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TRAINING OF FUTURE STEAM TEACHERS: COMPARISON BETWEEN PRIMARY DEGREE STUDENTS AND SECONDARY MASTER'S DEGREE STUDENTS

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Abstract

In recent years, the presence of the acronym STEAM has been growing in the educational field. All around the world we are faced with a growing demand for professional STEM skills, however, who has the responsibility to train future STEAM teachers? In this article, we explain the results of an investigation with university students pursuing a degree in primary education and Master's degree students in secondary education, with technology speciality, participating in a seminar about STEAM projects design in two consecutive academic calendar years (18/19 and 19/20). We analyse the responses to a questionnaire which was specifically designed to discover their knowledge about STEAM and the predisposition towards its extended study with a set of semi-structured interviews to delve into the causes of the responses. Previous knowledge about the meaning of STEM and the predisposition of pre-service teachers towards the future design of projects based on the STEAM disciplines are compared. The results show significant differences between the previous knowledge and the perceptions of the teachers from both specializations: primary and secondary level. The results also confirm the low levels of prior knowledge with a slight tendency towards improvement when two consecutive courses are compared. The findings emphasize the need to integrate STEAM teacher training into official curricula.

***Keywords* –** Primary education, Science education, Secondary education, STEM/STEAM, Teacher training.

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1. Introduction

Many documents published by official organizations report on the need to adapt the objectives of science education to the reality of the present moment. A good example is the Scientix Observatory Report (Nistor, Gras-Velazquez, Billon & Mihai, 2018) published by the European Commission. This report establishes new challenges for education in Science, Technology, Engineering and Mathematics, summarizing them in five priorities: 1) Attract more students and teachers to STEM Education through a global approach, 2) Break barriers with pragmatic initiatives to improve the quality of STEM education, 3) Design an inclusive curriculum and evaluate pedagogical innovations to transfer successful experiences to European education systems, 4) Develop a common European framework of reference for STEM education and 5) Foster deeper collaboration with universities and organizations in the industry to develop the skills of STEM teachers. In fact, some authors speak of integrated learning in science, technology, engineering and mathematics as one of the learning trends of the 21st century (Pathoni, Ashyar, Maison, & Huda, 2022).

In order to meet and overcome these challenges, it is necessary to clarify who should lead these pedagogical actions and ensure who should be responsible for defining and implementing them. If this responsibility has to be assumed by the teachers of the future, it is necessary to introduce training paths with a STEM perspective within the educational system to prepare them. Voluntary extra-curricular training courses are insufficient.

Since Zollman (2012) called the current generation the STEM generation, the presence of this acronym has been growing within the educational environment with a variable meaning that has integrated different perspectives. Those focused on robotics and/or programming languages have been the most common. Many researchers have tried to formalize the meaning of this new concept for science education. Balka (2011: page 7) proposed: "STEM literacy is the ability to identify, apply, and integrate science, technology, and math concepts to understand complex problems and innovate in their solution".

It is important to recognize that the real cause of the arrival of STEM in education has to do with economic needs; professionals must be trained for a new technological society. Assuming this fact, the way these training plans are designed must include the work of education professionals in order to ensure that the educational perspective is properly integrated into this new challenge. Following this perspective, there are important considerations that have already been analysed from educational research. Literacy in science and technology, through STEM approaches, should not be seen as a new specific content area or as a methodology (Domenech, Lope & Mora, 2019), but should be understood as a project-based learning approach oriented to the scientific field (Domenech-Casal, 2017). This interdisciplinary approach must be inclusive and must attract teachers from different disciplines, so this shared responsibility will help teachers meet the challenges outlined above. Continuing with the idea of defining the actions to develop STEM education with a pedagogical perspective that includes the situations and aspects related to the training of future STEAM teachers, what Grimalt-Álvaro and Couso (2019) define as "stance on STEM" to refer to how students feel and act about STEM. For decades it has been observed that boys and girls do not act with the same perspective towards the STEM field: the interest of students in STEM subjects decreases in secondary education with a marked decrease in students from low socio-economic backgrounds (Barmby, Kind & Jones, 2008; Rocard, Csermely, Jorde, Lenzen, Walwerg-Heriksson & Hemmo, 2007). This trend continues to remain true today (Fuentes-del-Burgo, Sánchez, Ballesteros & González-Geraldo, 2022; OECD, 2019; UNESCO., 2017), especially in relation to technology and physics (Grimalt-Alvaro, Couso, Boixadera-Planas & Godec, 2021). A student's stance on STEM is a prior condition that determines their future participation in STEM learning activities. It is, therefore, an important factor that must be taken into account when defining STEM learning activities at any educational level, with greater emphasis on the primary and secondary stages.

A first global action born with this objective is the inclusion of the "A" as a representative of artistic disciplines (also humanistic) within STEM projects to transform them into STEAM. The inclusion of the artistic disciplines is not arbitrary and, in addition to broadening the interdisciplinary perspective by incorporating an external area into the scientific field, it responds to the need to break with the international stereotypes anchored in the technical sciences for more than 40 years (Ortega-Torres, Verdugo & Gomez, 2019). These patterns identify STEM professions as men, white and brainy (Archer, Dewitt & Osborne, 2015).

Following with the intention of showing relevant aspects for STEM training, a block on the concept of self-efficacy should also be included in the training of future teachers. Scientific research has shown consistent evidence on the relationship between self-efficacy and performance and interest in STEM (Cartagena-Beteta, 2008; Grimalt-Álvaro, Ortega-Torres, Couso & Paloma-Romeu, 2021). The self-efficacy defined by Albert Bandura (1997) to explain the belief in one's abilities to perform a specific task, when related to STEM can be called "STEM self-efficacy". Underrepresented students in STEM fields tend to underestimate their own performance in this field. Therefore, another aspect to include in STEM educational projects should be the improvement of the perception of STEM self-efficacy of these students. Some authors have established different action steps to achieve this improvement in the students' own perception within a learning process. Zimmerman (2000) showed that there are four categories to classify these actions: 1) experiential actions, 2) bring referents closer, 3) social reinforcement and 4) self-regulation learning activities. Hence, the way to achieve the challenges defined by the European Commission in STEM education must include an inclusive interdisciplinary approach, including the arts (or disciplines linked to the humanities) and the improvement of self-efficacy perceptions in STEAM training pathways to prepare all types of students for the STEM future that is already here.

2. STEAM Teacher Training

From the perspective set forth in the introduction to this article, it is assumed that future STEAM teachers will be students of the Primary Education degree and the Master's Degree in Secondary Education Teacher Training. Responding to the previously raised question about who should assume the leadership of STEAM education, these students, as future teachers, should be the ones who lead the inclusion of STEAM projects in the didactic plans of the corresponding levels. Their role as future teachers in the implementation of these practices is key (Sulaeman, Efwinda & Putra, 2022) and therefore requires prior analysis.

For this, the first problem that must be addressed is to integrate training in the design of STEAM learning activities into the official curricula that define the study plans, both for the Primary Education Degree and for the Secondary Education Master's Degree. There is no official STEAM reference in the Spanish National Curricula to date; although they do appear in the recently approved "LOMLOE" (2020) where some explicit references are included (see the challenges and objectives defined in https://www.educacionyfp.gob.es/destacados/lomloe.html).

2.1. STEAM Seminar for Teachers in Training

While waiting for structural solutions that integrate STEAM training itineraries into the official curricula, there are various proposals in the university training of future teachers that try to incorporate actions that can serve this purpose. The training action presented in this article is one of them and was designed and implemented with the aim of preparing future teachers in the design of STEAM learning activities for both primary and secondary schools.

The training action was carried out in the format of a compulsory seminar included in the annual planning of the subject "Didactics of Science: Matter, Energy and Machines" (scientific subject within the 4th year of the degree in primary education) and Learning and Teaching of Technology (subject inside the specialty of Technology and industrial processes of the Secondary Education Master).

The seminar lasted 12 hours; 3 sessions of 4 hours each with the structure shown in Table 1.

Session	Content block
Session 1	What is STEM? Why STEM? Project Based Learning Approach
Session 2	Self-efficacy concept From STEM to STEAM STEAM Approach
Session 3	Good practices of STEAM projects We design a STEAM project

Table 1. Structure of the STEAM Seminar

2.1.1. Description of the Sessions

Session 1: The first session focused on describing the meaning of the acronym STEM and discovering the students' previous knowledge of this concept (see Figure 2). During the session, there was an emphasis on the reason why STEM is important in the training of both primary and secondary education students. Before starting the work on the STEM concept, the students were asked to answer a questionnaire (on-line version) with five brief questions aimed at knowing their previous notions about STEM/STEAM. After that, the students were organized in groups of 4-5 people to contrast their previous knowledge. The specific objective of this session was focused on ensuring that after its completion, all the participating students could explain the meaning of the STEM approach and the reasons for its introduction in the educational field. In addition, the essential characteristics of project-based learning are introduced in this session following the work of Hasni, Bousadra, Belletête, Benabdallah, Nicole & Dumais (2016) among other authors.

Session 2: The second session focused on analysing the importance of self-efficacy in science education and in the future students' aspirations. The concept was presented based on the definition of Bandura (1997) and examples of actions in the classroom to improve the perception of self-efficacy were shown based on the works of Zimmerman and Campillo (2003). In this case, the session was different for the primary education group and the secondary Master's group, these differences especially affect the idea of interdisciplinary connections between subjects for the creation and/or management of STEAM projects. In primary education, the same teacher leads almost all subjects and in secondary education, there are different teachers for each discipline. This structural difference was included in the orientation of the STEAM approach in the sense of the design of didactic sequences. For elementary school students, a holistic approach is proposed that includes the STEAM disciplines; on the other hand, for the students of the Secondary Education Master's Degree, emphasis is placed on the need to integrate a transdisciplinary approach that includes disciplines (or subjects) other than Technology (it should be remembered that the group of students was studying the Technology modality of the Secondary Education Master's Degree).

Session 3: In the last session, the students had to analyse the characteristics of some STEAM projects carried out in different schools (for the Primary or Secondary level, depending on the group). The criteria for the analysis of the projects are exposed and explained: *Type of assignment, Context, Learning objectives, Contents, Classroom activities, Technologies and Interdisciplinarity*. Students are asked to apply them to a list of pre-selected STEAM projects. Next, the students are in a position to design their own STEAM project idea using the "Canvas for STEAM projects" tool shown below in Figure 1.

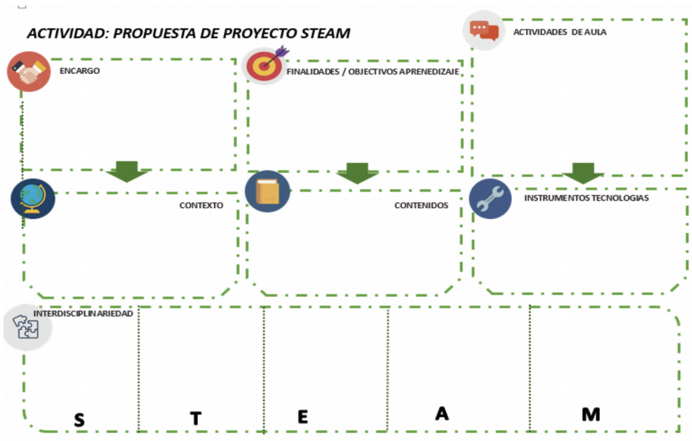

Figure 1. Canvas to design STEAM projects

The "Canvas for the design of STEAM projects" tool is a panel divided into 3 blocks. The first two are made up of three elements that are connected to each other two by two: The element of block 1 "Assignment" is linked to the element of block 2 "Context": this connection is established with the aim that the students locate the assignment of the project in a context as close and real as possible. For example, the implications are not the same if the assignment is to take a mathematical photograph of the environment of the school as if it is said that this photograph is going to be part of an exhibition that will be held in the municipality's house of culture so that families and neighbours can visit it. The change in the context raises the level of involvement and "enlarges" the challenge posed.

The second element of block 1 "Learning objectives" is linked to "The contents". In this case, it is intended that the students (future teachers) know the curriculum of the subjects of a specific course and that they can differentiate and relate objectives with contents with the purpose that the designed STEAM project can be translated into a "standard" classroom planning document. During the completion of this section, students understand how to describe the objectives and the difference between them and the contents. The skills and/or learning standards linked to the learning objectives prioritized in the project are also worked on.

The third element of each block is "Classroom Activities" and "ICT Tools": In this case, the aim for students is to make a first approach to a didactic sequence that defines the designed project and to anticipate the ICT tools that they will need to be able to carry out each proposed session. In this case, the aim is to make students aware of the number of classroom lessons that may be required to carry out a given activity and the type of resources that will be necessary for its development.

Finally, there is a third block with the initials of each of the disciplines linked to STEAM projects. In this case, a description of how the different disciplines are present in the project idea is required. The objective is to specify the contribution of each discipline and inspire new ideas that help to integrate disciplines that are not present in a first version of the project. The usual doubts in this block are based on knowing the difference between the "T" and the "E". In this sense, the "T" represents the discipline of Technology with the objectives of technological literacy established by the curriculum. On the other hand, the "E" which stands for Engineering represents the so-called "engineering thinking" related to the ways of planning, reviewing and improving the processes of elaboration of a specific technological product.

In this last block of the tool, emphasis is placed on explaining that it is not essential that there is a perfect balance between the presence of all the disciplines, and a high-quality STEAM project can be created dominated by one of the disciplines or without the presence of one of them (Domenech-Casal, 2018).

3. Research Methodology

A mixed methodology research was carried out based on the combination of two instruments:

1. For the quantitative approach, after the last session of the seminar described in the previous section, a self-prepared questionnaire (online version) composed of 15 questions was given to the participating students. This questionnaire was focused on knowing their vision about the difficulties of implementing STEAM projects in the educational level where they will be teaching. The questionnaire was structured in 3 blocks: Block 1) characterization of the participating students with 4 questions; Block 2) previous knowledge about STEAM with 4 questions, two of a dichotomous nature and two in an open format and Block 3) difficulties of applying and designing STEAM projects with 7 questions, 4 with multiple choice answers and 3 with a 7-point Likert scale.

   Subsequently, a statistical analysis was carried out with SPSS 22.0 T.M through a double-entry contingency table: Pearson's Chi-square test to compare proportions of independent data in order to verify if the differences found between the two samples analysed (Teaching students vs. Master's students) were significant. Being a non-parametric sample, Cronbach's alpha (0.557) is calculated to check the reliability of the instrument created with a mean reliability result that invites the design of a new phase of qualitative research to expand the information obtained in the questionnaires.

2. From the qualitative approach, three months after the seminar, individual interviews were conducted with 3 participants from the Primary education degree group and two interviews with participants from the Secondary Education Master's group. All the students (4 girls and one boy) interviewed had completed the final internships of the 4th year in the Primary Education degree or those corresponding to the Secondary Education Master's degree. These interviews were semi-structured and seeked to validate the responses obtained in the questionnaire and delve into the

reason for the differences found between the responses of both groups. The average time for the interviews was 35 minutes in online format.

3.1. Participants

The seminar was taught during two consecutive courses (18/19 and 19/20) with two different groups in each course. One group of students was in their last year of primary education (4th grade), and the second group was formed by students in the Secondary Education Master's Degree within the speciality of Technology. The choice of the subgroups of the sample is based on the current situation in primary and secondary schools. The primary teachers, without a certified specialty in their grades, are those who lead the STEM-STEAM projects in primary education. On the other hand, teachers of the technology in secondary schools are those who usually lead these types of projects. For the Primary Education degree, students receive different "mentions" depending on which subjects they choose during the program: language, science, among others. Thus, in the current study, the sample of students came from those within the scientific mention. However, for the Master's in Secondary Education, there are specialties, and those that participated in the current study were within the Technology specialty. The total number of participating students was 180 distributed as shown in Table 2.

Course	Primary Education Degree	Secondary Education Master's Degree (Technology Speciality)
18/19	39	45
19/20	44	46

Table 2. Participants

4. Results and Discussion

The most relevant results obtained after administering the online questionnaire described above and the subsequent comments obtained through the interviews are shown below.

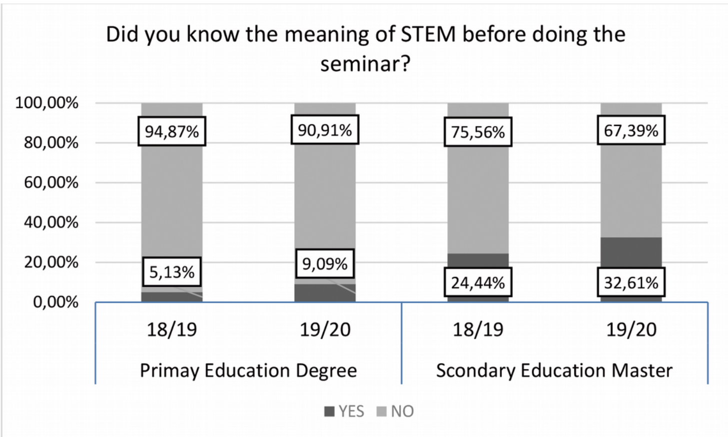

Figure 2. Comparison between prior knowledge about the meaning of the acronym STEM between Primary Education degree students and Secondary Education Master's students

As we can see in Figure 2, the future teachers participating in this research state that they are unaware of the meaning of STEM. This lack of knowledge showed higher percentages in the group of primary education degree students compared to the group of secondary education Master's students. Statistical analysis using Pearson's Chi-square calculation shows that the differences regarding prior knowledge between the samples (Primary Education degree vs. Secondary Education Master's degree) are significant with $p<.005$. This difference can be justified for two reasons: the secondary education Master's students were taking the technology modality, so their previous studies were engineering (63%), architecture (14%) and other degrees in the scientific-technological branch. Therefore, the term STEM should be closer to them a priori. In contrast, the students of the primary education degree have few science credits and most of them studied non-scientific modalities in their prior high school before beginning their education degree (Verdugo-Perona, Solaz-Portolés & Sanjosé-López, 2017) so that, the STEM concept, a priori, should be more foreign to them. Despite this difference, it is important to highlight the high percentage of ignorance about the meaning of the STEM acronym shown by the students of the Technology specialty of the secondary education Master's degree: more than 67% did not know the meaning of STEM before participating in the seminar. These results influence the trend shown in previous research that underscores that the STEM concept is better known in educational research and not so much by future science teachers (Ortega-Torres, 2018) or that there is a "fluid perspective" according to the recent naming of Sulaeman et al. (2022).

As the results shown by Figure 2, a trend can be seen in terms of the positive evolution that is taking place regarding the knowledge of the meaning of STEM shown by future primary and secondary teachers. It is observed that future primary teachers almost double their knowledge about the meaning of STEM from the 18/19 course to the following 19/20 course, despite showing a high level of ignorance of more than 90%. As far as future secondary school teachers are concerned, their knowledge also improves from one course to the next, going from 24.44% to 32.16%.

Subsequent interviews confirm these results. Table 3 below highlights the answers related to the category "Previous knowledge of STEAM" related to the results shown in Figure 2.

After the seminar, with the knowledge acquired about the meaning of the STEM concept and the examples of the STEAM projects analysed and devised by the students themselves, the third block of the questionnaire was given to deepen the perception of the possible difficulties that the future teachers think they can find when designing STEAM projects. The results shown in Figure 3 highlight the existence of some important differences between primary and secondary future teachers.

The statistical analyses carried out show significant differences in terms of the perception of difficulty for the integration of disciplines T and E ($p < .005$ in both cases). In this case, in the opposite direction: for the inclusion of T-Technology, the Master students consider that there is less difficulty and for the inclusion of E-Engineering, the consideration of the Master students is of greater difficulty. On the other hand, the differences found for disciplines S, A and M analysed individually comparing the two samples are not significant ($p > .005$ in the three disciplines compared).

Student	Observation
A1: 4th grade primary education degree student	"I had never heard of that but after the seminar I saw it on a school's website"
A2: 4th grade primary education degree student	"I had no idea before the Seminar. Later I found on a web page of a publisher of my student of English review classes as part of the planning is about STEAM"
A3: 4th grade primary education degree student	"I had heard of globalizing projects, but specifically of STEAM I had not heard of. I haven't heard it since."
A4: Student of the Master in Secondary Education (specialty in Technology) with a previous degree in Environment Science	"I had never heard of it, but precisely where I am doing my internship they are in a project on STEAM related to robotics and Scratch"
A5: Student of the Master in Secondary Education (specialty in Technology) with a previous degree in Telecommunications Engineering	"The first time I heard it was in the Master's Program. Later, in the center where I am doing the internship, they do have STEM projects"

Table 3. Answers related to the category "Previous knowledge about STEAM"

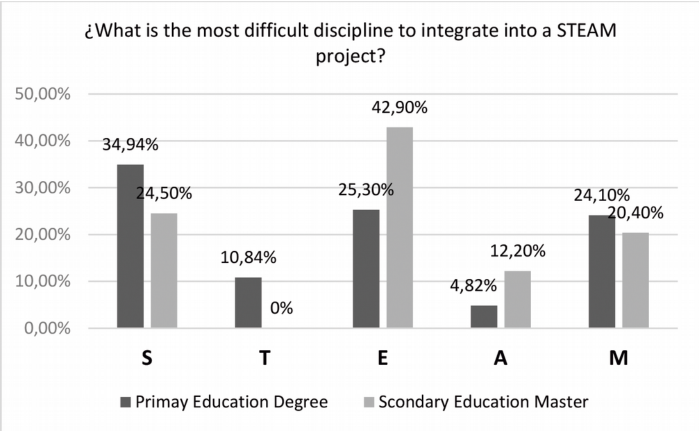

Figure 3. Difficulties in integrating the STEAM disciplines in the design of a project

Regarding future secondary school teachers, the perception of "without difficulty" to include actions related to the discipline of technology in a STEAM project stands out. This was an expected result because the students belong to the Technology specialty group (T) of the Secondary Education Master's Degree. However, it is interesting to verify that despite the fact that most of them (63%) started with a previous engineering training, they considered engineering itself (E) as the most complicated discipline to integrate into a STEAM project (42.90%), with a perception of less difficulty for undergraduate students, as mentioned before. It is also noteworthy to observe that the artistic discipline (A), apparently the knowledge most foreign to them, was perceived as the least difficult to integrate into a STEAM project (after T), which even was perceived as being less difficult than Sciences (24.5%) or Mathematics (20.40%).

Regarding the results obtained according to the perception of future primary school teachers, it can be seen that the discipline perceived as the most difficult to integrate into a STEAM project was Science (34.94%), followed by Engineering (25.30%) and Mathematics (24.10%). It is noteworthy to verify that once again the arts (A) were the discipline with a perception of least difficulty to include in a STEAM project.

Comparing the two groups of future teachers, some similarities can be seen: the Arts is the discipline with the least difficulty perceived to be included in a STEAM project (leaving Technology aside for secondary Education Master's students). This data reveals a possible preconceived error that starts from the possibility of including this discipline in a superficial way, without giving it the relevance that is granted to the rest of the STEAM disciplines; and therefore, the perception of low difficulty. This is a common trend that should be avoided in order to balance the different perceptions of self-efficacy that students (primary and/or secondary) start with when they are going to participate in a STEAM project (Grimalt-Álvaro & Couso, 2018). To confirm this possibility, a part of the interview was devoted to this aspect (see Table 5).

Another similarity found is the perception of high difficulty to include Engineering. In this case, this difficulty must be related to the absence of this discipline as a subject in the formal curriculum. This absence means that there are no previous references of educational activities on which to inspire new actions.

Regarding the perception of high difficulty in including Science, especially in future primary school teachers, it may be due to the already mentioned lack of science training credits in their undergraduate studies (Verdugo-Perona et al., 2017) and the low perception of knowledge of the content with which future primary school teachers start their degree. Finally, the perceived difficulty of including Mathematics in STEAM projects is also high; this situation could be understood from the traditional difficulty associated with mathematics (Romero-Bojórquez, Utrilla-Quiroz & Utrilla-Quiroz, 2014) shown by primary school teachers in training.

In order to delve into the causes of these differences, questions were included in the interviews on these aspects. Table 4 shows some of the responses related to the difficulty in incorporating the different disciplines integrated into STEAM projects.

The answers included in this category of analysis "Difficulty in the inclusion of STEAM disciplines" reveal a new interpretation about Secondary Education Master's students showing an assignment of greater difficulty to the inclusion of disciplines based on the distance between their own previous training and the students' knowledge (see responses A5 in Table 4). A fundamental value is assigned to content knowledge without thinking of a possible solution through the pedagogical content knowledge that the teacher must have. It seems that the complication is only linked to the students' previous knowledge of the content and is not related to the teaching role.

Table 5 below shows some of the responses related to the difficulty of incorporating the arts into STEAM projects.

Student	Observation
A2: 4th grade primary education degree student	"It is often said that Arts is easier because you make them draw, use colors or make a model. But I think it's easier to teach science because it's all around you. You accidentally have to learn science every day. For example, they must understand what fog is formed by, for example..."
A3: 4th grade primary education degree student	"I really don't think any of them are too complicated, but if I had to say something I would say Arts, because mixing Science and Arts, I wouldn't know what approach to give it"
A4: Student of the Master in Secondary Education (specialty in Technology) with a previous degree in Environment Science	"For me the most difficult part is the math, because to transfer this to levels, measurements, I see it more complicated. Because it can no longer be like a game, it must be, yes or yes, exact. I see it easier to do everything together until the inclusion of mathematics."
A5: Student of the Master in Secondary Education (specialty in Technology) with a previous degree in Telecommunications Engineering	"For me the most complicated thing is to introduce the E because I have found students without an engineering background" "I found a lack of engineering awareness" "They have deficiencies in many fields, but where it is most is in engineering." "They have a science base that in relation to engineering they do not have"

Table 4. Answers related to the category "Difficulty for the inclusion of STEAM disciplines"

Student	Observation
A1: 4th grade primary education degree student	"I don't see any difficulty in integrating Arts, but I see it as cheating. You put Arts and you put them to paint and it seems that you are integrating art, but I don't know to what extent it is real, but of course if we remove the A from Arts you do what you always do. You work the sciences and that's it".
A2: 4th grade primary education degree student	"But including Art in a natural way would not have them make a model. It would be necessary to do activities that are not like English (a glob) but that everything is a process. Take advantage of the M they need, the Art they need in their environment and that they learn in a way, as they say, without doing anything."
A3: 4th grade primary education degree student	"I find it more difficult to integrate the Arts because it shouldn't be painting or drawing, but working well on the artistic part of something, going further. It should not be a simple craft."
A4: Student of the Master in Secondary Education (specialty in Technology) with a previous degree in Environment Science	"I don't see it as difficult to integrate the artistic part. For example, you can integrate Music that has a lot of mathematics. In the design part you can make a sketch, etc."

Table 5. Answers related to the category "Difficulty for the inclusion of Art"

Following with the intention of deepening the perceptions about STEAM that future primary and secondary teachers show after the described training seminar, the future predisposition they would have to implement STEAM projects is analysed. In this case, results found showed a positive predisposition. As shown in Figure 4, there is a high or very high assessment (the sum of both groups being over 80%)

on the need to include STEAM projects in formal education curricula: 92.3% of future secondary school teachers show this assessment, and 81.92% of future primary school teachers. Performing a statistical analysis of the differences between both groups of students, grouping the responses into two categories: [Very Few+Few] vs. [High+Very High], it can be seen that there are no significant differences in the level of importance they give to the inclusion of this type of project in their educational level ($p > .005$).

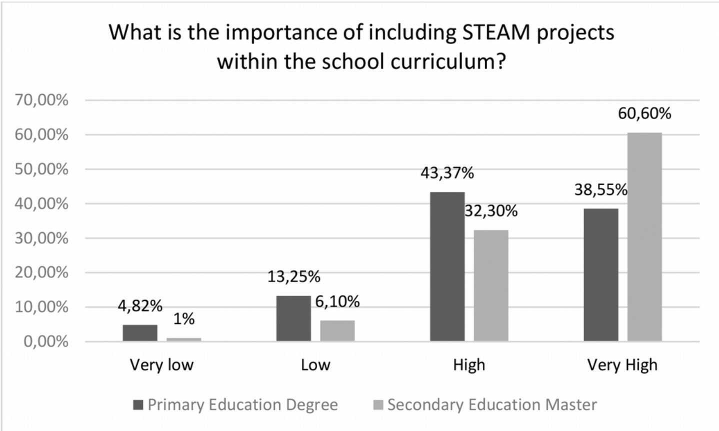

Figure 4. Level of importance for the inclusion of STEAM projects in the formal curriculum

5. Conclusions

As a first conclusion, we can verify that the first objective of this research has been fulfilled: it has been possible for future teachers to learn the meaning of the STEM/STEAM concept and its modes of integration in the classroom as a science learning approach. Future teachers still have little knowledge about the meaning of STEAM, but this instruction has helped to bring the concept closer and foster a good predisposition for its integration. In this sense, the results also show an interest in the inclusion of STEAM projects in the study plans. Therefore, we can affirm that at the moment when teachers acquire knowledge about STEAM, they consider these types of projects as necessaries in the educational curriculum.

On the other hand, we can conclude that there is still an important difference between the understanding and knowledge about STEAM between future primary and secondary school teachers. This fact highlights the need to start planning training proposals on the design of STEAM projects with more emphasis on the study plans of the primary education degree to allow continued action that lasts in secondary education and post-compulsory studies.

Finally, the importance of finding strategies to include expert teachers in the artistic discipline in the work teams that are going to design and implement interdisciplinary STEAM projects is remarkable: their experience and knowledge of the area is the way to ensure the relevance of the discipline, and their correct involvement within a STEAM project, preventing them from becoming seen as less important, due to the perception of easy integration of the Arts shown by the students in the sample.

This research highlights the positive evolution that is taking place regarding the recognition and knowledge of STEAM in education and needs to be complemented with new research/planned actions with the same objective to provide a more thorough analysis regarding if this improvement is consolidated or is only a start.

This research shows a proposal for action in the classroom in order to improve the application of the STEAM approach in primary and secondary schools. The conclusions are conditioned by the limitations of the sample size.

Declaration of Conflicting Interests

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References

Archer, L., Dewitt, J., & Osborne, J. (2015). Is science for us? Black students' and parents' views of science and science careers. *Science Education,* 99(2), 199-237. https://doi.org/10.1002/sce.21146

Balka, D. (2011). Estándares de práctica matemática y STEM. *Boletín informativo del conector Mathscience,* 6-8.

Bandura, A. (1997). *Self-efficacy: the exercise of control.* New York: W.H. Freeman. https://doi.org/10.1891/0889-8391.13.2.158

Barmby, P., Kind, P.M., & Jones, K. (2008). Examinar las actitudes cambiantes en la ciencia de la escuela secundaria. *Revista Internacional de Educación Científica,* 30 (8), 1075-1093. https://doi.org/10.1080/09500690701344966

Cartagena-Beteta, M. (2008). Relación entre la autoeficacia y el rendimiento escolar y los hábitos de estudio en alumnos de secundaria. *REICE. Revista Electrónica Iberoamericana sobre Calidad, Eficacia y Cambio en Educació,* 6(3).

Domenech-Casal, J. (2017). Aprenentatge Basat en Projectes en àmbits STEM. *Ciències: Revista del Professorat de Ciències de Primària i Secundària,* 33, 2-7. https://doi.org/10.5565/rev/ciencies.7

Domenech-Casal, J. (2018). Aprendizaje Basado en Proyectos en el marco STEM. Componentes didácticas para la Competencia Científica. *Ápice. Revista de Educación Científica*, 2(2), 29-42. https://doi.org/10.17979/arec.2018.2.2.4524

Domenech-Casal J., Lope, S., & Mora, L. (2019) Qué proyectos STEM diseña y qué dificultades expresa el profesorado de secundaria sobre Aprendizaje Basado en Proyectos. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias,* 16(2), 2203. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2019.v16.i2.2203

Fuentes-del-Burgo, J., Sánchez, J.M., Ballesteros, J.A., & González-Geraldo, J.L. (2022). Exploratory study on didactic aspects used in scientific-technical (STEM) dissemination conferences for students of secondary education. *Journal of Technology and Science Education,* 12(1), 96-111. https://doi.org/10.3926/jotse.1318

Grimalt-Álvaro, C., & Couso, D. (2018). *Incrementar la autoeficacia en STEM, una forma de brindar oportunidades para todos (04).* Descripción de las principales estrategias para aumentar la autoeficacia en STEAM utilizadas en el proyecto STEAM4U.

Grimalt-Álvaro, C., & Couso, D (2019). "No va amb mi" La influencia del disseny d'activitats STEM sobre el posicionament de l'alumnat en aquest àmbit. Universitas Tarraconensis. *Revista de Ciències de l'Educació,* 1(2), 133-144. https://doi.org/10.17345/ute.2019.2.2658

Grimalt-Alvaro, C., Couso, D., Boixadera-Planas, E., & Godec, S. (2021). "I see myself as a STEM person": Exploring high school students' self-identification with STEM. *Journal of Research in Science Teaching,* 59(5), 720-745. https://doi.org/10.1002/tea.21742

Grimalt-Álvaro, C., Ortega-Torres, E., Couso-Lagarón, D., & Paloma-Romeu, L. (2021). Influencia en la autoeficacia del grado de autenticidad de la indagación de dos proyectos de ciencia de secundaria. Estudio de caso. *Revista Eureka Sobre Enseñanza Y Divulgación De Las Ciencias,* 18(2), 2101. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2021.v18.i2.2101

Hasni, A., Bousadra, F., Belletête, V., Benabdallah, A., Nicole, M.C., & Dumais, N. (2016). Trends in research on project-based science and technology teaching and learning at K–12 levels: a systematic review. *Studies in Science Education,* 52(2), 199-231. https://doi.org/10.1080/03057267.2016.1226573

LOMLOE (2020). Texto completo con las modificaciones de la LOMLOE. Available at: https://www.educacionyfp.gob.es/dam/jcr:d458fa45-e9c0-4854-8787-f468015b968e/web-loe-completa-con-lomloe.pdf (Accessed: May 2020)

Nistor, A., Gras-Velazquez, A., Billon, N., & Mihai, G. (2018). Science, Technology, Engineering and Mathematics Education Practices in Europe. *Scientix Observatory report.*

OECD (2019). *PISA 2018 results (volume II): Where all students can succeed.* OECD Publishing. https://doi.org/10.1787/b5fd1b8f-en

Ortega-Torres, E. (2018). Apropant la perspectiva STEAM a docents de tecnologia en formació. Ciències: Revista del Professorat de Ciències de Primària i Secundària, 36, 30-35. https://doi.org/10.5565/rev/ciencies.398

Ortega-Torres, E., Verdugo, J.J., & Gomez, C.B. (2019) *Docente STEAM. En Rizomatrans Educar para cambiar la mirada* (130-133). Valencia: Edicions Florida

Pathoni, H., Ashyar, R., Maison, M., & Huda, N. (2022). Measuring lecturer's perception in STEM approach based contextual learning implementation. *Journal of Technology and Science Education,* 12(1), 132-146. https://doi.org/10.3926/jotse.1297

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walwerg-Heriksson, H., & Hemmo, V. (2007) Science Education Now: A new pedagogy for the future of Europe. *Report for the European Commission.*

Romero-Bojórquez, L., Utrilla-Quiroz, A., & Utrilla-Quiroz, V.M. (2014). Las actitudes positivas y negativas de los estudiantes en el aprendizaje de las matemáticas, su impacto en la reprobación y la eficiencia terminal. *Ra Ximhai,* 10 (5), 291-319. https://doi.org/10.35197/rx.10.03.e1.2014.20.lr

Sulaeman, N., Efwinda, S., & Putra, P.D.A. (2022). Teacher readiness in STEM education: Voices of Indonesian physics teachers. *Journal of Technology and Science Education,* 12(1), 68-82. https://doi.org/10.3926/jotse.1191

UNESCO (2017). *Cracking the code: girls' and women's education in science, technology, engineering and mathematics (STEM).* UNESCO.

Verdugo-Perona, JJ, Solaz-Portolés, JJ., & Sanjosé-López, V. (2017). El conocimiento didáctico del contenido en ciencias: estado de la cuestión. *Cadernos de Pesquisa,* 47 (164), 586-611. https://doi.org/10.1590/198053143915

Zimmerman, B.J. (2000). Autoeficacia: Un motivo fundamental para aprender. *Psicología Educativa Contemporánea,* 25(1), 82-91.

Zimmerman, B.J., & Campillo, M. (2003). Motivating Self-Regulated Problem Solvers. In Davidson, J.E., & Sternberg, R.J. (Eds.), *The Psychology of Problem Solving* (233-262). Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9780511615771.009

Zollman, A. (2012). Aprendizaje para alfabetización STEM: Alfabetización STEM para aprender. *Ciencias y Matemáticas Escolares,* 112(1), 12-19.

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