartels et al. (2019) [40] studied trainee teachers, concluding that, even if they had planned and implemented STEM lessons, they could not define STEM as a term with confidence. Moreover, in many cases they could not agree on the number of disciplines that are needed for an educational approach to STEM [31] and, in fact, expressed different conceptions [41].

Despite the variety of conceptions, several studies have shown that teachers generally hold positive views towards STEM and STEAM, and tend to see their value, although most teachers claim to be unsure about implementing these approaches in the classroom [35,39,42]. In addition, they are often unfamiliar with activities related to engineering [43], science, technology, and mathematics. This unfamiliarity may be due to several issues: ideas linked to STEAM disciplines and the difficulty of their content [44,45]; a feeling of having inadequate skills in these areas [46]; and concern over their own integrated content knowledge [47]. Although satisfactory levels of teachers' confidence towards STEM and STEAM were observed in earlier studies, there was a need to balance hands-on learning with traditional teaching among more than half of the teachers using these models in their classrooms [39].

Given the influence that the conception of STEM and STEAM seems to have on educational practice, it is necessary to understand teachers' conceptions, attitudes, and related factors to provide meaningful resources and supports [31,48].

3. Research Questions

Given the underlying picture, we posed the following research questions:

- Q1: How does a group of practicing and trainee teachers linked to Early Childhood Education and Primary Education conceive of STEAM?
- Q2: What are their attitudes towards STEAM?
- Q3: What initial relationship is found between the general teaching experience, STEAM training, and STEAM teaching experience and their conception of the approach?

4. Methodology

4.1. Design

A qualitative, multiple instrumental case study was selected, in order to examine the theory proposed in this research for further understanding, beyond any specifically selected cases [49].

4.2. Participants

Eleven subjects were selected, seven of whom were in-service Early Childhood Education or Primary Education teachers, and four of whom were students in the last semester of the Bachelor's Degree in Early Childhood Education or the Bachelor's Degree in Primary Education. All subjects had been involved in one way or another with the STEAM approach, either through specific training (curricular or extracurricular), through the development of practical experiences (in formal or non-formal education), or both. Table 1 shows a detailed description of each participant's general training, general teaching experience, STEAM training, and STEAM teaching experience.

Table 1. Detailed description of the participants.

Participant	General Education	General Teaching Experience	STEAM Training	Teaching Experience in STEAM
1	Doctor of Science, Bachelor of Science in Food Science and Technology, and Bachelor of Science in Chemistry	10 years in extracurricular scientific activity, associate university lecturer in Science Didactics and teacher at an adult education school	STEAM expert degree and member of the European STEM teacher network	Out-of-school teaching, university teaching, and adult education
2	Fourth-year undergraduate degree in Primary Education	Two academic internships	Two science teaching subjects (six ECTS on STEAM)	Out-of-school teaching and project management
3	Degree in Primary Education, Degree in Early Childhood Education, Master's Degree in Educational Research and Innovation, University Expert in CLIL, and Degree in Educational Centre Management	20 years in primary education and associate university lecturer in English language teaching	One subject in Science Didactics (three ECTS on STEAM)	Master's thesis, out-of-school teaching, university teaching, and project work

Table 1. *Cont.*

Participant	General Education	General Teaching Experience	STEAM Training	Teaching Experience in STEAM
4	Bachelor's Degree in Primary Education and Master's Degree in Educational Research and Innovation	Two years in university teaching	STEAM expert degree and STEM-related postdoctoral scholarship	University teaching
5	Degree in Primary Education	12 years in Primary Education	One subject of Didactics of Science (three ECTS on STEAM)	Carrying out projects
6	Doctorate in Audiovisual Communication and fourth year of a degree in Primary Education	Private teacher, two academic internships, and extracurricular teaching using STEAM	STEAM expert degree	Out-of-school teaching and managing an internship project
7	Degree in Early Childhood Education and a Degree in Interpreting for the Deaf	28 years in Early Childhood Education and specialist in international science projects	STEAM expert degree, member of the European STEM teachers' network, and courses in Schoolnet and School Gateway	Teaching in Early Childhood Education, carrying out projects through the European e-twinning platform and Science on Stage
8	Bachelor's Degree in Primary Education and Bachelor's Degree in Early Childhood Education	Four years in Primary Education	STEAM expert degree	Extracurricular teaching and project work
9	Studying fourth Year of Degree in Primary Education	Two academic internships	Two subjects of Didactics of Science (6 ECTS on STEAM)	Final Degree Project, extracurricular teaching, and implementation of internships
10	Degree in Primary Education and Degree in Early Childhood Education	Four academic internships	STEAM expert degree and three subjects in Didactics of Science (nine ECTS on STEAM)	Master's Degree Final Project and extracurricular teaching
11	Degree in Early Childhood Education and Diploma in EGB in science and mathematics	35 years in Early Childhood Education	Courses in programming and training in Science Didactics	Project implementation

The participant selection strategy, non-probabilistic convenience sampling, took into account all relevant information provided in answer to the research questions. This strategy was used in order to ensure that subjects could provide relevant information for the research. The adequacy of the number of participants was verified *a posteriori*, using the saturation indicator [50]. The stopping criterion applied to define the theoretical saturation level was set at one unit of analysis. The absence of new categories was identified from the tenth case onwards so that case-size adequacy could have been set at ten units. Consequently, the exclusion of the eleventh case or unit could not limit an informative increase in relation to total cases (N = 11).

4.3. Data Collection

Data were collected from three different sources for this research, and informed consent was obtained from all subjects involved in the study. First, participants were asked, following the STEM Reflection Protocol [41], to produce a visual representation of their conception of STEAM, a written explanation of the model drawn, and a description of any experiences (including those related to their professional development) that had helped shape their model. Second, they participated in a photo-elicitation in which they were presented with eight conceptual models of STEM education proposed by Dare et al. (2019, p. 1708) [31]. From these they had to pick one or more according to their preferences: (A) STEM as an acronym (a traditional model of teaching science and/or mathematics in separate classrooms with little emphasis on the roles of technology and engineering pedagogies); (B) Real-world problem-solving as context (STEM education as focusing on the relationship between school and the real-world, providing contexts to make STEM concepts relevant to students' lives.); (C) Science as context (STEM education as teaching scientific concepts while calling upon technology, engineering, and mathematics as needed); (D) STEM as separate disciplines (depicting siloed disciplines that included other disciplines as supporting roles but that did not integrate across the disciplines in meaningful or substantial ways); (E) Integrated disciplines (having components that represent the confluence of science, technology, engineering, and mathematics teaching); (F) Engineering design process as context (focusing on the iterative process of engineering design as the process by which students learn science and mathematics concepts using technology); (G) Science and engineering design process as context (placing an equal emphasis on teaching scientific concepts and the engineering design process using technology and mathematical concepts when appropriate); and (H) Engineering as context (representing an emphasis on engineering calling upon science, technology, and mathematics as needed). We indicate that, although these are models originating from STEM education, we consider their use here appropriate, as they represent forms of curricular integration with which the subjects may feel an affinity.

Finally, a semi-structured interview [51] was conducted, lasting 25–30 min. For its construction, we started from a theoretical basis on the different alternatives of STEAM integration and on the attitudes and factors that influence the implementation of didactic proposals framed within this approach. Specifically, this interview was adapted from the one proposed by Tao (2019) [35] in his research on the confidence and attitudes of Early Childhood Education teachers towards STEAM, covering the three dimensions proposed by Van Aalderen-Smeets et al. (2012) [52] towards which to observe teachers' attitudes: cognitive, affective, and perceived control. The first dimension included opinions on the importance of STEAM and the difficulties that could be encountered when implementing it. In the second dimension, questions were related to the teacher's level of anxiety and enjoyment in implementing the approach. The last dimension concerned teachers' self-perception of their ability to implement STEAM. In total, eleven questions were asked (see Appendix A).

4.4. Data Analysis

First, the visual representations were analyzed using inductive coding [53] for categorization in accordance with the eight STEM integration models proposed by Dare et al. (2019) [31]. Inductive coding consisted of initial open coding, axial coding to relate conceptually similar codes, selective coding to examine relationships between axial codes, and final categorization. Explanations provided by the subjects about their drawings were analyzed as secondary sources, to mitigate bias and subjectivity of interpretation, extracting keywords that might have otherwise aided categorization.

On the other hand, the models chosen by the teachers in the photo-elicitation were recorded. This was done in order to obtain both individual and general information on the frequency with which they represented the conception of the total number of cases.

Finally, the semi-structured interviews were subjected to a thematic analysis [54] of each of their dimensions to try to find common meanings among the participants. Thus, we extracted the drivers and obstacles that the participants mentioned, directly and indirectly, on the implementation at school of STEAM, divided into three categories (cognitive, affective, and logistical), with each giving rise to a set of six subcategories. To complete this analysis, a count was made of the number of times aspects of each subcategory were mentioned in order to determine at what frequency drivers and barriers were considered most important when working with the STEAM approach.

It should be noted that the research questions, consistent with their complexity, were addressed using data from different sources. Thus, in answer to the first question, the information was obtained from the visual representations with their explanation. As support, answers to questions two, three, and four of the semi-structured interview were used. Both categories resulting from the analysis of the visual representations and the answers to the corresponding semi-structured interview questions, therefore, were related to the descriptions of the levels of complexity of disciplinary integration proposed by Gresnigt et al. (2014, p. 52) [34], thereby composing a profile on the participant's conception of integration:

- Isolated: separate and distinct subjects or disciplines. Often considered the traditional form of teaching.
- Connected: An explicit connection between different disciplines is established, deliberately linking subjects rather than assuming that students will automatically understand the connections.
- Nested: A skill or knowledge from another discipline is directed to a subject/discipline. The content of one subject in the curriculum can be used to enrich the teaching of another subject.
- Multidisciplinary: Two or more subject areas are organized around the same theme or topic, but the disciplines retain their identity.
- Interdisciplinary: In the interdisciplinary course, reference may not be made to individual disciplines or subjects. Disciplinary perspectives are lost, and the emphasis is on skills and concepts across subject matter rather than within disciplines.
- Transdisciplinary: The curriculum transcends individual disciplines and focuses on the field of knowledge exemplified in the real world.

The overall profile was then compared with the choice of models in the photo-elicitation in order to check for consistency in the statements of the participants.

The information gathered in the semi-structured interview was used in the answers to the second research question. To answer the third research question, the overall profiles resulting from the first research question and the information on the participants' education and experience were used. The training and experience data were categorized as shown in Table 2.

Table 2. Categorization scales for the indicators of general teaching experience, STEAM training, and teaching experience in STEAM.

Indicators	Scale Score			
	0 = Not at All	**1 = Little**	**2 = Quite a Lot**	**3 = A Lot of Experience**
General teaching experience	No experience	Traineeship	Up to 10 years	More than 10 years
STEAM training	No training	Extra-curricular training (courses)	Curricular training (university degrees)	Extra-curricular and curricular training
Teaching experience in STEAM	No experience	Development of up to two activities/projects	Development of several activities/projects	Intensive curricular and extracurricular implementation

It should be noted that the whole process of data analysis was first carried out independently by two of the authors of this paper, and the final categorization was obtained through discussion until consensus was reached among the three authors.

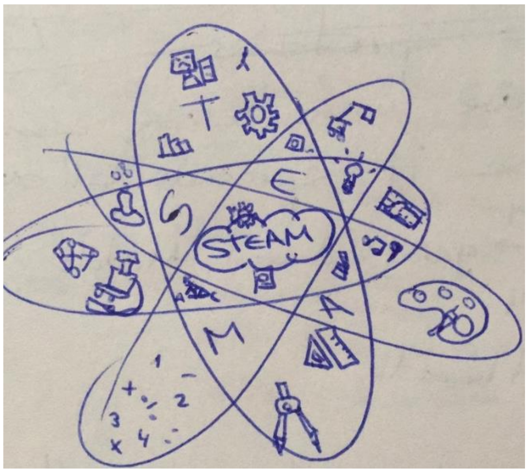
5. Results

The results are presented below, grouped in relation to the research questions that were proposed.

5.1. Teachers' Conception of STEAM

Table 3 shows an example of the results corresponding to the data analysis of the first research question, from which the overall profile of each participant emerges. Appendix B shows the particular information of the other participants.

Table 3. STEAM conception and overall profile subject 5.

Visual representation and explanation	 "Each letter of the acronym can be seen in an ellipse, with characteristic drawings of each discipline. Each ellipse passes through the centre, so all the letters contribute."	Model E Multidisciplinary level
Question 2 interview: STEAM teaching experience	"We started to work by projects, we created a palette of multiple intelligences, and we created a project in which we had all the intelligences and we associated one with each subject [...]. The projects were based on the teachers' own initiative and coordination between them, my colleague is not really in favour of this work, so if we don't coordinate with all the teachers, it can't be done"	Multidisciplinary level
Question 3 interview: definition of STEAM	"Integrated STEAM education means that all of this, art, science, engineering, technology and mathematics, is all integrated in one project."	Multidisciplinary level
Question 4 interview: STEAM integration	"Integration implies that it should always be within the same classroom, that it should be a complete project [...]. When you do the project, the classes and the teachers must be brought together, so that you can work on different tasks, different aspects within the same project at the same time."	
Global profile	Multidisciplinary	

All participants presented a broad integrated profile: two nested, two connected, four multidisciplinary, one interdisciplinary, and two transdisciplinary.

Regarding the accounting of the models chosen by the teachers on the conception of STEAM, Table 4 shows the overall picture found after obtaining the respective frequencies.

As can be observed, subjects widely chose model B which emphasizes the importance of bringing the school closer to the real world because of its integrated character. Model E was the next model chosen, representing the notion of integration between areas. Then the next two models most chosen were F and G, in which proposals are associated with what, in many people's minds, is considered the most characteristic of these approaches: engineering design.

Table 4. Frequency of teachers' choice of conceptual models.

Model	Frequency of Choice
A	1
B	13
C	2
D	0
E	9
F	6
G	3
H	0

The results show differences between what is drawn, what is said (or considered correct, as in the photo-elicitation activity), and what is said to be done in practice. Thus, most of the subjects, although adhering to some form of integration in all the instruments, presented no unique conception, a result which might imply that the STEAM conception is not yet sufficiently defined. For example, subjects preferred representations where the importance of integration starting with real-world problems and with all disciplines is appreciated (models B and E). This was an aspect that they insisted on in the interviews (the real world as a channel for the approach) and which denoted conceptions that fit in with higher levels of integration (inter- and transdisciplinary). However, when they explained their drawings or gave examples based on their practice, it was possible to detect that most of them practiced at less sophisticated levels of integration. This variation in conception could be relatively normal and equally extrapolated to other subjects, but in relation to STEAM it becomes particularly relevant, precisely because it could be getting in the way of a more consensual understanding of the approach.

5.2. Teachers' Attitudes towards STEAM

Following the thematic analysis of the data referring to the second research question, several subcategories were obtained in each of the three initial categories, which could be grouped into barriers and drivers for the implementation of STEAM proposals. The resulting subcategories are shown in Table 5.

Table 5. Categories of drivers and barriers for each group mentioned by teachers.

<table>
<tr><th>Category</th><th></th><th>Subcategory</th><th>Frequency of Reference</th></tr>
<tr><td rowspan="6">Cognitive</td><td rowspan="2">Barriers</td><td>Lack of methodological training</td><td>4</td></tr>
<tr><td>Lack of training in content</td><td>6</td></tr>
<tr><td rowspan="4">Drivers</td><td>Link to the real world</td><td>7</td></tr>
<tr><td>Inclusive education</td><td>5</td></tr>
<tr><td>Meaningful learning</td><td>9</td></tr>
<tr><td>Real assessment process</td><td>3</td></tr>
<tr><td rowspan="6">Affective</td><td rowspan="3">Barriers</td><td>Discomfort with content</td><td>6</td></tr>
<tr><td>Insecurity in teaching</td><td>6</td></tr>
<tr><td>Costly adaptation</td><td>2</td></tr>
<tr><td rowspan="3">Drivers</td><td>Comfort with content</td><td>8</td></tr>
<tr><td>Security in teaching</td><td>8</td></tr>
<tr><td>Involvement and active participation of students and third parties</td><td>9</td></tr>
</table>

Table 5. *Cont.*

Category		Subcategory	Frequency of Reference
Logistic	Barriers	Lack of teaching coordination	7
		Separate subjects	4
		Extra work	3
		Assessment difficulties	3
		Lack of material resources	4
		Lack of time	6

At a cognitive level, the majority of teachers valued the importance of STEAM for meaningful learning linked to the real world, although they also expressed some concern over their lack of training in both methodology and content. As for the responses related to the affective category, although some teachers found the process of student adaptation to this approach an obstacle, almost all of the participants were aware that STEAM could lead to an improvement in student motivation, involvement, and participation, results that coincided with those of Fridberg et al. (2022) [55]. However, half of them feel insecure when implementing STEAM due to their self-perceived lack of knowledge in the areas to be addressed. Thus, the teachers with the greatest insecurity were, for the most part, teachers with little experience both in general and with STEAM; on the other hand, all the subjects at a more advanced level of integration claimed greater confidence when implementing STEAM. Only a few obstacles were pointed to in the logistical category, the main barrier being the lack of coordination between teachers and alluding to the fact that this approach cannot be worked on individually in the classroom if the most advanced levels of integration are to be reached. Another important obstacle is the inadequacy of the educational system to deal with this approach in its entirety, either because of the separation of subjects, the lack of time in the classroom, or the difficulty of assessment. In this last subcategory, however, some teachers considered that, even though assessment was more difficult to carry out, it was more authentic and self-explanatory. Participant 5 described the implementation of the STEAM approach like this: "*I think that the educational system* [in Spain], *despite the fact that it demands this, is not prepared for the implementation of STEAM education, but rather that right now in those places where this education is being carried out, it is everyone doing the war on their own, a specific experience is carried out, it does not have continuity*." Finally, another of the teachers' concerns was the lack of material resources.

There were no notable differences between trainee and in-service teachers. Thus, although all teachers were aware of the advantages and benefits that STEAM could bring, they were also aware of their lack of training, a factor that can create insecurities and difficulties when implementing the STEAM approach in the classroom [42,56]. It is known that this approach poses several barriers or limitations that hinder its implementation; however, these barriers (with the exception of coordination between teachers) are those already commonly expressed by teachers regarding any changes to the didactics of experimental sciences [57].

5.3. Initial Relationship Found between General Teaching Experience, STEAM Training, and STEAM Teaching Experience and the Conception of the STEAM Approach

Finally, Table 6 shows the grouping of the overall profiles resulting from the first research question and the information on the training and experience of the participants.

Table 6. Scale of indicators for each participant and global profile.

Participant	Global Profile	General Teaching Experience *	STEAM Training	STEAM Teaching Experience
1	Interdisciplinary	2 (Primary)	3	3
2	Multidisciplinary	1 (Primary)	2	1
3	Multidisciplinary	3 (Primary)	2	1
4	Transdisciplinary	2 (Primary)	3	3
5	Multidisciplinary	3 (Primary)	3	2
6	Connected	1 (Primary)	2	1
7	Transdisciplinary	3 (Pre-primary)	3	3
8	Nested	2 (Primary)	2	2
9	Multidisciplinary	1 (Primary)	2	1
10	Connected	1 (Pre-primary)	2	1
11	Nested	3 (Pre-primary)	1	1

* In brackets, the educational stage at which experience is available.

With these values, the extent to which these indicators are related to the conceptions of STEAM among teachers could be studied. Figure 1 shows the link between the conception of STEAM and the other indicators through the profile of each teacher.

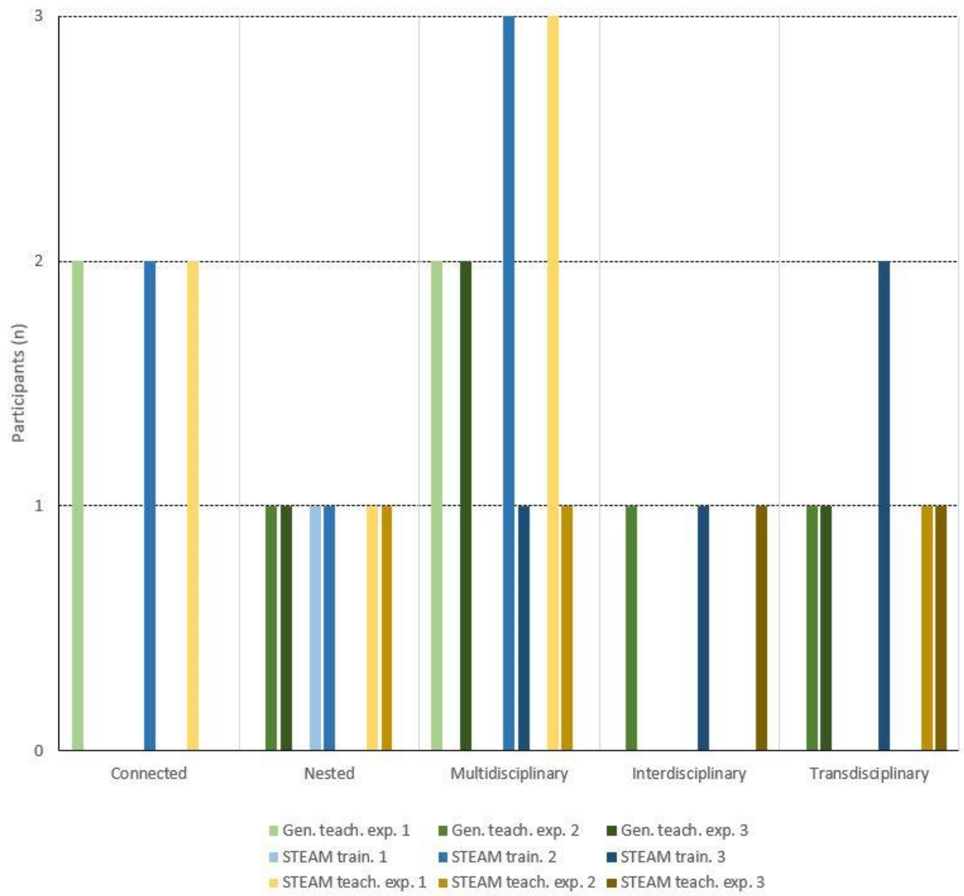


Figure 1. Link between general teaching experience, STEAM training, and STEAM teaching experience with the conception of STEAM.

Teachers with less teaching experience were not found in either of the two most advanced profiles. In contrast, teachers with only extracurricular training in STEAM had the least integrated profiles among those observed, whereas there were teachers with only curricular training up to a multidisciplinary level of integration. However, those with both extracurricular and curricular training in STEAM were at the three most advanced levels of integration, results similar to those reported by Hourigan et al. (2021) [58]. There also appeared to be a relationship between STEAM teaching experience and the overall profile of the teachers: all those with a lot of STEAM teaching experience were at the two most advanced levels.

Finally, we collected some of the main characteristics of the different teacher profiles found in this study, taking into account their training and/or experience and their perceived confidence in implementing these approaches:

- Connected profile: the subjects found in this profile have little teaching experience in general and in the teaching of STEAM. However, they have curricular training obtained during their undergraduate training. In terms of perceived control, the participants claimed to feel insecure with the implementation of STEAM and noted a lack of training in scientific content.
- Nested profile: participants in this profile showed a lack of teaching experience in STEAM, but their levels of confidence towards STEAM approaches varied.
- Multidisciplinary profile: in this profile, the participants still do not have much STEAM teaching experience, but have a medium or high level of STEAM training. At an affective level, they show some insecurity when teaching.
- Interdisciplinary profile: teachers in this profile have extensive teaching experience and high levels of STEAM training. As far as the affective level is concerned, there is no methodological or content-related insecurity.
- Transdisciplinary profile: at the most advanced level of disciplinary integration are teachers with a great deal of STEAM teaching experience and high levels of training (both in STEAM and in general, for example, with doctoral studies), showing no insecurities when bringing STEAM into the classroom.

These results coincide with the findings of Gresnigt et al. (2014) [34]: from the multidisciplinary level onwards, projects require major changes. Therefore, a higher degree of general preparation is needed, both in our case and generally in STEAM proposals, which is associated with higher levels of confidence. In relation to these results, it is necessary to emphasize that we have simply tried to describe the relationships found between some variables and the conception of STEAM. These relationships do not imply an influence, the study of which would have to be carried out with a larger sample and reliable statistical tests.

6. Discussion

The aim of this study was to find out the conceptions that defined integration, as well as the attitudes presented by a group of teachers in Spain with some kind of experience and training in implementing STEAM approaches in the classroom. First, it is worth noting that all subjects presented integrated STEAM conceptions. However, as stated in several studies [31–33], teachers presented a limited understanding of the meaning of STEAM which is manifested, for example, in the lack of a single vision of what STEAM is, as has been detected in this research.

In relation to their attitudes, teachers with a connected, nested, or multidisciplinary profile indicated lack of time as a drawback, while the majority of those with interdisciplinary and transdisciplinary profiles never mentioned the issue. Even so, the fact at this level is that much more time and effort need to be invested in the development of didactic proposals. Another important feature is that most of the subjects with multi-, inter-, and transdisciplinary profiles alluded to the importance of teacher coordination, a detail that Gresnigt et al. (2014) [34] also highlighted in their research and one of the essential elements for achieving integrated approaches [59]. The same authors showed that teachers who use interdisciplinary and transdisciplinary approaches were generally more enthusiastic, committed, and less insecure when implementing STEAM projects, an aspect that also surfaced in our research.

In relation to STEAM training and experience, our results were consistent with those obtained by Thibaut et al. (2019) [48]: the higher the level of (mainly practice-related) STEAM training and participation in professional development, the more positive the attitudes that teachers tended to have towards the key principles of STEAM. However, in the same study, they also found that teachers with considerable educational experience, who were approaching the end of their careers, tended to hold negative attitudes toward the new educational approaches, a relationship that was not found in our group. In line with this issue, a large majority of the teachers who were interviewed indicated that perceived barriers included a lack of methodological or content-related teacher training in STEAM, a finding that was consistent with Tao's (2019) study [35]. Therefore, short-term trainings hardly appeared sufficient to make robust progress in integration thinking, but they did appear to be of greater effectiveness when accompanied by practice.

7. Conclusions and Recommendations

All the teachers, regardless of the profiles associated with them and their training, although making cognitive, affective, and logistical obstacles explicit, were unanimous in considering the value of the STEAM approach for providing learning opportunities for practical skills, problem-solving skills, 21st-century skills, and for motivating students, as shown in several studies [10].

A better understanding of STEAM is more likely to lead to more meaningful and stimulating approaches for students [17,18] while maintaining a coherent integration and a common thread linked to the real world, both of which are intrinsic characteristics of the interdisciplinary and transdisciplinary levels. We propose, therefore, a series of recommendations for each of the disciplinary integration profiles that we have identified. If we know the teachers' profiles, our recommendations can guide their disciplinary integration profile and help them to gain greater confidence and competence.

Thus, for teachers at the connected and nested integration levels, both extracurricular and curricular training in STEAM approaches, mainly accompanied by theoretical reflection, is recommended in order to overcome their insecurities and to reach a better understanding of the approach. It is also recommended to these teachers that their teaching practice should be based on projects linked to the real world and that these projects should have continuity over time and not be one-off ventures. For teachers at the level of multidisciplinary integration, extracurricular and curricular training is still recommended, helping them to develop projects within the framework of related subjects and with common objectives that respond to the objectives of the project itself. It was also suggested with regard to the interdisciplinary profile, that, in order to reach the next transdisciplinary level, in addition to starting from projects related to the real world and involving students, special attention should be paid to ensuring that the educative action intrinsic to the projects is of relevance in society. Finally, for teachers at the last level of integration (i.e., the transdisciplinary profile) with advanced experience and practice of STEAM, it may be particularly fruitful to explore new ways of implementation (e.g., using different methodologies, varying student groupings, and integrating a wider range of disciplines). In all cases, it would be advisable for teachers to have the opportunity to learn how to develop and implement such projects in co-teaching, as they have been shown to have a positive influence on the development of integrated approaches [60]. In addition, knowing the profile of the teachers, we have developed a specific training for 15 ECTS during one semester at the University of Burgos (Spain). This training includes two subjects in three areas, so we plan to continue investigating the development of the teachers' conceptions. The results of this study contribute to shedding light on teachers' conceptions of and attitudes toward STEAM, providing resources for their practice. Nevertheless, the nature of the case study must be considered with these conclusions and recommendations, in terms of its focus on particular phenomena.

In relation to the limitations and perspective of this work, although the saturation indicator [50] supported the case size used in this research, in future work, we intend to expand the sample in order to transcend the mere knowledge of initial relationships between certain variables and the conception of STEAM to the concrete determination of their influence. On the other hand, all the participants selected had some training and experience in STEAM. Therefore, the scenario shown here could be more positive and differ from other realities less advanced in STEAM knowledge. This selection was made for convenience (had the teachers not known what they had been talking about, the interviews could hardly have been fruitful), but future research could show a more comprehensive scenario of each population to be studied. In this sense, foci on teachers with a clear idea about STEAM are worth noting in the literature; however, in no way is the possibility of further research precluded in that regard, which we think is important. In this sense, other instruments that were not so sensitive to the need for some prior knowledge about STEAM could and, in fact, should be employed to show a broader and more realistic picture, which we aim to incorporate in our next studies.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data is contained within the article.

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Appendix A. Semi-Structured Interview

Cognitive dimension:

1. How familiar are you with STEAM education? Have you attended any kind of training?
2. What kind of experience, as a teacher, have you had with this approach? Could you describe in detail what you have done? Where did you start? What was your goal? What was your aim?
3. How would you define integrated STEAM education?
4. How do you understand this integration to take place?
5. Do you find any kind of barrier or limitation that makes it difficult for you to implement STEAM in the classroom?
6. How important do you see integrated STEAM education in the classroom?

Affective dimension:

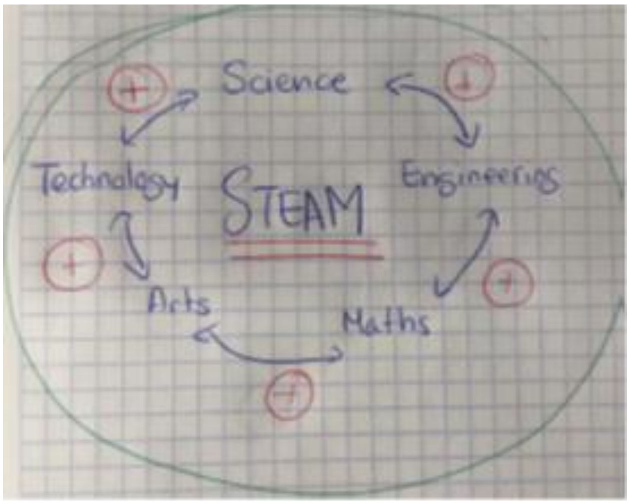
7. How confident are you in incorporating STEAM education into your teaching practice?
8. How comfortable are you when dealing with content related to mathematics, science, robotics, technology, and/or engineering with children of this age group?
9. Do you feel confident in planning, teaching, and assessing STEAM activities?

Perceived control dimension:

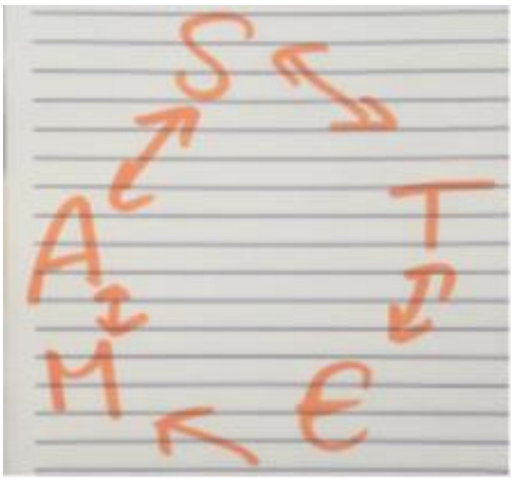
10. Do you see yourself being able to build new STEAM content and incorporate it into the existing curriculum?
11. Do you feel that your knowledge of mathematics, science, technology, and/or engineering is adequate to deal with STEAM content in the curriculum?

Appendix B. The Teachers' Conception of STEAM and Their Overall Profiles (Subject 5 is on the Main Article)

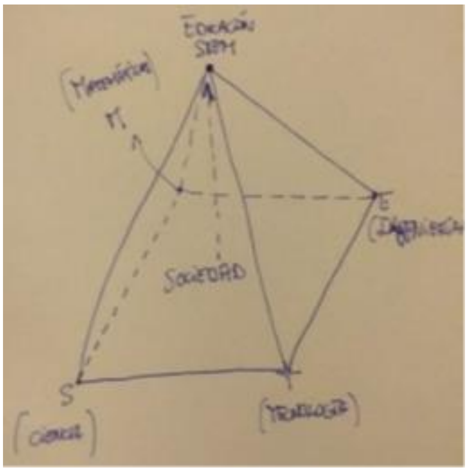
	Subject 1	
Visual representation and explanation	 "STEAM is linked to science: science is in everything and everyone. There is also a clear link to the real world: it is in the real world, science is everywhere and it is in coordination and in union with everything else, music, literature, sport, in relation to people, etc."	Model C Interdisciplinary level
Question 2 interview: STEAM teaching experience	"Whenever there is a real problem that we start from, that we want to solve, we try to approach it from different points of view, always involving the students [. . .]. Sometimes they are enquiry projects, sometimes they are engineering projects, but they start from a real problem, they have a social part, and they always reach an end."	Transdisciplinary level
Question 3 interview: definition of STEAM	"It is that they are not really separate subjects or subjects, but that they are really 100% linked, that there is an intrinsic link between them and that they are complementary to each other."	Interdisciplinary level
Question 4 interview: STEAM integration	"Integration happens through dialogue and cooperation between different teachers."	
Global profile	Interdisciplinary	

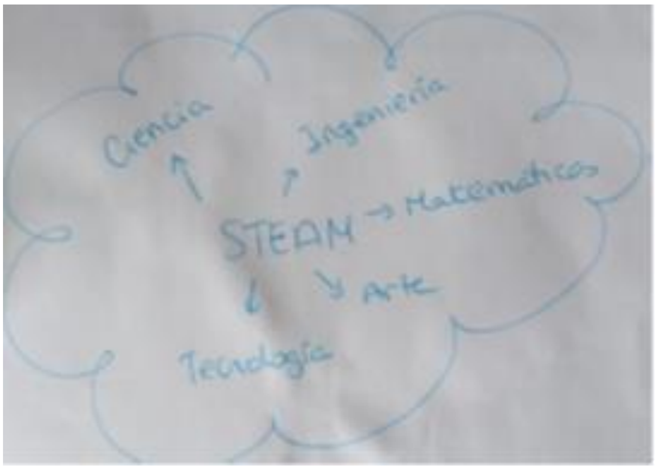
<table>
<tr><th colspan="3">Subject 2</th></tr>
<tr><td>Visual representation and explanation</td><td>

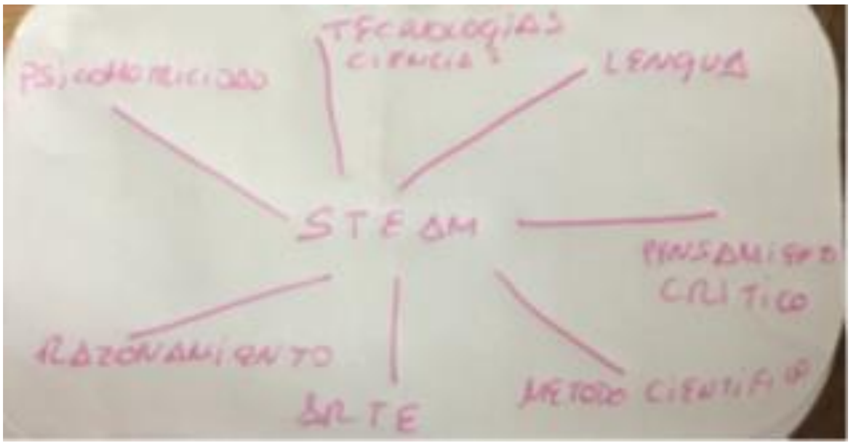
"In the drawing, apart from writing the meaning of each letter of the acronym, it can be seen that the subjects or areas are linked to each other, there is an integration between the disciplines where they all add something to each other."</td><td>Model E Multidisciplinary level</td></tr>
<tr><td>Question 2 interview: STEAM teaching experience</td><td>"I've always liked the idea of mixing different things because I think that each child can be good at something. In the end, if you use this, you make a group of children and you will always get something positive out of it [. . .]. I did separation of mixtures, I started a bit with science content (what each mixture is, each solution . . .) and then I continued with engineering and technology [. . .]. It was a project, they had to make a poster . . . ."</td><td>Multidisciplinary level</td></tr>
<tr><td>Question 3 interview: definition of STEAM</td><td>"STEAM is Science, Technology, Engineering, Art and Mathematics. It is to include all subjects or areas. You can put in content from everything and have it all weigh the same and they can learn from all subjects."</td><td rowspan="2">Multidisciplinary</td></tr>
<tr><td>Question 4 interview: STEAM integration</td><td>"Integrative, that it is something that children can use, with their own experiences and that they live, they understand it much better."</td></tr>
<tr><td>Global profile</td><td colspan="2">Multidisciplinary</td></tr>
</table>

<table>
<tr><th colspan="3">Subject 3</th></tr>
<tr><td>Visual representation and explanation</td><td>
</td><td>Model E Multidisciplinary level</td></tr>
<tr><td colspan="3">"In this scheme, you can see each letter of the acronym linked by a double arrow to the others. The subjects or areas are linked to each other, and there is an integration between the disciplines."</td></tr>
</table>

<table>
<tr><th colspan="3">Subject 3</th></tr>
<tr><td>Question 2 interview: STEAM teaching experience</td><td>“When you do something in the classroom, the aim, above all, is that they like it, that they are motivated and that they learn. Starting with some hypotheses on the blackboard, starting to think and think about it, seeing that we have a problem and how we could solve it breaks the structure of a traditional classroom.”</td><td>Multidisciplinary level</td></tr>
<tr><td>Question 3 interview: definition of STEAM</td><td>“STEAM is preparation to the real world, it has to be all very applied to projects [. . .].”</td><td rowspan="2">Interdisciplinary level</td></tr>
<tr><td>Question 4 interview: STEAM integration</td><td>“Integration is difficult, then you have to be very coordinated with a partner to do a project and they give you a hand.”</td></tr>
<tr><td>Global profile</td><td colspan="2">Multidisciplinary</td></tr>
</table>

<table>
<tr><th colspan="3">Subject 4</th></tr>
<tr><td>Visual representation and explanation</td><td>
“In this drawing you can see a pyramid, at the base of which the disciplines are represented. Each of the disciplines ascends towards the top, which is where STEAM is located and also the problems of society.”</td><td>Model B Transdisciplinary level</td></tr>
<tr><td>Question 2 interview: STEAM teaching experience</td><td>“The theme of the intervention was to pose a problem to the students, a hypothetical problem but related to reality, focusing on science and physics content. We also addressed technology, engineering and mathematics [. . .]. Our aim was to develop this social participation [. . .] the aim was to come up with a solution to the problem [. . .]. Various problems arose during the course of the research. This whole learning process was accompanied by a process of social and ethical reflection. They had a practical training, not only theoretical.”</td><td>Transdisciplinary level</td></tr>
<tr><td>Question 3 interview: definition of STEAM</td><td>“It is an educational approach that integrates the four disciplines in problem solving, real or hypothesized problems based on a real context, planned by us.”</td><td rowspan="2">Interdisciplinary level</td></tr>
<tr><td>Question 4 interview: STEAM integration</td><td>“Mixing disciplines to solve a real problem. It is not necessary to include the adjective integrated, with STEAM education we are already alluding to this integration.”</td></tr>
<tr><td>Global profile</td><td colspan="2">Transdisciplinary</td></tr>
</table>

	Subject 6	
Visual representation and explanation	 "In the diagram you can see the meaning of each letter of the acronym and that it is all in a cloud as a context."	Model E Connected level
Question 2 interview: STEAM teaching experience	"We start with questions about the subject we want to deal with, we guide them with the answers they give us, we give them the materials so that they can try them out. From there, I guide them and help them to do the activities, and we also exemplify it with everyday things. The aim is for the children to work on their own learning, to explore and manipulate, for them to learn and see that they have the capacity to do so."	Nested level
Question 3 interview: definition of STEAM	"In STEAM we have five categories or disciplines, the way to work with them is from a focus, to see what other parts I can work on."	Connected level
Question 4 interview: STEAM integration	"The disciplines have to be related through a project."	
Global profile	Connected	

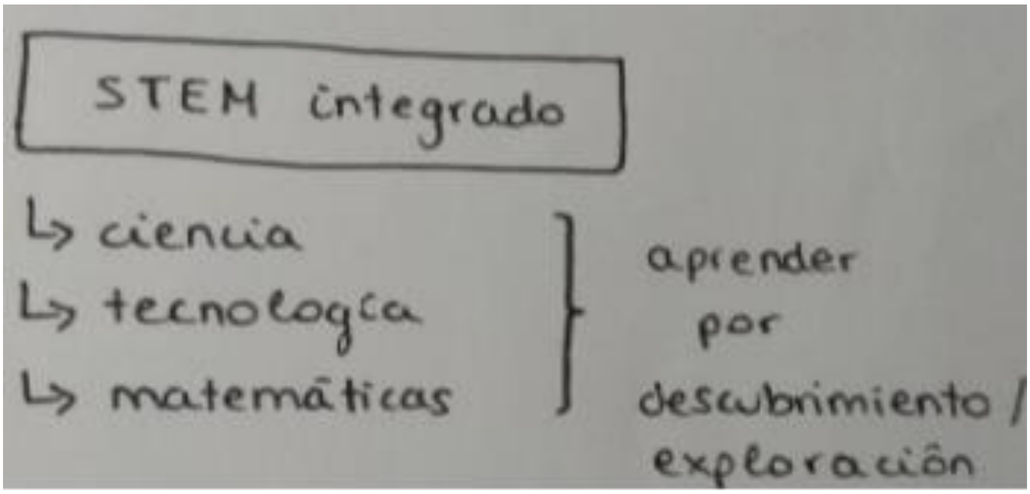
	Subject 7	
Visual representation and explanation	 "STEAM is based on different competences, that is to say, they do not work on disciplines, but emphasize basic skills or competences of the real world as opposed to areas or disciplines [. . .]."	Model B Transdisciplinary level

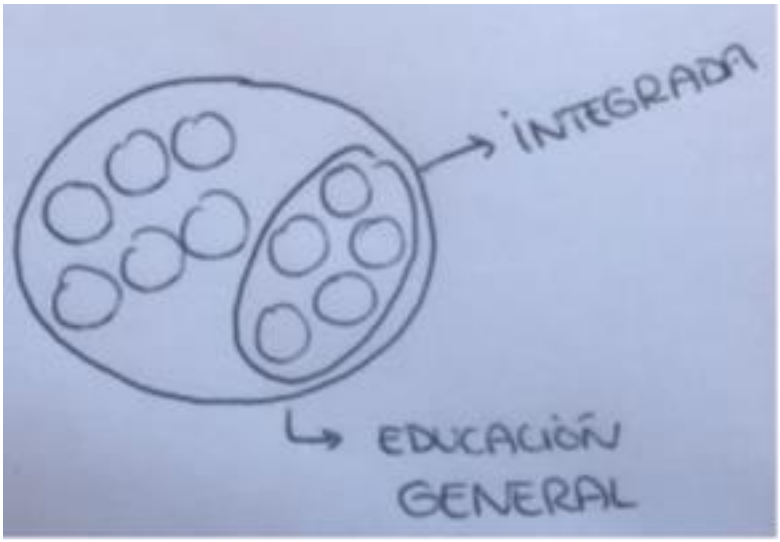
	Subject 7	
Question 2 interview: STEAM teaching experience	"I see that it is a real use of starting to do logical thinking, reasoning, an introduction to engineering [. . .], it favours them a lot [. . .]. You present science to them as a fun project, parents are very involved [. . .]. I get them to ask themselves questions, they have a lot of curiosity and if you develop their interest from a very young age, it will be much better and they also manipulate a lot, which is very important [. . .]. I give them material; we start to investigate, and I leave them time to investigate and to ask themselves questions and then we start to do the activity."	Transdisciplinary level
Question 3 interview: definition of STEAM	"It is to work on absolutely everything, starting from a project to integrate it all, and to integrate all the areas."	Interdisciplinary level
Question 4 interview: STEAM integration	"Integrating it for infants is very easy, I have my own timetable, I am the only one who enters my class, I programme the activities, the visits, because it is also important that experts come to the area in which I am working. I organize the visits and activities with my colleague [. . .]."	
Global profile	Transdisciplinary	

<table>
<tr><th></th><th>Subject 8</th><th></th></tr>
<tr><td>Visual representation and explanation</td><td>

"In the drawing you can see the meaning of the acronym. In addition, you can see the knowledge or competences that are developed in each of the areas. All of this is included in the same cloud, from which another small morsel comes out referring to social work."</td><td>Model E Interdisciplinary level</td></tr>
<tr><td>Question 2 interview: STEAM teaching experience</td><td>"It depends on the team I work with. We always try to put a small project in the area of natural sciences. Of course, we collide head-on with the curriculum, so when you have such separate areas and with the division of bilingual and non-bilingual, it makes it a bit difficult to put the projects into practice [. . .]. In the end, the children like it and are much more interested in it. The projects always start from the textbook, it's something we have to adapt to all the tutors [. . .], we have a worksheet that we've been working on since the first year, the scientific method, so they fill in the worksheet, make their hypotheses, their observations and draw their conclusions. The good thing about having been working along the same lines since the first grade is that the children have a certain command of the working method."</td><td>Nested level</td></tr>
</table>

Subject 8		
Question 3 interview: definition of STEAM	"Starting from a topic or content, taking it to the classroom, starting from curriculum content, looking for ways of integrating various areas through the scientific method."	Nested level
Question 4 interview: STEAM integration	"Look for the relationship between various areas to do something that is manipulative and that they can experiment with."	
Global profile	Nested	

Subject 9		
Visual representation and explanation	 "I have represented some of the disciplines that make up the approach and some of the methodologies that can be used."	Model A Nested level
Question 2 interview: STEAM teaching experience	"All the sessions start with or are oriented towards a real-life problem or a problem that is generally based on something that can occur in daily life and you have to make sure that it is closely related or relate it in some way to the concepts you are going to work on in the areas you are going to tackle [. . .], the problem is presented to them and it is they who have to ask questions, you have to support them, and guide them and orient them towards the question they are going to work on, following the phases of the scientific method. I think it's important for them to be aware that they are doing research and they have to go through these phases."	Multidisciplinary level
Question 3 interview: definition of STEAM	"It is a methodology that aims to tackle concepts and content from different areas together."	Multidisciplinary level
Question 4 interview: STEAM integration	"An interrelation of disciplines to try to find a solution to an initial problem."	
Global profile	Multidisciplinary	

Subject 10		
Visual representation and explanation	 "There is general education, where the circles are separate, and integrated education, which is within general education, where the circles are together. The small circles represent the different subjects of the curriculum." "STEAM does not conceive that the acronyms are separate, it is understood that each of the disciplines has to favour the following ones and they also have to complement each other."	Model D Connected level
Question 2 interview: STEAM teaching experience	"Through the centre project (the cathedral), we included robotics and STEAM [. . .]. We worked for nine sessions in a progressive way [. . .], concepts of mathematics, technology, engineering, psychomotricity, etc. One of the main objectives we had was that they should have an embodied cognition, all through different activities [. . .]."	Multidisciplinary level
Question 3 interview: definition of STEAM	"STEAM is not thought of as separate letters in an acronym, it is understood that each one of the disciplines has to favour the others and they have also to complement each other."	Connected level
Question 4 interview: STEAM integration	"I understand that not everything has to be there all the time, but if a little bit can be introduced so that everything forms a puzzle and everything fits together, all the better."	
Global profile	Connected	

Subject 11		
Visual representation and explanation	 "You can see the children in a circle and around them four circles with the acronym corresponding to interdisciplinarity, the family environment, experience and society."	Model B Interdisciplinary level

	Subject 11	
Question 2 interview: STEAM teaching experience	"We do projects on something that can motivate the children: magnets, solutions and mixtures, starting with a project related to the Prado Museum, for example [. . .], following the scientific method, observing, manipulating, experimenting, trying to deduce, launching hypotheses and arriving at conclusions."	Nested level
Question 3 interview: definition of STEAM	"The aim is to raise awareness among the children and ourselves, that is to say, that in the face of the logical questions that our children have, starting from the concerns they have and, through small steps that we take systematically, through all the fields and taking into account the objectives we have, we formulate or see and respond to these objectives."	Nested level
Question 4 interview: STEAM integration	"Combining all the fields to achieve the objectives."	
Global profile	Nested	

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