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Academic debate as a STEAM competences' learning strategy

El debate académico como estrategia de aprendizaje de competencias STEAM

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Abstract

The STEAM approach (Science, Technology, Engineering, Arts & Mathematics) has remained largely absent from fields such as educational sciences. However, its integration is essential, given its influence on the education of future generations and the high proportion of women in these fields. This study aims to contribute to this end by focusing on the training of future teachers through digital literacy and educommunication, using the methodology of academic debate. A qualitative methodology based on action research was employed, implemented in a teaching innovation project carried out across three university campuses, involving six lecturers and nine subjects. Data were collected through four focus groups with students and systematic observation by the lecturers. The analysis enabled the identification of learning outcomes, skills and dispositions among the students.
The results show a high level of student motivation, a significant improvement in communication skills, critical thinking, digital literacy, and approach to STEAM, as well as a positive assessment of debate as an active learning strategy. It is concluded that academic debate constitutes an effective and transferable methodology for the acquisition of STEAM skills in educational qualifications, with potential that remains underutilised in higher education and relevant implications for teacher training and pedagogical innovation.

Keywords: academic debate, pedagogical innovation, STEAM, digital literacy, teacher training, higher education.

Resumen

El enfoque STEAM (Science, Technology, Engineering, Arts & Mathematics) ha permanecido alejado de ámbitos como las ciencias de la educación. Sin embargo, resulta fundamental su incorporación, dada su influencia en la formación de futuras generaciones y su fuerte feminización. Este estudio pretende contribuir al desarrollo de la formación del profesorado mediante la alfabetización digital y la educomunicación, empleando para ello la metodología del debate académico. Se utilizó una metodología cualitativa basada en investigación-acción, implementada en un proyecto de innovación docente desarrollado en tres campus universitarios, con la participación de seis docentes y nueve materias. Los datos fueron recabados a través de cuatro grupos de discusión con estudiantes y observación sistemática por parte de los docentes. El análisis permitió identificar aprendizajes, competencias y predisposiciones en los estudiantes.
Los resultados evidencian un alto nivel de motivación del alumnado, una mejora significativa en habilidades comunicativas, pensamiento crítico, alfabetización digital y aproximación al ámbito STEAM, así como una valoración positiva del debate como estrategia de aprendizaje activo. Se concluye que el debate académico constituye una metodología eficaz y transferible para la adquisición de competencias STEAM en titulaciones educativas, con un potencial aún infrautilizado en la educación superior y con relevantes implicaciones para la formación docente y la innovación pedagógica.

Palabras clave: debate académico, innovación pedagógica, STEAM, alfabetización digital, formación docente, educación superior.

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1. Introduction

The contemporary educational landscape poses a multitude of challenges for higher education in general and for initial teacher training in particular. Among these challenges is the pressing need to incorporate pedagogical approaches that foster the development of scientific, technological, communicative, and critical competencies within educational domains traditionally dissociated from the STEAM (Science, Technology, Engineering, Arts, and Mathematics) field.

Contrary to common public perceptions, the STEAM approach is not confined solely to disciplines associated with the experimental sciences; rather, it is highly relevant in fields such as education, where the competency-based training of future educators directly influences the quality, equity, and trajectory of educational systems.

At the beginning of the century, the European Commission's report on science education warned of a progressive decline in student interest in scientific disciplines—a persistent trend corroborated by subsequent studies, such as that of Ospina (2018). Nonetheless, the majority of research has focused on pre-university levels or specialized science degree programs, leaving initial teacher training and the specific methodologies used to introduce the STEAM framework to pre-service teachers comparatively understudied.

The progressive digitization of society has catalyzed the emergence of new processes, systems, challenges, and societal demands. Faced with this rapid transformation, higher education institutions must design and implement curricula that go beyond merely satisfying digital requirements, actively fostering a critical and reflective disposition toward technology. In this regard, university programs within the education sector bear an even greater societal responsibility, as they train the future educators who will directly shape the learning experiences and digital citizenship of forthcoming generations.

Media and digital literacy have become an essential requirement across all demographics, albeit necessitating contextual adaptations based on age, needs, and baseline knowledge. The COVID-19 pandemic marked a critical turning point in remote work, exposing widespread systemic deficiencies in digital competencies (Salaverría et al., 2020) at the macro-social level, the meso level (educational institutions), and the micro-individual level. Crucially, these needs extended beyond basic functional digital literacy, revealing severe deficits in essential soft skills and critical thinking capabilities (Pérez, 2022).

Under these premises, the STEAM framework is intrinsically linked to the acquisition of key competencies—such as digital literacy, the critical analysis of information, complex problem-solving, applied creativity, and effective communication—all of which are foundational to the field of edu-communication. This interrelationship reinforces the interdisciplinary essence of the STEAM approach, successfully integrating technological, cognitive, and social dimensions into teaching and learning processes.

However, this theoretical consensus is not yet reflected in the empirical literature. There remains a scarcity of systematic studies that integrate media literacy, the STEAM framework, and active learning methodologies within initial teacher education. More specifically, very few empirical works explore academic debate as an intentional pedagogical strategy in teacher training programs. This gap is particularly notable given the documented potential of debate to foster structured argumentation, critical reflection, and cooperative learning—competencies that are highly relevant to professional teaching practice.

Grounded in these literature gaps, this study addresses the historically weak integration of STEAM competencies within initial teacher education when utilizing active and reflective methodologies. This issue is particularly pronounced in female-dominated degree programs, which have historically experienced greater distance from scientific and technological fields. Recognizing these systemic shortcomings, the investigation defines its core research problem around the insufficient integration of STEAM competencies through active, reflective pedagogical frameworks—specifically within female-dominated education majors traditionally alienated from scientific-technological domains. Within this structural framework, the main objective is to analyze the potential of academic debate as an innovative methodology for developing STEAM competencies in undergraduate education students. More

specifically, the study aims to examine the extent to which this interactive strategy contributes to the development of critical thinking, media and digital literacy, communication skills, and a critical, reflective approach to the STEAM field itself.

1.1 Challenges and Responses from Universities in the Current Context

This study is grounded in the premise that higher education, both in Spain and globally, is currently navigating a rapidly shifting landscape shaped by intensive social and technological transformations. This context necessitates a fundamental rethinking of university education; it is no longer merely a matter of transmitting specialized content, but rather of fostering the development of core competencies that enable students to critically interpret reality and thrive in highly dynamic environments.

Hernández-Serrano and Muñoz-Rodríguez (2020) highlight a pervasive lack of interest among secondary school students in science, technology, engineering, art, and mathematics (STEAM) disciplines, suggesting that a main explanatory factor is the persistence of traditional teaching methods characterized by teacher-centered, lecture-style dynamics. This finding is particularly critical for initial teacher education, as it underscores the urgent need to overhaul the pedagogical methodologies used at the university level if the goal is to transform future classroom practices.

This line of research demonstrates the suitability of employing innovative methodologies aligned with STEAM themes. Indeed, recent empirical experiences offer new instructional models with excellent results in disciplines such as mathematics (Ledezma et al., 2024).

The educational sector's interest in digital communication and the development of critical skills is not a recent phenomenon. In the late 1970s, the educommunication approach emerged under the aegis of UNESCO, recognizing media as active agents in the processes of content creation and perception. According to Aguaded et al. (2022), the main function of educommunication is to promote a more critical and active citizenry, thereby enabling democratic participation and independent thought. Along these lines, Van Dijck (2016) emphasizes the necessity of cultivating the habit of questioning received information within the "culture of connectivity," as well as recognizing the inherent lack of neutrality in mass media, social networks, and individual digital actors. Educommunication provides essential tools to understand and mitigate the risks of transmedia production by fostering reflection and self-critical thinking at both individual and collective levels (Kaplún, 2010). The implementation of this project links these analytical tools to the critical evaluation of diverse information sources, reflection on the responsible use of digital environments in the face of widespread disinformation, and the acquisition of competencies for the ethical consumption and production of information.

Precedents indicate that education provides democratic environments conducive to fostering a critical attitude and an awareness of the consequences of consuming digital services and information, as well as the systemic risks posed by the most harmful dimensions of disinformation and hate speech (Morales-Romo et al., 2023). This educommunicative potential is further highlighted by Coe and Yeung (2019), who focus on the cultural production of educational systems and their complex relationship with economic and cultural markets.

The intersection between educommunication and STEAM has been previously explored in works such as those by Mateo and Arroyo (2020) and Diego-Mantecón et al. (2021). However, the gaps identified in the literature highlight the importance of intensifying efforts aimed at integrating educommunication directly into STEAM learning processes. In this vein, we propose strengthening the implementation of active methodologies that foster the development of key competencies (Peña-Acuña, 2022; Marcos Salas et al., 2020), in alignment with the recommendations of international organizations such as the OECD (2023). Nevertheless, these proposals are not always explicitly linked to the STEAM framework or to media literacy, which curtails their overall educational impact. Integrating educommunication into STEAM learning allows students not only to master scientific content but also to critically analyze its media representations, societal applications, and ethical consequences.

1.2 Gender Gap and STEAM

There is a wealth of studies and empirical data confirming that women are significantly underrepresented in STEAM degree programs (Sáinz, 2017; Reinking and Martin, 2018). The motivations driving the choice of a specific college major are neither simple nor straightforward. Akosah-Twumasi et al. (2018) analyzed 30 studies on this topic and identified three clusters of key factors influencing this decision: intrinsic (personal characteristics, expectations), extrinsic (expected salary, prestige, job quality), and interpersonal (influences from family, peer groups, and educators). For their part, Rodríguez-Muñiz et al. (2019) focused on the interplay between intrinsic and extrinsic factors, emphasizing the greater relative influence of the former.

In stark contrast to the pronounced male dominance in STEAM disciplines (Tellhed et al., 2017), studies in education reveal a strong female dominance, which intensifies at lower educational levels. This phenomenon represents a form of horizontal segregation in education with far-reaching social impacts. This division not only shapes academic and professional trajectories but also directly affects how scientific knowledge is transmitted and legitimized within the educational system.

Consequently, there is a clear access gap for women in STEAM degree programs. Furthermore, various studies indicate that women who pursue STEAM careers face distinct obstacles, such as a lack of female role models, implicit gender biases, and persistent workplace inequalities (Botella et al., 2019), which collectively discourage other women from entering these fields. These dynamics reinforce the urgent need to intervene, beginning with initial teacher education, which serves as a strategic avenue for deconstructing stereotypes and fostering an inclusive scientific culture.

Another major contributing factor is the persistence of gender roles and stereotypes. According to Jackson et al. (2014), men are more likely to endorse stereotypes regarding women in STEAM fields, suggesting that these biased perceptions negatively impact women's education, labor market entry, career advancement, and job stability within these domains. Beyond strictly educational and occupational realms, gender gaps and educational differences remain a constant issue when examining other factors, such as digital environments. For instance, an analysis of YouTube channels dedicated to scientific content related to STEAM disciplines identified 391 channels, of which fewer than 10% were hosted by women (Amarasekara and Grant, 2019).

Importantly, this gap begins to materialize in the earliest stages of schooling, highlighting the necessity of addressing it starting in early childhood education, as argued in the systematic review by Briñez et al. (2025). This pattern persists through subsequent academic stages, although existing research has not reached a consensus on whether gender-based expectations and limitations in STEAM fields worsen as educational levels rise. While Grañeras et al. (2022) contend that the gap widens as students progress through the educational system, other researchers suggest that social factors and individual experiences can influence or shift this trend (Rivera et al., 2025; Baldeón et al., 2020).

The current state of the field therefore poses significant challenges for pre-service teachers, who can play a pivotal role in deconstructing gender biases and stereotypes associated with STEAM fields. In this context, the project presented here aligns with this objective by proposing an active methodology—academic debate—to introduce the STEAM approach to a highly feminized university population, thereby contributing both to competency development and to critical reflection on gender inequalities in the domain of scientific knowledge.

2. Methodology

The study was grounded in a qualitative and interpretive approach (Lüdke and André, 2017; Corbin and Strauss, 2008) aimed at facilitating an understanding of learning processes, the construction of meaning, and the predispositions of pre-service teachers. More specifically, an educational action-research design was adopted, directed at understanding socio-formative practices (Thiollent, 2025) and focused on academic debate. This design enabled systematic classroom observation, targeted pedagogical interventions, and joint interpretive analysis by both students and faculty.

Following the guidelines of similar studies conducted with pre-service teachers (Pascual-Arias and López-Pastor, 2024), strategies for the structured observation and systematic recording of debates

were applied to analyze the underlying processes of meaning-making.

The general objective of this initiative was to promote academic debate as an innovative methodology for acquiring STEAM competencies among undergraduate education students.

This general objective is broken down into the following specific objectives:

- To apply the STEAM approach to assess the application of knowledge in real-world contexts.
- To foster critical and analytical thinking within the STEAM domain.
- To develop essential competencies and transferable skills, such as collaboration, critical thinking, creativity, and problem-solving.
- To promote cooperative methodologies that facilitate the creation of an environment of reflection and critical engagement with scientific knowledge.
- To enhance media literacy and educommunication.
- To teach communication and conflict resolution strategies through information exchange and management.
- To provide training in the appropriate use of technology for information search and management.

These objectives were operationalized through specific activities carried out during the preparation, implementation, and evaluation of the debates, allowing for their observation and analysis using the qualitative techniques described. In this regard, several objectives manifested in observable dimensions, such as argumentative development, communicative interaction, information management, and active classroom participation.

The participants consisted of university education students enrolled in nine courses taught across three campuses, with voluntary participation in the focus groups (7–8 students per group). The participating courses spanned fields such as General Didactics, Sociology of Education, and Research Methods, providing an interdisciplinary framework consistent with the STEAM approach. The sample exhibited a significant overrepresentation of female students, consistent with the structural feminization of these degree programs.

Data collection was conducted through the systematic observation of discussions, teaching diaries, rubric-based assessments, and four focus groups. These focus groups were guided by a semi-structured interview protocol focusing on student perceptions of learning, the debate methodology, and the competencies developed.

Data analysis was carried out through a process of thematic coding, combining deductive categories derived from the study's objectives (STEAM competencies, critical thinking, media literacy, and communication skills) with inductive categories emerging directly from the students' discourse.

To ensure qualitative rigor, criteria of credibility and analytical coherence were applied by triangulating sources (students and teachers), techniques (observation, assessment, and focus groups), and stages of the process. Furthermore, the research team's reflexivity and peer debriefing among instructors helped minimize interpretive biases.

The methodological procedure was structured into three interrelated phases: preliminary training, the implementation of the debates, and the collection of qualitative data.

2.1 Methodological Training

To ensure the project's proper implementation, the teaching team designed a preliminary training plan based on coordination meetings, with the goal of giving students the conceptual, technical, and attitudinal resources necessary to optimize both the research processes and the expected pedagogical outcomes.

Although academic debate was the central focus of the project, significant emphasis was placed on training, preparation, and reflective analysis processes.

In the initial phase, the teaching team designed and delivered preliminary methodological training focused on giving students key conceptual, argumentative, and communication tools. This training comprised:

1. Initial instructions: Students received structured guidance on how to approach their oral presentations, which helped them organize their arguments and identify effective rhetori-

cal strategies. Rather than focusing solely on the final outcome of the debates, the cornerstone of the project lies in these developmental and preparatory stages, during which numerous competencies and soft skills were honed.

2. Conceptualization and explanation of key argumentative elements: This included the identification, analysis, and application of empirical evidence, counter-objections, and logical fallacies.
3. Rules and criteria for the debate: A series of strict guidelines were provided to guarantee and enrich the processes of argumentation and counterargumentation while ensuring pedagogical objectives were met. Key guidelines included avoiding ethnocentrism, directly linking contributions to course objectives and content, promoting clarity of expression, fostering tolerance and mutual respect, practicing constructive criticism, ensuring linguistic precision, and actively avoiding prejudices or gender stereotypes.
4. Modes of reasoning: Various types of argumentation were introduced to diversify students' discursive strategies, specifically symptomatic, causal, analogical, and generalization-based reasoning.
5. Digital and educommunicative literacy: One specialized session per academic year was dedicated to training students in the selection and critical analysis of information, the identification of reliable sources, the ethical use of artificial intelligence tools, and skills related to digital knowledge management.

2.2 Intervention Procedure and Data Collection

In the second phase, academic debates were implemented as an active learning technique integrated across the various subjects. Each class was organized into working groups that participated in public classroom debates on topics directly addressing the intersection of the STEAM framework and contemporary educational issues:

- Does technology contribute to human improvement?
- Quantitative versus qualitative techniques in social research.
- Science education in schools: an unresolved issue?
- Artificial intelligence: ally or enemy of teaching and knowledge?
- Merit, prestige, power, and compensation: Is the disparity among STEAM professions fair?
- The emergence of ICT in education: a revolution or simply a pedagogical improvement?
- The Feminization of Teaching and the Masculinization of STEAM: Pros and Cons.

Digital and Media Literacy in Schools: Panacea or Reality?

These topics were selected based on three rigorous criteria: their direct connection to STEAM competencies and contemporary educational challenges, their potential to spark intense debate and foster critical thinking, and their alignment with the curricular content of the respective subjects. The team agreed upon this thematic selection during the prior coordination sessions.

The institutional Moodle platform was utilized to announce the activities and manage participant registration for the debates.

The activity was structured as follows: each class was divided into eight working groups, with each group participating in two public debates held in the classroom. The specific distribution by groups is outlined below.

Figure 1. *Distribution of Work Groups and Debates*

Note: For example, Debate 1 will be conducted by Groups 1 and 2; Debate 2 by Groups 5 and 6; and so on.

The debates followed a standardized timeline, which encompassed the initial presentation of positions, a dynamic exchange of arguments, audience participation, conclusions, and an evaluation phase.

While the ultimate outcome comprised the eight debates held across the participating subjects and courses, the preparatory phase was deemed critical to achieving the study's core objectives. During this preparatory stage, a flipped learning methodology was employed, providing students with pre-class materials alongside ongoing guidance, feedback, and targeted tutoring sessions.

Data collection was carried out using multiple qualitative techniques to capture both the instructional processes and the participants' subjective perceptions. These techniques included:

- Systematic observation of the live debate sessions.
- Teaching diaries and evaluative records compiled through structured field journals, with observations systematized in accordance with established assessment criteria.
- Performance evaluations conducted using a consensus-built assessment rubric.
- Four focus groups consisting of 7–8 students, guided by a semi-structured interview protocol designed to evaluate the pedagogical methodology, perceived learning outcomes, developed competencies, and encountered difficulties.

2.3 Data Analysis and Assessment Tools

The data were analyzed using a thematic qualitative analysis approach, combining deductive categories derived directly from the study's objectives (STEAM competencies, critical thinking, media literacy, and communication skills) with inductive categories emerging from the students' discourse.

The collected data were processed through a sequence of open coding, axial categorization, and subsequent grouping into the dimensions of emergent analysis.

Methodological rigor was ensured through validation via data triangulation (Terán et al., 2022), which included:

- Triangulation of sources (integrating both student and teacher perspectives).

- Triangulation of techniques (combining systematic observation, rubric-based assessment, and focus groups).
- Cross-teacher comparison during the analysis and interpretation of the results.

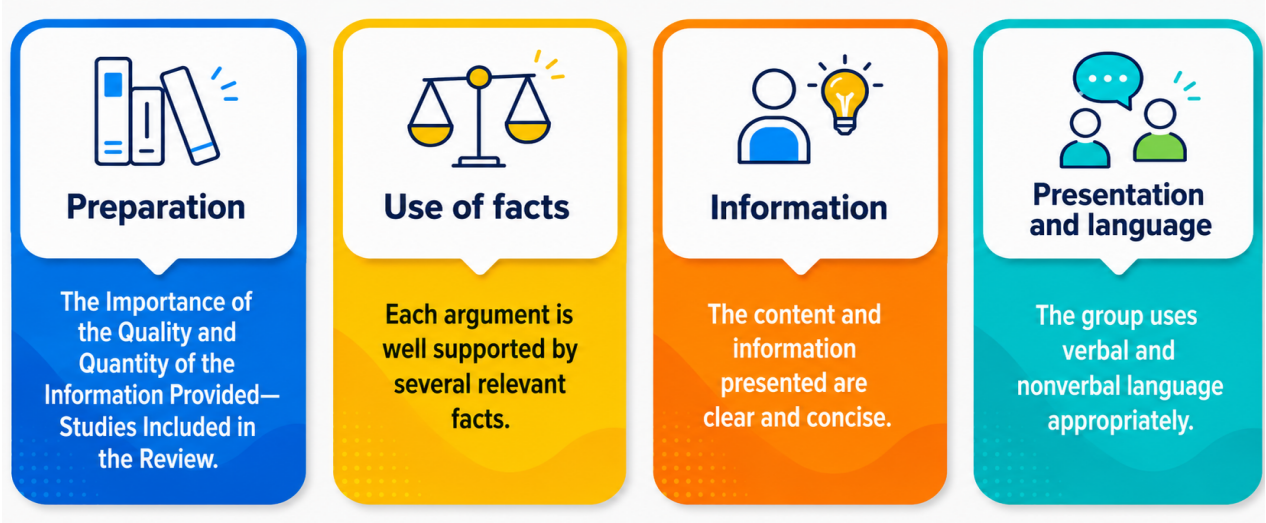
Furthermore, the research team's active reflexivity allowed for the identification and minimization of potential interpretive biases, thereby reinforcing the transparency of the analytical process and the interpretive validity of the findings.

The performance assessment was implemented using a rubric developed through consensus among the participating faculty, adapted from the evaluation framework proposed by CEDEC (National Center for Curriculum Development). This instrument was designed to evaluate various dimensions related to the achievement of the project's objectives and the execution of the different tasks carried out.

Figure 2. Key elements of the evaluation rubric

proyecto y las distintas tareas desarrolladas.

Figure 2. *Key Elements of the Assessment Rubric*



Note. Prepared by the authors based on the CEDEC rubric (scale: 4 = Excellent, 3 = Satisfactory, 2 = Needs Improvement, and 1 = Insufficient).

Likewise, the teachers' perceptions were incorporated as a specific unit of analysis, allowing for a comparison between the students' discourse and expert observation of the educational process, thereby reinforcing interpretive validity through triangulation.

3. Results

The results are presented based on a thematic analysis of the focus groups and teacher evaluations, organized into analytical categories consistent with the study's objectives and methodological design. Overall, the data reveal a highly positive assessment of academic debate as a STEAM learning strategy, alongside the identification of distinct benefits and limitations in its implementation. There is also evidence of an emerging awareness of gender inequalities regarding access, development, and recognition within STEAM fields; however, this dimension appears less developed compared to other analytical categories, suggesting a critical need to explore it more deeply in future educational interventions.

3.1 Student Perceptions

3.1.1 Relevance of the Topics and Connection to Teacher Education

A primary analytical category relates to the evaluation of the debate topics. Students highlighted their connection to education studies, their practical applicability, and their relevance to everyday situa-

tions, all of which increased motivation and interest in the activity.

> I think that, besides the fact that the debates are a lot of fun, the topics were really good. You could look up a ton of information, and it was interesting… You learn more about real life. [GD2]

> At the end of the day, we're all sick of lectures… practical activities that deal with real-world issues… they interest you much more. [GD3]

These statements underscore the importance of linking STEAM learning to socially relevant issues that are closely tied to future teaching practice.

3.1.2 Prior Conceptions and the Reframing of the STEAM Approach

A second category relates to students' prior conceptions of the STEAM approach. The findings reveal an initially limited and stereotypical understanding, primarily associated with technical disciplines and perceived as unrelated to the teaching profession.

> We're in the fourth year, and except for our Mathematics course… we've hardly talked about STEAM. [GD3]

> I thought STEAM was only about Mathematics and Computer Science… I didn't know the Arts were included as well. [GD4]

However, participation in the discussions fostered a gradual reframing of the STEAM approach, leading students to recognize its relevance to education and its cross-curricular potential.

> I enjoyed the discussion about scientific research in schools because I think it is important that we teach our future students to conduct research from an early age. [GD2]

3.1.2 Prior Conceptions and Reinterpretation of the STEAM Approach

A second analytical category refers to students' prior conceptions of the STEAM field. The results reveal limited and highly stereotypical initial knowledge, related to technical disciplines and perceived as distant from educational practice.

> We are in our fourth year [of university], and except for math class… we've hardly talked about STEAM at all. [GD3]

> I thought STEAM was just about math and computer science… I didn't know the arts were included too. [GD4]

However, participation in the debates fostered a gradual reinterpretation of the STEAM approach, enabling students to recognize its profound relevance to education and its cross-curricular potential.

> I liked the discussion on scientific research in school because I think it's important that we teach our future students to conduct research from a young age. [GD2]

3.1.3 Assessment of Academic Debate as a Learning Methodology

The third analytical category focuses on the evaluation of academic debate as a pedagogical methodology. Students identified multiple strengths, including enhanced communication skills, conflict resolution, information search and selection, the development of digital competencies, and the highly motivational nature of the activity.

> At first I thought I was going to die… but in the second one I participated a lot. [GD3]

> You learn a lot in a fun way… in some of the debates we laughed a lot. [GD4]

> I'd say the debates are innovative for us. [GD2]

Likewise, the findings highlight the pedagogical value of activities that involve role-swapping and presenting opposing arguments—an exercise that actively fosters cognitive flexibility.

> …they switched roles for five minutes… arguing exactly the opposite. [GD2]

3.1.4 Perceived difficulties and limitations

Alongside the benefits, a category related to the challenges of the process emerges. The main limitations identified are related to preparation time, the complexity of finding reliable information, and initial communication difficulties, particularly in early-stage courses.

> At first we were a little shy… but by the third discussion, everyone wanted to speak. [GD2]

> A lot of time is wasted looking for information because not all sources are reliable. [GD3]

> I've found it hard to stop and think… but I also see that it's necessary. [GD1]

3.2 Teachers' Perceptions

The analysis of faculty perceptions corroborates the findings derived from student discourse, serving as a triangulation mechanism that imparts interpretive robustness to the study. Overall, the teaching faculty concurred in their highly favorable evaluation of academic debate as a pedagogical strategy, highlighting its close alignment with educational objectives and its efficacy within a competency-based higher education framework.

3.2.1 Pedagogical Assessment of Debate and Contributions to Teacher Training

Academic debate has established itself as an effective and powerful methodology in the training of pre-service teachers, as it promotes the active construction of meaningful learning experiences and the acquisition of core competencies essential for their future professional practice.

The versatility and applicability of this approach across diverse topics and academic subjects are particularly noteworthy. Furthermore, academic debate offers significant potential to integrate STEAM content with communicative and social dimensions, thereby fostering familiarity with scientific knowledge and facilitating its incorporation into degree programs traditionally alienated from this field.

3.2.2 Competencies Developed and Student Progress

The teaching team noted significant progress in the acquisition of cross-curricular competencies, highlighting critical and reflective thinking, oral communication, and collaborative teamwork. This acquisition occurred continuously throughout the entire project and persisted even after its completion, as these are competencies that can be easily applied and transferred throughout the entirety of students' university education.

Finally, although challenges associated with the extensive time investment required for preparing and executing the project were acknowledged, the pedagogical opportunity cost was considered highly worthwhile.

In short, the faculty involved in the project confirmed the methodological and pedagogical suitability of academic debate as a strategy for integrating STEAM into education degree programs, noting that the skills it fosters are profoundly cross-disciplinary and highly applicable to other subject areas.

4. Discussion and Conclusions

The obtained results suggest that academic debate is not merely another participatory technique, but rather a demanding pedagogical practice that fosters the simultaneous acquisition of diverse competencies. In this sense, the findings align with complex argumentative approaches wherein cognitive, emotional, and ethical dimensions overlap (Paul and Elder, 2003; Nussbaum, 2016; Maliandi, 2006). However, beyond this theoretical convergence, what remains particularly relevant is how these dimensions are activated within specific teacher-education contexts. These contexts are further shaped by disciplinary (Di Fabio, 2005) and intercultural (Yama, 2018) differences—factors that have been highly prominent in this study. One of the most thought-provoking aspects is the observed shift in how students interpret the STEAM approach. Far from viewing it as an alien or exclusively technical field, they are beginning to perceive it as an open domain connected to social and educational issues. This shift is by no means minor; it reinforces the notion that active methodologies facilitate content acquisition and reshape prior representations of knowledge.

This enables students to move beyond simplified or reductionist views, particularly in degree programs traditionally distant from science and technology. These findings align with previous research on the role of participatory practices in driving motivation and the construction of meaningful learning (Hernández-Serrano and Muñoz-Rodríguez, 2020).

Within the framework of the European Higher Education Area, these results reinforce the suitability of methodologies that shift the focus toward students as active agents of their own learning, in line with the spirit of the Bologna Process (Aránguiz et al., 2021). However, this shift does not occur automatically. The role of faculty emerges as a cornerstone, functioning not merely as transmitters of content, but as mediators capable of sustaining, guiding, and giving meaning to dynamics that, by their very nature, can be uncertain or demanding. Furthermore, the high proportion of female students in the analyzed degree programs introduces a sociological dimension that deserves specific attention. The results suggest that academic debate can serve as a space of mediation to challenge traditional associations between gender and scientific-technological knowledge. However, it is also observed that this critical examination does not always translate into profound or sustained transformations.

The project confirms that academic debate constitutes a highly relevant avenue for introducing the STEAM framework to students in education degree programs. This approach becomes particularly significant when classroom dynamics are centered on socially relevant issues closely tied to future professional practice. In these cases, there is a clear increase in student engagement, as well as an enhanced quality of learning processes, which are no longer perceived as abstract or disconnected from reality.

An analysis of the discourse—from both students and faculty—reveals that the project's debate-centered methodology fosters the acquisition of key cross-cutting competencies, such as critical thinking, oral communication, information management, reasoned argumentation, and problem-solving—all of which are central to the STEAM approach. A gradual gain in confidence, increased self-assurance when speaking in public, and the ability to respectfully express disagreement are other vital socio-emotional aspects that emerged strongly throughout the analyzed experience.

From a sociological and pedagogical perspective, the findings highlight two particularly relevant dimensions: first, the importance of viewing students as active participants in their own learning process; and second, the relevance of addressing the gender gap in STEAM settings, given the historical overrepresentation of women in education majors. These results reinforce the premise that the STEAM approach should not be restricted to specific disciplinary fields but should instead be integrated transversally across teacher-training curricula.

Nonetheless, the analysis also identifies several limitations to consider. Among these are the high costs in terms of time and effort required to prepare the debates, the initial communication barriers experienced by some students, and the necessity of continuous faculty support to guarantee the quality of the educational process. These identified difficulties do not invalidate the methodology; rather, they highlight the critical importance of teacher monitoring and progressive structural planning, in line with prior research (Heise and Himes, 2010; Maclellan, 2008).

The experience described confirms that this approach can be successfully replicated in other educational contexts, disciplines, and academic levels, provided that the necessary adaptations are made based on the specific objectives pursued and student profiles.

Finally, the results open up promising avenues for future research, such as comparative analyses across different degree programs and genders, or the implementation and evaluation of debates in digital and hybrid learning environments.

In short, academic debate emerges as a pedagogical strategy with immense didactic and educational potential for introducing the STEAM framework, offering a robust space for critical reflection, the collective construction of knowledge, and the development of fundamental civic competencies vital to the knowledge society. This proposal aims to inspire other university faculty members interested in implementing innovative, critical, and socially engaged methodologies, thereby contributing to a higher education system that is more reflective and deeply connected to the challenges of contemporary society.

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Author Declaration – CRediT Taxonomy	
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Dr. Noelia Morales-Romo	Conceptualization, data curation, funding acquisition, research, methodology, project management, resources, supervision, writing, validation.
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Statement on the Use of Artificial Intelligence
The authors DECLARE that, in the preparation of the article "*Academic Debate as a Strategy for Learning STEAM Competencies*," artificial intelligence was used to expand on ideas regarding the main points to be addressed.