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STEAME projects in basic education: validating a competence framework for educators

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1 Introduction

Teacher training, both initial and in-service, must consider all the challenges involved in teaching practice today. It is essential to provide training that enables teachers to understand the complexity of their professional practice and the school context in which they work to perform teaching tasks that respond to students and their demands in cultural, social and employment terms, among others (Vaillant & Manso, 2012).

The most current learning approaches are clearly committed to learner-centred methodologies, which give new roles to both students and teachers. Students become true epistemic agents (Stoupe, 2014), taking active responsibility for the learning processes. Consequently, teachers cease to be merely transmitters of knowledge and become guides and companions in the process of knowledge construction (Trigwell, et al., 1999; Trigwell & Prosser, 1996). Indeed, previous research has highlighted the link between learner-centred teaching and better learning outcomes (Ramsen, 1992; Trigwell et al., 1996). From this perspective, role change requires teachers to engage in continuous development and training to master a wide array of competences.

One of the premises of high-quality teacher education is to identify what competences are needed and how to achieve good performance. For example, in recent years, skills for reflecting on educators' own practice as a way of learning, i.e. a way of learning to learn, have been added to the key competences that teachers should have (Sánchez-Tarazaga & Matarranz, 2022). Specifically in the training of basic education professionals, in recent years curricula have changed to incorporate a variety of teaching methodologies as part of educators' pedagogical training. Among these methodologies is Project Based Learning (hereafter, PBL) (Tempera & Tinoca, 2022).

In some countries, these changes in how educators' professional practices are defined not only have had an impact on teacher education curricula but into regulatory frameworks of public employers. These changes pose a new challenge to teacher education

providers, as expressed in the need to revise their programs to provide training that is consistent with the new educational conceptions and needs. One of the possible strategies for systematising these training needs is through the definition of teacher competence frameworks, which can be useful for teachers to establish their professional learning objectives (Tigelaar et al., 2004).

These frameworks must be adapted to the existence of different teaching profiles and contemporary pedagogical approaches. In this sense, there is an important distinction in the perspective from which competency frameworks are designed: those that focus on teacher behaviour and those aligned with more contemporary learner-centred perspectives (Kember, 1997).

In the STEAME Teacher Academy project (https://steame-academy.eu/), an initiative financially supported by the European Union, a first approach to a framework of interdisciplinary teaching competences was made. The purpose of the study reported in this article is to develop and validate this framework. This framework is valuable because it conveys the understanding of PBL that is shared among most researchers and education professionals. For this reason, it holds potential to be used as a starting point for the integration and assessment of different teaching competences to enable more effective project development in primary and secondary education.

1.1 Integrating disciplines in basic education: STEM, STEAM, STEAME

In addition to changes in the roles of teachers and learners, there is a need to strengthen students' competences in critical thinking, creativity, problem solving and the use of digital technologies in different disciplines, among many others (Land, 2013; Ozkan et al., 2021). These enable them, as citizens, not only to master different disciplines but also to solve problems through reasoning, interpret real situations, make assumptions, design strategies, and verify solutions (Organisation for Economic Cooperation and Development [OECD], 2019).

Science, Technology, Engineering and Mathematics (hereafter, STEM) education originally proposed a model for integrating these disciplines in the curriculum to better prepare students for their future professional development (Ly et al., 2021; Salinger & Zuga, 2009). This notion was later supplemented with an 'A' to highlight the importance of the arts in interdisciplinary learning, thus incorporating studies in language, music, fine arts, etc. In this way, the STEAM approach appeared (Yakman, 2008). From a teaching perspective, STEAM education allows teachers to observe how students put their competences into practice in an interdisciplinary way in different real-life experiences (Benton et al., 2019; Kuure et al., 2010). More recently, the final 'E' has been integrated to reinforce competences linked to entrepreneurship, thus giving way to the new concept: STEAME (Colucci-Gray, 2022; Kovatcheva & Koleva, 2021; Makrides, 2022). The inclusion of entrepreneurship in STEAME distinguishes it from STEAM by embedding entrepreneurial principles that enhance students' problem-solving capabilities and real-world applications of knowledge (Stenard, 2021). This dimension also empowers learners to conceptualize innovative ideas with the skills needed to execute these ideas in practical contexts, thus bringing the gap between theoretical understanding and practical execution. These are critical attributes in today's rapidly evolving job market (Makrides, 2022).

This being said, literature specifically addressing the intersection of entrepreneurship and STEAM remains limited, likely due to the novelty of this framework.

These approaches seek not only to teach knowledge from different disciplines in an integrated way, but focus on the students' learning process, combining knowledge construction and their everyday life (Capraro et al., 2013). Students can understand concepts and processes, make connections between different curricular areas, discuss problems, and eventually apply their proposals to a real-life situation (Chang & Yang, 2013; Ly et al., 2021). For teachers, these approaches imply unique and differentiated practices, being intrinsically different from others because of their interdisciplinary nature (Spyropoulou & Kameas, 2021; Spyropoulou & Kameas, 2024).

1.2 STEAME projects

Previous studies show that the most coherent and successful strategy in the development of STEAME areas is through PBL (Benton et al., 2019; Diego-Mantecón et al., 2021; James, 2016). Students can shape their goals, investigate, and acquire knowledge and skills (Song, 2020), generate new knowledge, and apply it (Druin, 2002) in solving a problem or challenge identified in their specific immediate context (Hawari et al., 2020; Ly et al., 2021).

Project Based Learning has its roots in constructivist approaches to learning, grounded in classical authors such as Piaget and Dewey. It emphasises contextualised, dynamic, interdisciplinary / multidisciplinary / transdisciplinary, collaborative, and student-centred learning (Adriyawati et al., 2020, Quigley et al., 2020a). Thibaut et al. (2018) define 5 dimensions of PBL: content integration, problem based centred, inquiry-based, design-based and cooperative learning.

The integration of STEAME and PBL is closely associated with creativity, ethics, aesthetics, innovation and interculturality (Quigley et al., 2020b; Diego-Mantecón et al., 2021). It allows students to make sense of their learning through the facts of their everyday lives, encouraging motivation to ask questions, explore different ways to find information, design answers and verify them cooperatively (Adriyawati et al., 2020; Kokotsaki et. al., 2016). On the other hand, there seems to be no agreement on the role that teachers should adopt during the development of a STEAME project (Diego-Mantecón et al., 2021). While some consider that projects should be student-driven (Quigley et al., 2020a), others argue that teachers should support the students' process by scaffolding questions (Berardi & Corica, 2021) or guiding collaborative work (Nguyen et al., 2021).

1.3 The STEAME Teacher Facilitators competence framework

The systematisation of teaching practice is essential for quality teacher education (Caena, 2014; Sánchez-Tarazaga & Matarranz, 2022). However, most of the work done to determine interdisciplinary teaching competences concerns higher education professionals. Below we summarize relevant aspects in defining a teachers' competence framework for STEAME projects according to the literature.

In terms of purpose or scope, the recommendations of the European Union (Council of the European Union, 2014) call for the creation of conceptual teaching frameworks that serve both initial and continuing education, that can be transferred between countries and that take into account the diversity of different education systems. In terms

of their structure, they should include: areas, competences, performance levels and descriptors (Spanish Ministry of Education and Vocational Training, 2022).

Regarding educators' competences, they must be organised into cross-cutting areas or areas that correspond to different perspectives on the content or object of the competency framework (Nessipbayeva, 2012; Martínez-Izaguirre et al., 2017; van Werven et al., 2023; Sánchez-Tarazaga & Matarranz, 2022). Furthermore, competences are represented as the interaction between several entities (Sulaiman & Ismail, 2020; Corres et al., 2020; Feng & Holtta-Otto, 2022). The most common formulation is to represent them as an integration between teacher knowledge, skills and attitudes, as promoted by Tigelaar (European Commission, 2013; Caena & Redecker, 2019). In terms of knowledge, existing proposals for educators' competences for interdisciplinary teaching include a combination of content knowledge (CK), pedagogical content knowledge (PCK), and pedagogical knowledge (PK) (Feng & Holtta-Otto, 2022).

All these aspects were taken into account to determine the STEAME Teacher Facilitators competence framework. The framework was organised into 4 areas and 12 competences, as shown in Table 1.

Following recommendations from the literature, each competence was described in terms of knowledge, skills and attitudes, and it was related to learning outcomes for student teachers and service teachers. Furthermore, each competence included actions in which it is manifested, as well as performance levels. For example (Table 2):

2 Method

2.1 Context of the research

The design and validation of the STEAME Teacher Facilitators competence framework was carried out in the context of the STEAME Teacher Facilitators Academy project (https://steame-academy.eu/), which aims to create training academies

Table 1 Initial list of areas and competences of the STEAME Teacher Facilitators competence framework

Area 1: Projects for STEAME, in context
Competences
1. Design and plan STEAME projects
2. Consider formal education standards in STEAME projects
3. Monitoring STEAME projects and reporting
Area 2: PBL as a pedagogical approach to STEAME education
Competences
4. Embed learning in meaningful and authentic STEAME projects
5. Guide student learning in STEAME projects
6. Support STEAME projects with the right learning climate
Area 3: Student agency in STEAME PBL teaching
Competences
7. Involve students in STEAME projects
8. Promote student self-regulation and metacognition in STEAME projects
9. Engage and coach to support learning
Area 4: Sustainability of PBL applied to STEAME
Competences
10. Reflect on performance as a STEAME projects facilitator
11. Apply creativity and innovation in STEAME projects
12. Keep learning about STEAME projects and share the knowledge

Table 2 Example of one competence of the initial version of the framework

Competence 4: Embed learning in meaningful and authentic STEAME projects **Description: To facilitate student learning in and across two or more STEAME subjects through meaningful and authentic projects, supported by appropriate resources.**
Contents of this competence Knowledge • Understanding of core concepts in science, technology, engineering, arts, mathematics, and entrepreneurship • Understanding of the sociocultural context, including cultural norms, values, and local community resources. • Familiarity with technology tools and software relevant to STEAME fields • Knowledge of digital citizenship and online safety, ensuring responsible use of technology resources • Understanding how STEAME areas intersect and relate to one another, allowing for the creation of holistic and integrated projects Skills • Ability to design projects that are culturally responsive, inclusive, and relevant to students' lived experiences. • Ability to leverage technology for research, collaboration, data analysis, and project presentation Attitudes • Genuine interest in exploring new ideas and technologies, leading to innovative project designs. • Willingness to consider diverse perspectives and approaches, allowing for creative solutions and interdisciplinary connections
Actions in which this competence is manifested 1. Plan and design PBL activities that balance disciplines, either quantitatively (2 or more STEAME disciplines) or qualitatively (the importance of each STEAME discipline) 2. Decide, communicate or agree with students about the starting point and expected product of their learning (portfolio, blog, video, poster, service, game…) 3. Engage students in disciplinary practices (act like scientists / artists / engineers / enterpreneurs...) 4. Demonstrate genuine enthusiasm for the subject matter and the learning process, inspiring students to be passionate about their research-like activities and the project as a whole.
Performance levels of this competence Level 1: 1. Integration of at least two STEAME subjects in projects with limited use of appropriate resources as support for student learning 2. Projects show a moderate level of depth and coherence 3. Projects have isolated components of authenticity, but they may not fully engage students in real-world applications Level 2: • Integration of two or more STEAME subjects in projects with sufficient use of appropriate resources as support for student learning • Projects show a high level of depth and coherence • Projects have a certain degree of authenticity, and they partially engage students in real-world applications Level 3: • Integration of four or more STEAME subjects in projects with innovative use of appropriate resources as support for student learning • Projects show a very high level of depth and coherence • Projects have a high level of authenticity, and they fully engage students in real-world applications

throughout Europe for in-service and preservice teachers to learn about and implement STEAME projects in schools. Therefore, the competence framework should enable them to improve their professional practice and teaching skills in this domain. The process of developing the competency framework consisted of 3 phases (Fig. 1):

1. Review of previous projects: a systematic review and analysis of 24 European projects thematically related to teacher education in STEAME projects was carried out. Through a PRISMA diagram we'll outline the steps of project selection, while specifying the inclusion and exclusion criteria as derived from the systematic review:

From this inductive content review (Guba & Lincoln, 1994) three dimensions emerged for consideration: technical and contextual information on the proposals; specific information on the creation of conceptual frameworks for teaching competences; and information for the operationalisation of STEAME areas through PBL.

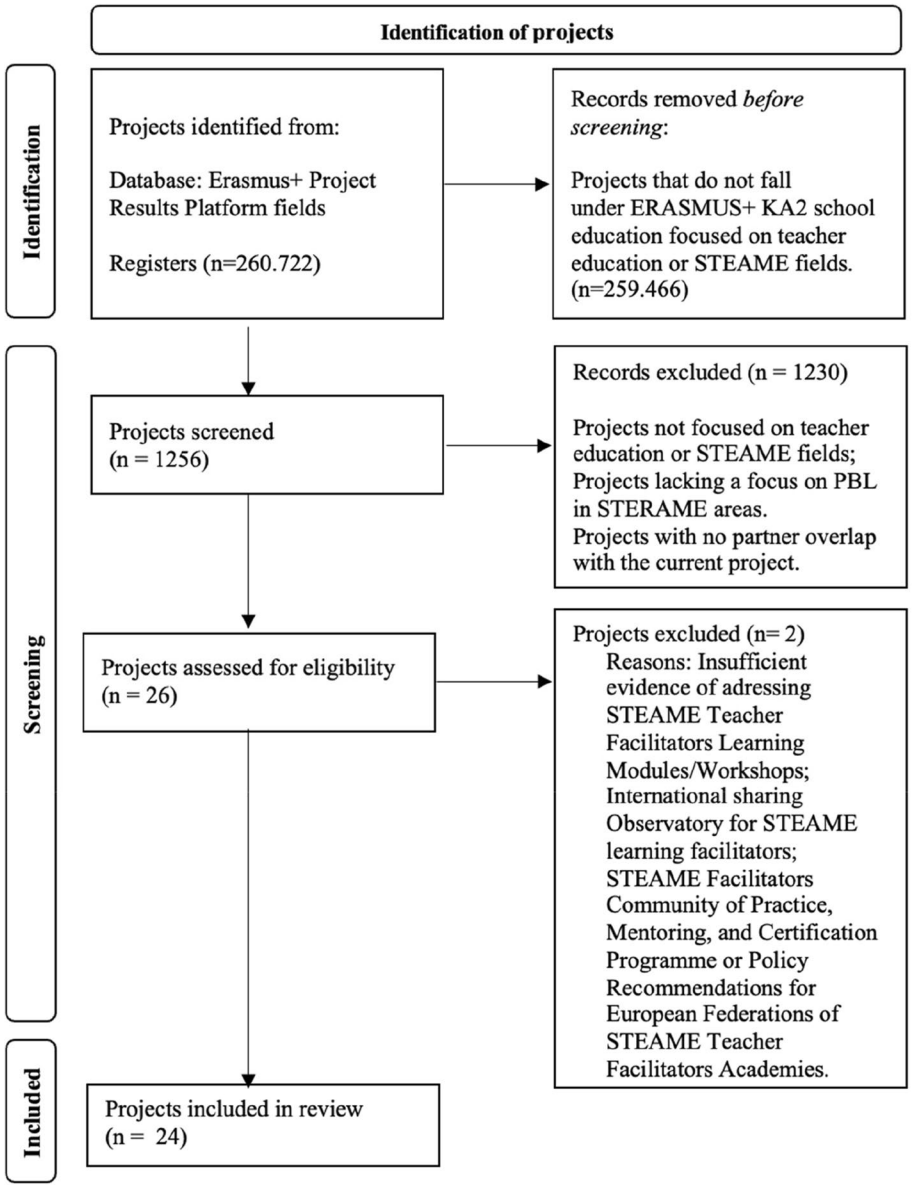

Fig. 1 PRISMA diagram, based on Page et al. (2021)

The review of the results was carried out and validated by academics and experts from 14 European institutions through peer review.

2. Design of the first version of the competency framework: based on the information collected in the first phase, the project team created a first version of the competence framework. This process consisted of two main steps. First, six of the 24 projects were analysed in more detail, as they were found to be the most relevant to the creation of the framework, to the extent that they explicitly propose an approach to STEAM or STEAME teaching. As a result, the groundings of the STEAME teacher competence framework were established, namely: 1. Competences will be organised in groups, which will be referred to as "areas". Areas must be described, discussed and justified. Competence areas must explain how a group of competencies responds to a need in STEAME

projects. 2. Competence areas, as well as the competences defined, must not necessarily correspond to the chronological way to describe the teaching profession (design or plan – deliver – reflect). According to the most recent approaches to teacher education, these three aspects of teaching are increasingly related, therefore calling for another way to describe them. 3. Each competence must have a title, in the form of a noun, noun + adjective. 4. Each competence must have a description in a competence-based way, this is, emphasizing the integration of knowledge, skills and attitudes. 5. Each competence must include a description of the contents (knowledge, skills and attitudes) that play a role in it. 6. Each competence must include specific actions in which this competence is manifested. Actions must be described through action verbs. For example: use, apply, design, consider... 7. Each competence must have a description of the performance levels. 8. The framework will have a maximum of 12 competences. 9. There will be three levels of proficiency. After establishing these criteria, a set of learning outcomes was defined, and the learning outcomes were grouped according to their content. This proposal was discussed at a face-to-face meeting with those who had participated in the process to review the projects. After that, they rated the Learning Outcomes from 1 (not very important) to 5 (very important) through a shared spreadsheet. Once the list of learning outcomes was final, the title and definition of competences and areas emerged. For each competence, the knowledge, skills, dispositions and the definition were made by researchers from the leading institution, thus producing the first version of the competence framework.

3. Validation of the competency framework through focus groups: the first version of the framework was subjected to debate and validation through the Focus Group technique (Kitzinger, 1994; Sánchez-Santamaría & González-Such, 2014), the purpose of which was to obtain coherent information from the discursive production of groups of experts, professionals and stakeholders in the educational field on the proposed competency framework. Based on the contributions from the focus groups, the final proposal for the teaching competency framework for the development of STEAME projects was established.

This research presents the results of the validation process of the competency framework, based on 10 focus groups in 7 European countries, with participants involved in the field of education.

2.2 Research design

A qualitative and interpretative method was applied, through which it was possible to carry out an in-depth study of subjective data regarding the teaching competence framework. It was designed in line with the proposals of Merriam and Tisdell (2016) and Twining, Heller, Nussbaum and Tsai (2017), who recommend this type of methods when the goal is not to reject theories but to interpret the participants' point of view in an inductive manner using qualitative techniques.

More specifically, the teaching competence framework undertook content validation through a focus group discussion system. Gaining expert input in the validation of a competence framework is a usual practice in the European context, in which this study is framed. This is the case, for example, of the competence framework for creative teaching

(Docent Project Consortium, 2018) and the competence framework for STEAM teaching (Spyropoulou & Kameas, 2024).

The focus group technique consists of 'a meeting of a group of individuals selected by the researchers to discuss and elaborate, from personal experience, a topic or social fact that is the subject of research' (Korman, 1986, p.52). Thus, the focus group participants made a qualitative assessment of the proposed competency framework, providing the modifications they considered relevant to improve it (Creswell, 2012).

The following components undertook validation from the focus groups: 1) Areas, 2) Competences, 3) Achievement levels. In order to carry out a systematic (though not closed) exploration of the contributions, a discussion structure was designed for each component of the competency framework according to commonly used criteria described by Carmines and Zeller (1979):

1. Consistency: degree to which each area, competence or level is described coherently and without contradictions.
2. Relevance: degree of appropriateness and relevance of the content of each area, competence or level to the current time, period, or circumstances; of contemporary interest.
3. Sufficiency: the extent to which the content within the same area, competence or level is sufficient to obtain the necessary information.
4. Written explanation/Clarity: the extent to which the area, competence or level, as worded, is not misleading due to grammatical bias and is easily understood.

These dimensions were translated into questions that the focus group moderator/s could ask the participants to promote discussion. For example, to assess the consistency of the competence areas, the question would be "Do you consider that there is a good level of consistency between the competences?".

Structuring the discussion in these four areas allowed each component of the competence framework to be analysed from different perspectives, all of them important in the quality of the framework. The intersection between the competence framework components and the dimensions of analysis constituted a matrix of analysed aspects as shown in Table 3 below.

Methodological decisions have been taken in accordance with the guidelines of The University of Barcelona's Code of Conduct for Research Integrity (2020), especially in respect of honesty, rigor, procedures, methods and conflicts of interest. All the

Table 3 Matrix of relationships between components and dimensions analysed, which constitute the analysed aspects of the competency framework

	a. Consistency	**b. Relevance**	**c. Sufficiency**	**d. Written explanation**
1-Areas	1a. Areas / Consistency	1b. Areas / Relevance	1c. Areas / Sufficiency	1d. Areas / Written explanation
2-Competences	2a. Competences / Consistency	2b. Competences / Relevance	2c. Competences / Sufficiency	2d. Competences / Written explanation
3- Levels	3a. Levels / Consistency	3b. Levels / Relevance	3c. Levels / Sufficiency	3d. Levels / Written explanation

participants gave their informed consent to collaborate in this research study and they agreed to the production of a report of their respective statement. The quotations were anonymized in such a way that do not contain any personal data that might enable the authors of the answers to be identified.

2.3 Participants

The participants of the focus groups responded to different professional profiles, gathering diverse sensitivities and experiences (Hamui-Sutton & Varela-Ruiz, 2013). Following the guidelines of Merton and Kendall (1946), all of them had specific experience around the implementation of STEAME projects, allowing an exchange of experiences and knowledge on the topic under investigation. Based on these criteria, the sample was selected using the convenience sampling technique (Given, 2008), assuring the maximum variation, according to gender, age, country and professional profile (Cohen et al., 2007).

The sample consisted of 111 participants from 7 different countries, namely Cyprus, Portugal, Greece, Romania, Bulgaria, Spain and Belgium. From the total participants, 66 were women and 45 men. In terms of profiles, more than three quarters of the sample were either a) in-service teachers / educators (53,1%) or b) academics (39,6%). The other profiles were represented as follows: c) Education inspector, consultant, pedagogic councellor or teacher trainer (3,6%); and d) education policy makers (3,6%). It is worth noting that 15,9% of the in-service teachers or educators also hold a position as manager, head or department coordinator.

Most focus groups took place face-to-face and a few of them online. The option to do the focus group online enabled us to prioritise the participation of the participants with the right profile, as opposed to those that were available to be in a given place at a given time. The following table (Table 4) details the distribution of participants in the different focus groups:

The maximum level of balance between important characteristics of the focus groups was pursued to ensure maximum validity of the study, given that it relies on the integration of their results (Krueger & Casey, 2014). For example, the average number of participants of the focus groups was 11,1. The majority of focus groups fall within +/- 35% of this number. Only focus group 1 has a substantially bigger number of participants than

Table 4 Focus groups participants and their modality

Focus group no.	Country	Participants	Modality
1	Cyprus	18 participants	Face-to-face
2	Portugal	8 participants	Face-to-face
3	Greece	10 participants	Online
4	Greece	7 participants	Face-to-face
5	Romania	14 participants	Online
6	Romania	9 participants	Online
7	Bulgaria	13 participants	Face-to-face
8	Bulgaria	10 participants	Face-to-face
9	Spain	15 participants	Face-to-face
10	Belgium	7 participants	Face-to-face

the average (+62%). Regarding participant profiles, the aforementioned pattern is in general reproduced across focus groups. Although with significant variation in their percentages, in-service teachers / educators and academics are more broadly represented across the focus groups. Education managers are, in proportion, equally represented in six out of the four focus groups (see Table 5 below).

2.4 Data collection and analysis

2.4.1 First phase: carry out focus groups and report

To conduct the focus groups in a consistent manner, a guide for moderators and rapporteurs was designed. According to this guide, all focus groups followed the same structure: 1) Opening the session (5 minutes); 2) Discussion (90 minutes); and 3) Closing the session (10 minutes). All sessions were recorded with written consent from the participants.

The main part, i.e. Discussion, was split into four sets of discussion items: 2.1) About competence organization into 4 competence areas; 2.2) About the 12 competences; 2.3) About achievement levels defined for each competence; and 2.4) Closing questions. The discussion items included in 2.1, 2.2. and 2.3 assessed the parameters from each of the chosen perspectives, i.e. consistency, relevance, sufficiency, and written explanation.

For the content analysis, each institution responsible for carrying out the focus group coded the contributions, with the intention of grouping the responses in each dimension of validation identified. The starting point was selective coding, in which the data were identified and related to the pre-established dimensions (consistency, relevance, sufficiency, writing), with a certain margin for the incorporation of elements that emerged inductively (Gibbs, 1997). Thus, the analysis involved a process using both inductive and deductive reasoning through researchers' careful examination data (Zhang & Wildemuth, 2017). Different software (*Excel*, and *Atlas-ti*) was used for the analysis.

Data collection took place over a period of eight weeks from December 2023 to January 2024, i.e. the time between the first and the last focus group delivery. Each institution made available to all a focus group report, which included two sections. The first section concerned focus group information, including: date, duration, number of participants, and participants' names and affiliations. The second section concerned the focus group results, i.e. bullet points that emerged from the data collected in the focus group inductively. The results were organised in four sub-sections, i.e. one for each component of the framework. Additionally, quotations from the participants that illustrated the results were provided.

Making the focus group reports available to the others as soon as possible ensured that the data collection and analysis were not separate but continuous, thus improving the quality of the investigation (Krueger & Casey, 2014). This includes the possibility to make up for topics that have not been covered in sufficient detail, or the chance to formulate a question in a different way, among other advantages.

2.4.2 Second phase: integrating results from reports

Once all focus groups had been carried out and their reports delivered, the meta-analysis started. This step consisted of applying content analysis to these results. According to Janis' (1965) classification, the study deployed semantic content analysis

Table 5 Representation of each profile by across the 10 focus groups

Profile	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10
In-service teacher / Educator	33.3%	38.5%	30.0%	50.0%	88.9%	25.0%	20.0%	100%	50.0%	57.1%
Manager	8.3%	7.7%	10.0%	0%	0%	8.3%	6.7%	0%	0%	28.6%
Academic	50.0%	38.5%	50.0%	50.0%	11.1%	50.0%	73.3%	0%	40.0%	14.3%
Policy Maker	0%	7.7%	10.0%	0%	0%	16.7%	0%	0%	0%	0%
Other	8.3%	7.7%	0%	0%	0%	0%	0%	0%	10.0%	0%

in its form of attribution analysis, to the extent that we investigated how the different analysed aspects of the framework were characterised or described in a certain way (Stewart & Shamdasani, 2014). To that goal, an inductive process was followed and iterated until reaching data saturation (Guba & Lincoln, 1994).

The meta-analysis was carried in an iterative way until the research team reached an intersubjective agreement on the interpretations (Cohen et al., 2007). More specifically, the results that were common in six or more of the focus groups were considered as *main result*, the results found in five focus groups were considered *secondary result.* Last, the results that are true in three or more (up to five) focus groups were considered as *other results*. This process was supported by CAQDAS software (*Excel, Atlas-ti*)

3 Results

The results obtained according to the validation by the focus groups are described below.

The first finding to emerge from the analysis is that the aspects of the framework that obtained most results were the areas and the competences, when analysed from the point of view of relevance (see Table 6). Together, they represent almost half of the total number of results reported in the focus groups.

When analysing the content of the focus group reports, the second finding to emerge is the prevalence of positive results, within each focus group, and for each of the components of the framework. This suggests that, in general, the framework has been validated. Specifically, the 'Areas' component of the competency framework is the most clearly validated, with an average of 77% of the results from the 10 focus groups being positive. In second place is the 'levels' component, which received 73% positive results out of the total number of results. In last place was the 'competences' component, which received, overall, the lowest percentage of positive results (Table 7).

Table 6 Number of results received for each of the analysed aspects of the competence framework

	Number of results received by FG										TOTAL
Analysed aspect	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1a. Areas / Consistency	1	6	2	2	1	1	1	1	2	2	19
1b. Areas / Relevance	2	9	18	5	4	3	2	2	4	5	**54**
1c. Areas / Sufficiency	1	3	1	2	1	1	1	1	0	2	13
1d. Areas / Written explanation	1	1	1	1	1	1	1	1	1	0	9
2a. Competences / Consistency	1	4	1	1	1	1	1	3	1	1	15
2b. Competences / Relevance	4	12	10	2	2	4	5	3	5	5	**52**
2c. Competences / Sufficiency	1	1	1	1	1	1	1	1	0	3	11
2d. Competences / Written explanation	1	4	1	1	1	1	3	0	0	0	12
3a. Levels of achievement / Consistency	1	5	7	1	1	0	1	1	1	3	21
3b. Levels of achievement / Relevance	0	2	1	1	1	1	1	1	1	2	11
3c. Levels of achievement / Sufficiency	0	2	1	1	1	1	1	1	1	1	10
3d. Levels of achievement / Written explanation	0	5	1	1	1	0	0	0	1	0	9

Table 7 Positive results for components of the CF with respect to the total

FG/ CF component	1	2	3	4	5	6	7	8	9	10	Avg.
1. Areas	60%	47%	73%	80%	100%	100%	80%	100%	71%	56%	**77%**
2. Competences	43%	33%	62%	80%	80%	71%	50%	57%	83%	89%	**65%**
3. Levels	0%	36%	60%	100%	100%	50%	100%	100%	100%	83%	**73%**

3.1 Results regarding the competence areas

As mentioned above, the structure of the competence framework in four areas, as well as the content of the areas, were overall validated. Specifically, in all but one focus group, the positive comments represent between 56 and 100%, reaching 100% in three of them.

More specifically, participants in 7 of the 10 focus groups were unanimous in their views on the consistency of the four areas. They remarked on a good balance between the areas, they noticed that the information is well organised, well defined, with a clear structure, that can be easily understood and implemented, and no logical contradictions were identified. The most frequently used reasoning to support this claim was the holistic character of the set of competence areas, the ease of understanding and their applied nature, the latter often articulated in the concept of sustainability. For example, as expressed in focus group 5, "These areas of competencies are well organised, with a clear structure and can be easily implemented" (FG5, P1). Someone else said, "The way the competences have been organised is comprehensive, well-structured and reflects a good approach as it focuses on the learner, the teacher, the process, and sustainability" (FG5, P1). Participants from the focus group 8 felt that the areas appeared to be concentrated on encouraging significant issues and sustainability in education, which was thought to be very positive. "The way the areas are written is accessible, easy to understand and it is likely to be applied into schools" (FG5, P3) stated a participant from focus group 5.

Another outcome agreed upon by seven focus groups is that there is no need to remove any of the existing areas, as each plays a key role in the overall implementation of PBL in STEAME education. More specifically, in 6 focus groups participants agreed that all four areas covered by the framework are equally relevant. According to data from focus group 4, these areas play a major role in the development of STEAME education, design, learning, performance evaluation, and artistic activities for the future.

This being said, ideas to improve the competence areas have also been extracted from the analysis of the focus groups, as follows. The most pressing concern, as it appeared in at least three focus groups, was a confusion where area 1 was thought to refer to the design of STEAME projects and area 2 to the implementation of STEAME projects, whereas the framework is not conceived as a chronological process but transversal. Participants from focus group 5 agreed that "area 1 and 2 should be swapped: perhaps area 2 can be first because the pedagogical approach can influence competences mentioned in area 1". (FG5, P5), while in focus group 9 it was suggested that just the names of Area 1 and 2 should be swapped to avoid confusion. Participants in focus group 7 discussed this issue in terms of the written explanation of the areas. They agreed that Areas 1 and 2 should be written in a similar way as areas 3 and 4: "Maybe the areas could follow a logic or coherence: for instance, the first could be 'contextualization in the STEAME projects', i.e. using a noun like in areas 3 and 4" (FG7, P13).

3.2 Results regarding the competences

As mentioned above, the 12 competences that make up this framework were validated with an average of 65% positive results among the focus groups. In 8 of the 10 focus groups, positive comments on the competences represent 50% or more. More specifically, data from 7 focus groups supports that the competence list is comprehensive, well designed, relevant, and clearly written. In the words of two participants from focus group 5: "The competences presented holistically integrate knowledge, skills and attitudes, which is good." (FG5, P1), and "This competency approach allows STEAME teacher training to be delivered in an accessible way." (FG5, P5). Also, in 7 focus groups participants agreed that there was no need to remove any competence. In six focus groups a very good level of consistency among the competences was found, this is to say, no logical contradictions among them. As expressed by one participant: "[The competences] reveal a correct sequence (...) because there it is, the introduction to the methodological part that has to do with the teacher, then the last 2 have to do with students and the relationship between teacher and student and the stimulus that can develop the project. Therefore, I think it is extremely consistent and with a very well-organized timeline" (FG2, P6).

The next result, also backed up by data from six focus groups, is a suggestion. It was made clear that student assessment should be more present in the competences. In a few of these countries, assessment is understood as the collection of information about student performance in STEAME projects. For example, in focus groups 1 and 2 participants mentioned that the evaluation that teachers do is not clear because there are no evaluation methods for STEAME. In other countries, there is a need to include assessment in the framework in a broader way. In focus group 7, for instance, participant 14 states that "It is not the same to assess the design of a STEAME project than to assess student learning" (FG7, P14). Similarly, according to the results from focus group 8, "Teachers need competences to tell to what extent a STEAME project is good (quality criteria)" (FG8, P1).

A common suggestion, i.e., true in six of the ten focus groups, was to emphasise more the skills that would lead teachers to motivate or engage students in STEAME projects. In focus group 1, participants suggested "to include teachers' ability to manage students who are not interested, who are indifferent. In other words, those students who are there because of the parent's choice, not their own. Students need motivation" (FG1, P6). This is also true for focus group 6, where it was suggested to include gamification as part of competence 7. In focus group 7, fostering student motivation is especially needed, as not always the teacher who implements a STEAME project is the one who designed it. As expressed by Participant 11: "In our schools projects are designed by some teachers and implemented by others. Those who implement them need skills to maintain student engagement and motivation in projects they have not designed themselves" (FG7, P11). In focus group 9, participants mentioned that teachers should develop competences to identify stronger students and have them support weaker students, and it was observed that Competence 5 can be included in other competences, for example competence 6.

In three countries there was an explicit mention to the lack of technology use in the framework. In participants' opinion, technology is present in almost all dimensions of basic education teachers' profession: the curriculum, the teaching methodologies, the

assessment standards, etc. For this reason, they believe they should be more present in the framework. In the words of Participant 14 from focus group 7, technology should be included in the STEAME teacher competence framework because "The very word STEAME includes the T for technology, and the DigCompEdu framework itself says that teachers need to be able to transfer their digital competences to students" (FG7, P14). As expressed by another participant: "The framework should highlight the importance of teachers ICT skills in STEAME education as well. It is already stated but it needs to be more emphasized" (FG3, P3).

Also in three countries the need to clarify the definition of PBL in the framework was expressed. In focus group 6, participants expressed this need in the following terms: "a lot of experts cannot make the difference between PBL and Project Oriented Learning. So, in the first place, we need a standard for the way of teaching STEAME." (FG6, P5). Similarly, participants from the focus group 8 believe that a clearer definition of the integration of Art, Entrepreneurship and Mathematics in STEAME projects is needed in the framework. Participants also express the need "to properly define what a good STEAME project should meet (...). Even clearer criteria are needed" (FG8, P1). In focus group 7, this discussion spined around the design of the STEAME projects: In the words of Participant 5: "Integration is one of the biggest challenges: who leads the project? If STEAM is already complex because the science teacher may not know about the nature of science, now they need to know about arts or even entrepreneurship. Teachers may think we are asking them to do unclear things unless we make clear what we mean by interdisciplinarity" (FG7, P5). This participant also stated that "This also applies to assessment: It doesn't make sense that I have one rubric and you have another one, we need to be able to create joint rubrics for true interdisciplinary teaching to happen" (FG7, P5).

3.3 Results regarding the achievement levels

Similar to the previous components, participants of the focus groups were asked to provide their opinion and feedback on the achievement levels proposed in the competence framework. This included assessing the different levels of attainment of the competences, the addition or removal of one or more levels, and the way that these levels are written.

The highest level of unanimity was showcased regarding the sufficiency of the levels, as expressed in the removal or addition of one or more levels of achievement of a competence. In all the focus groups it was made clear that there is no need to add or remove any of the existing levels as presented, and that the three-level approach (beginner, intermediate, expert) is appropriate for the circumstances. In 6 focus groups participants completely agreed with the present levels of achievements, with some of their comments being that "there is nothing that I can think of to suggest in order to improve" (FG5, P5), and 3 levels - beginner, intermediate and advanced is a good and popular system for assessing competences (FG6, P1).

Unanimity was also reached regarding how the achievement levels are written. Participants from all focus groups expressed their opinion in favour of the proposed way of presenting the levels and in four of them participants did not raise any objection, and when asked did not propose any changes. Some of the comments in favour of the current writing of the levels of achievements were that "the writing is clear and it facilitates

the understanding of the differences in attainment regarding each competence" (FG 5, P2), and that "it is good what was mentioned about the mistakes, that they are seen as a normal part of the learning and an opportunity to reconsider the whole process" (FG5, P8).

The third result is that in five focus groups (Greece, Romania, Spain, Belgium, Romania2) the levels of achievement of the STEAME Teacher competence framework are relevant, i.e. appropriate to the current time, period, or circumstances. In four focus groups (Bulgaria, Greece, Cyprus, Belgium), the experts not only agreed but further elaborated on why the chosen approach to levels of competence is appropriate. Some comments relating to the previous statement were that "It's clear that the levels are well thought - out and well developed." and "the levels of attainment are carefully developed and that would help me as a teacher to better do my job" (FG5, P2). Another participant said that "they sound realistic, and the way they have been formulated is in line with the progressive stages encountered in practice" (FG5, P7). Similarly, someone expressed that the achievement levels are "good, they have a good structure and good differentiation", and that they are "clearly written" (FG3, P1).

Next, in three focus groups an imbalance was found between the knowledge and skills expected at Level 1, which was deemed too low, and the difficulty of achievement at Level 3, seen as too high. Some of the comments supporting this claim are that "In general there are 3 levels, but some competences have 5 levels (...) 5 levels are already a lot (...) keeping 3 is enough" (FG2, P2).

4 Discussion

Our study led to validating the STEAME Teacher Facilitators' competence framework with a high degree of confidence from all the dimensions analysed, i.e. relevance, sufficiency, and written explanation of the areas, competences, and levels of attainment. This confirms that organising a teacher competence framework in areas, competences and achievement levels is appropriate to operationalize teachers' professional practice not only in domains such as educator's digital competences (Redecker & Punie, 2017), but for the specific case of STEAME projects.

Moreover, our research showed that a total of 12 competences is perceived as sufficient to represent educators' professional practice for STEAME projects. This finding contrasts with other competence frameworks for similar domains, such as Spyropoulou and Kameas's STEAM Competence Framework for Educators (2024), which is composed of 44 competences. What is more, as expressed in educational research and policy, one of the roles of educators' competence frameworks is to bridge different dimensions of teachers' professional practice, including determining learning outcomes for teacher education programmes and professional development needs (Tigelaar et al., 2004; European Commission, 2013). Considering that participants in this consultation process belong to profiles that represent these different dimensions, the fact that the STEAME Teacher Facilitators' competence framework was, in general, well received constitutes proof that it successfully meets this need.

In terms of the content of the focus groups, the relevance of the competence areas and of the competences themselves were the most discussed aspects. This is to say, the degree of adequation and pertinence to the current time, period, or circumstances; their

contemporary interest. Compared to sufficiency or written explanation, i.e. the other points of view from which the components of the framework were analysed, relevance is most related to the content or, in other words, to the operationalization of the component. The higher number of results in these dimensions confirms that the concept STEAME is still under construction, as opposed to others that may be more known such as STEM or STEAM, as expressed in the literature (Colucci-Gray, 2022). Similarly, our study revealed the need for a clearer definition of PBL in the framework. This result reassures the recommendation for educators' competence frameworks that "rely on clear statements of the underlying educational philosophy" (European Commission, 2013).

Next, although they obtained sufficient positive results to consider that they are validated, competences received significantly fewer positive results than areas or levels. This finding confirms the difficulty to formulate educators' competences at the current time, where a broad range of visions and guidelines coexist. More specifically, due to the plurinational, pluri-cultural nature of the combination of focus groups, our research reinforces the statement that "The process of defining and reaching agreement on teachers' professional competences is not simple or straightforward, neutral or universal, but culturally bound and subject to change or contestation" (Caena & Redecker, 2019; p. 360).

Structuring the competences of the framework in 4 areas that are transversal to STEAME projects (1. Projects for STEAME, in context; 2. PBL as a pedagogical approach to STEAME education, 3. Student agency in STEAME PBL teaching; and 4. Sustainability of PBL applied to STEAME) was revealed to be a strength of this framework. This result breaks with previous conceptions of teachers' professional practice and contributes to anchoring a new way of organising competence frameworks, which is already used in frameworks such as DigCompEdu. What is more, our research proved that these areas sufficiently represent all the dimensions of teachers' practice involved in effective STEAME project delivery. As it turns out, these areas are in line with the framework for STEAM educators (Spyropoulou & Kameas, 2024). In this way, this study constitutes evidence that the STEAM and STEAME approaches are grounded on similar premises when it comes to educators' competences. Seeing that these areas cover teachers multi-faceted roles, attitudes for reflection and analysis of practice, innovation and collaboration, this result aligns the STEAME Competence Framework with the requirements for designing and implementing teacher competence frameworks in Europe (Caena & Redecker, 2019).

Regarding the competences, our research highlighted the need to make student assessment more present in the competences. This finding is similar to those from previous attempts to determine educators' competences, such as the case for STEAM by Spyropoulou and Kameas (2024), where all competences in the area "Feedback and assessment" had to be modified after consultation. It also constitues support for recent research about basic education teachers' lack of skills in assessment in PBL (Yasa & Asril, 2023).

Further, our study demonstrated the need to emphasize teachers' competences to motivate students towards learning. Hence, it suggests that in the case of STEAME, PBL emphasises contextualised, dynamic, interdisciplinary / multidisciplinary / transdisciplinary, collaborative and student-centred learning (Adriyawati et al., 2020; Quigley et al., 2020a). This outcome also suggests that the framework is aligned with the pedagogical

groundings of PBL, which put the learner at the centre and the teacher as guide and companion (Stoupe, 2014; Trigwell et al., 1999; Trigwell & Prosser, 1996). Further, the emphasis on teachers' ability to engage students in projects confirms that STEAME projects, to the extent that involve interaction between different disciplines, concern teachers' Content Knowledge (CK) but also their Pedagogical Content Knowledge (PCK), to the extent that they must a) know about the disciplinary areas that interact in a project, but also b) know how to teach each of these contents to a specific group of students (Feng & Holtta-Otto, 2022). Additionally, earlier in this article the two opposed views towards PBL in the literature were presented, depending on the degree of guidance provided by teachers. In this regard, our finding towards the importance of motivating students towards learning in STEAME projects constitutes evidence that the vision where teachers support students' learning process prevails (Berardi & Corica, 2021; Nguyen et al., 2021).

Last, it is also worth highlighting that as a result of the consultation process, the need to further stress teachers' management of technologies for learning emerged. This is consistent with the STEAM educators' competence framework proposed in the work by Spyropoulou and Kameas (2024), where the area "Digital skills" is the one with the highest number of competences of the whole framework. It also reinforces the assertions that put teachers' digital competences as a priority and transversal to their professional practice (Caena & Redecker, 2019).

5 Conclusions

Our study succeeded in assessing the validity of the first version of the STEAME Teacher Facilitators competence framework, as expressed by analysing its components (areas, competences, and achievement levels) from four perspectives (consistency, relevance, sufficiency, and written explanation). As shown by a majority of positive comments for all three components, we consider that the framework has been validated.

More specifically, the results about the four competence areas were encouraging. Most participants agreed with the Competence Framework's structure and commended its organization. They found each area relevant, coherent, and clearly written, and enhancing comprehension. The findings related to competences indicated that, in over half of the countries, the set of 12 competences was viewed as relevant, consistent, and well-articulated. There were no significant disagreements or differences between the project's proposed perspective about levels of achievement and that of the experts in the focus groups. Participants mainly agreed with the proposed approach and suggested improvements or minor changes that would overall enhance the final competence framework.

Considering the similarities between the STEAME teacher facilitators' competence framework and the most recent conceptualization of educators' STEAM competences, this study also provided evidence supporting that the STEAM and STEAME approaches are grounded on similar premises when it comes to educators' competences. This includes strong similarities in the definition of the areas and competences, as well as the importance of certain aspects such as teachers' abilities to design and carry out effective assessment, and using technologies for learning. All the while, our research

demonstrated that a shorter list of competencies can still effectively convey teachers' professional practice regarding STEAME projects.

Another key contribution of this study is the discussion generated by certain competences of the framework, especially when assessed from the point of view of relevance, this is, their content or meaning. This constitutes empirical proof that any educators' competence framework must be grounded in strong conceptual foundations, as already expressed by the European Union. In the specific case of PBL this study confirms that the student must be the center of the learning process. However, it was suggested that the teacher has a leading role in guiding student learning, as opposed to approaches that conceive projects as intrinsically student driven. This confirms, also, that different types of teacher knowledge play a role in this teaching approach, including pedagogical content knowledge (PCK), which concerns teachers' abilities to teach specific contents to a specific group of students.

Furthermore, the study paved the way for releasing a new version of the framework, based on the suggestions received. Most comments focused on potential enhancements or additions to the areas, as well as suggestions for refining the framework's written version. Common suggestions across several countries included incorporating technology throughout the framework, clarifying the integration of STEAME subjects in PBL, and placing more emphasis on assessing projects and student learning within them. These suggestions primarily concerned the approach to levels of achievement and consistency among them.

The new version of the framework will be supported by the methodological choices of the present study, including the profile of the experts, number of participants, quantity and quality of the insight gained. Moreover, it will be piloted with preservice and in-service teachers in the context of the STEAME Teacher Facilitators Academy project (https://steame-academy.eu/), which will represent new opportunities for research in this direction.

This study is also an example of successful collaborative research, as it involved 10 institutions from 7 countries. In this regard, it also has limitations. One of them could be the differences between groups in terms, for example, of having different facilitators in each focus group, and in data analysis, to the extent that each organisation responsible for a focus group not only carried it out but analysed it and produced a report. In this regard, we believe that the focus group quick guide and the reporting template, as well as frequent communication between the leading organisation and the others minimized the effect of these limitations. Moreover, all the organisations involved have experience in carrying out qualitative research.

Considering the implications of this study, we strongly believe that defining teachers' professional practices for STEAME projects is useful to develop knowledge about this teaching approach. From characterising teachers' practice to developing and assessing the impact of professional development, including the effect of teacher knowledge, beliefs or other aspects in practising STEAME projects, this framework can support invaluable research that can help to maintain and sustain STEAME projects as an effective educational practice.

Moreover, this study holds value to the extent that it can impact different educational agents and processes. By providing the first systematic attempt to operationalize

educators' competences for STEAME projects, it better equips teachers to carry them out in the classroom. Further, the framework can be a tool for teachers to determine their own performance in this teaching approach and reflect on it and even encourage their choices in professional development towards this direction. For teacher employers, the framework can be used as a reference to determine teachers' performance, knowledge, skills or attitudes in relation to STEAME projects. This framework can also be useful for national policy makers, as a support in possible attempts to promote interdisciplinary or PBL. More specifically, the areas or the competences can guide initiatives such as offering support, training, exchange spaces or resources for teachers and / or school managers.

Teacher education providers, in turn, may use this framework to support training activities, programmes or update their curriculum according to this framework. Although each teacher education provider is free to determine their own process to develop training, we consider that the European nature of this framework may encourage national or regional teacher education providers to follow this path, as it has been the case for other educational innovations. Moreover, the framework may encourage teacher training actions that represent collaboration between member countries, thus promoting knowledge exchange and mobility in education in Europe, which is an objective of the European Union.

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Authors' contributions
Both SAD and NMC participated in the research design, the data collection and the analysis. SAD made a first draft of the manuscript, and NMC made substantial contributions to it. Both SAD and NMC participated in revisions leading to producing the final manuscript. All authors read and approved the final manuscript.

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Data availability
The data can be made available upon reasonable request.

Declarations

Ethics approval and consent to participate
This study follows the guidelines of the Code of Good Practice in Research of the University of Barcelona (2020), especially in respect of honesty, rigor, procedures, methods and conflicts of interest.
Informed consent for participation was obtained from all individual participants included in the study.

Consent for publication
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