

RESEARCH ARTICLE

“I see myself as a STEM person”: Exploring high school students' self-identification with STEM

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Abstract

In the literature, STEM identity tends to be characterized either as students' relationship with the STEM field “as a whole,” or their relationship with a particular STEM area, such as science. With this study, we add to the existing scholarship by characterizing the profiles of students who identified themselves as “STEM people.” A 52-item questionnaire was administered to 1004 students aged 12–16 from high schools in and around Barcelona, Spain. To profile different groups of students, we performed a hierarchical cluster analysis that included responses relating to participants' interest, competence, self-efficacy, and aspirations to different STEM and non-STEM areas. Our analysis generated six different clusters, which we interpreted as ranging from positive to negative self-identification with STEM. Our particular interest was in the two clusters we interpreted as exhibiting positive STEM identity (C1 and C2). The analysis suggested that there were two different ways of considering oneself as a STEM person. Students who self-identified as STEM people were either more inclined toward technology and engineering (C1) or science (C2), particularly in terms of their aspirations. These two clusters were also strongly gendered,

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with C1 being dominated by boys and C2 by girls. Although our findings suggest the existence of a conscious “sense of STEM identity,” we suggest that students who self-identified as STEM people may have ascribed different meanings to the STEM based on their preferences. As such, this study questions the suitability of studying STEM identity “as a whole” without also considering how students relate to individual STEM and non-STEM areas.

KEYWORDS

cluster analysis, gender, secondary education, STEM identity

1 | INTRODUCTION

In recent years, there has been an increase of papers focusing on STEM education (Martín-Páez et al., 2019). Young people can nowadays enjoy a wide range of opportunities to engage with STEM content and STEM educational activities, which are arguably useful for them as future citizens (Zollman, 2012). Yet, in the literature, STEM education has been characterized in different and often somewhat contrasting ways. For example, some authors have argued that STEM is not a “real” construct with a “unique nature” (Akerson et al., 2018), but a socially constructed label to teach a particular STEM subject, while making connections to other STEM areas (e.g., teaching science while making connections to mathematics or technology). This approach has been usually labeled as S/T/E/M education, representing a domain with a focus on any of the four individual elements (McComas & Burgin, 2020). Other authors have advocated for an integrative perspective, often labeled as I-STEM, in which STEM education is conceptualized as an approach that emphasizes how STEM areas converge to address problems that require science “and” technology “and” engineering “and” mathematics rather than one subject “or” the other (Pleasant, 2020). There have also been different approaches to STEM instruction. While I-STEM education often emphasizes engineering and design-based STEM instruction—students need to design a technology that requires them to learn and/or use relevant science and mathematics concepts (Pleasant, 2020)—other authors have argued for many other different and necessary instructional approaches within STEM education, such as problem-based, project-based, or inquiry-based learning, among others (Thibaut et al., 2018). There are therefore strong reasons to investigate how this diversity of instructional approaches might contribute to creating involved, engaged, and informed citizens (Zeidler, 2016) and how students might feel about and relate to STEM.

Despite all the efforts, research has shown that girls and women are still underrepresented in STEM at the post-compulsory educational level, as women represent only 35% of students in the world enrolled in STEM-related areas (UNESCO, 2017). Although in Western Europe and the United States, there are approximately as many women as men in university-level education in STEM studies overall (Eurostat, 2020; National Science Board & National Science Foundation, 2020), differences are still found in the representation of women and men in the different STEM studies. For instance, girls more frequently follow the careers in healthcare and

biology, and boys are more likely to enter careers in computer science, engineering, and physics (OECD, 2019).

Gender inequities can also be identified within other constructs that relate to students' identity, such as interest and self-efficacy, from an early age onward. For example, research has found that girls' interest in science decreases much more than boys' from primary to secondary education (Archer et al., 2010). Due to the relevance of the impact of these inequities in education, new gender-sensitivity curriculums have been developed as, such as for example by Baker (2013). This suggests that concerns pertaining to STEM education are not only about what areas to include and focus on, neither only about how to teach them. The gender and equity perspective in STEM education, whatever the approach, cannot and should not be ignored.

A promising way to study how students relate to different STEM areas is by using the lens of identity, which provides a framework for understanding how, in front of the same STEM activity, some students may feel that STEM is "for them," while others not (Dawson, 2014). The majority of research studies have characterized students' STEM identity as a conglomerate of students' relationships with any of the different STEM areas, for example, in Ward Hoffer (2016), who have defined STEM identity as how one "thinks of themselves as a scientist, technology user, engineer, or mathematician" (p. xiii). Similarly, Kim et al. (2018) have defined STEM identity as a "socially based identity grounded in the extent to which individuals see themselves and are accepted as a member of a STEM area or field" (p. 3).

In some cases, the term STEM identity has been used interchangeably with science identity (e.g., Singer et al., 2020). We see this approach as problematic, not only because this composite of identities diminishes the capacity for understanding the particular traits and implications of different disciplinary identities, but also because this approach suggests that STEM identity could be a theoretical entity without an empirical existence. Therefore, it is important to ask how we characterize students' identity development within the context of integrated STEM educational activities, or in the early years, where the boundaries between science, technology, engineering, and mathematics are not clearly defined.

Other studies have proposed that there is a "general" STEM identity (Paul et al., 2020), characterized as the students' relationship with the STEM area "as a whole." Cohen et al. (2021) and Dou et al. (2019) have characterized STEM identity as how students view themselves as STEM people, their interest in STEM topics, and their perceived recognition as STEM people from relevant others. Another example can be found in Starr et al. (2020), who studied STEM identity as how students identify with people in STEM and how students perceived themselves as STEM people. These studies have shown that STEM identity can be measured with appropriate levels of validity and reliability, as in McDonald et al. (2019), and that STEM identity can be related to other constructs, such as early STEM experiences (Cohen et al., 2021) and STEM aspirations (Dou et al., 2019, 2021).

However, the research characterizing this "general" STEM identity is relatively recent and scarce, and consequently, is working through some conceptual challenges. For example, it remains unclear whether students view STEM as a specific profession or industry they identify with (e.g., game designer, video game industry) or a broad term that captures the specific academic areas they identify with (e.g., computer science), as some authors such as Dou et al. (2019) and Paul et al. (2020) have acknowledged. Further, although some studies have explored the relationship between this general STEM identity and a particular disciplinary STEM identity, such as engineering identity (Paul et al., 2020), the relationship between the general STEM identity and the identities related to all different STEM areas is not clear. We argue that given

the diversity of STEM educational approaches in which students can participate (e.g., integrated and non-integrated STEM instruction), it is necessary to better understand how identifying with different STEM areas might relate to this general STEM identity, and vice versa. We suggest that such understanding is especially important when considering demographic groups who continue to be underrepresented in STEM at the post-compulsory educational level, such as girls, whom we focus on in this study, but also other minoritized groups.

The study presented here was carried out during the first year of the implementation of a national STEM education program in Catalonia, Spain (STEAMcat), where different STEM educational approaches were implemented, and we experienced some of the same challenges regarding conceptualization of STEM to what we outlined above. In our study that we present in this paper, specifically, we sought to characterize the profiles of those students who identified with STEM by exploring how they related to different scientific, engineering, technological and mathematical activities, subjects, and careers, as well as to non-STEM areas, while also considering gender differences that might emerge in their identification. Our aim, in line with Takeuchi et al. (2020), was to provide insights to improve STEM learning opportunities for all students and contribute to improved and more engaging teaching of STEM. To this end, we selected four different constructs commonly adopted in the literature to characterize how students relate to STEM, namely interest, competence, self-efficacy, and aspirations. Each of these constructs, while unique, overlaps with the construct of identity, contributing to an understanding of students' STEM identity from the perspective of the constellation of motivational constructs constituting identity. In the subsequent subsections, we introduce our perspective on the notion of self-identification with STEM and review the background for the four constructs.

2 | STUDENTS' RELATIONSHIP WITH STEM AREAS TO UNDERSTAND THEIR IDENTIFICATION WITH STEM

2.1 | Self-identification as STEM people

Self-identification is one of the key constructs to characterize social identities as STEM identity. Burke and Stets (2009) describe self-identification as the process where "people, using the reflexive aspect of the self, name themselves with respect to positional designations or labels" (p. 26), such as for example a scientist or a student. When they do so, they invoke socially shared meanings and expectations regarding how a scientist or a student behaves, which becomes internalized as the parts of the self that are called identities (Burke & Stets, 2009). Although other processes can be used to characterize young people's STEM identity such as other's identification or recognition, we take the view that exploring self-identification is a responsive approach, as the information comes directly from the subject.

We argue that due to the rise and diversity of STEM education proposals, it might be relevant to consider STEM as a single construct, yet we also need to develop a deeper understanding of how students identify with STEM, as STEM, can be interpreted in different ways by different students, following Cameron's (2004) work on social identity. Although STEM identity might be a difficult construct to define, further exploration is needed to better understand the nature of this construct, especially given the diversity that can be found in its meaning and implications at the broader socio-cultural level, careers level, and at the academic and educational levels. In particular, we argue that, as a first step to understand how young people see themselves (self-identify) as STEM people, we need to explore how students both relate to STEM as a unified construct and how they relate to

each of the individual STEM areas. By doing this, we can begin to better understand if the term STEM seems to have a single meaning or entails different and complementary meanings for young people, when considering self-identification with the subject(s).

Moreover, and drawing upon the work of Herrera et al. (2012), we also consider it necessary to compare students' self-identification as STEM people with their relationship with other non-STEM areas in order to assess the relevance of this identification from a broader perspective. We acknowledge that there are many other group and community contexts that individuals might also identify with *outside* of STEM (Herrera et al., 2012) and that these intersections can provide a better understanding of the students' identity construction *within* STEM.

2.2 | Interest in STEM

Students' interest in STEM activities and/or topics has been identified as an important construct to explain how students identify with or develop their STEM identities (e.g., Dou et al., 2019; Paul et al., 2020). Students' interest has also been studied using various different models, such as the expectancy-value theory of achievement motivation (Wigfield & Eccles, 2000). Personal interest can be defined as a "personal desire to learn and/or understand" specific content and "participate voluntarily in activities" in a specific STEM discipline (Hazari et al., 2010, p. 983). Prior studies have situated high levels of interest as one of the strongest predictors of students' choice of subjects and subsequent courses (Jensen & Henriksen, 2015), and interest has been also related to students' engagement in science activities (Schmidt et al., 2018).

Gendered differences in terms of interest in STEM topics and activities have been found in the literature, with girls systematically showing lower levels of interest than boys in technology and physics (OECD, 2019; Wong & Kemp, 2018), whereas girls' interest in health and environmental topics (caring about others and the planet) were, on average, higher than their male peers (Sjøberg, 2002).

Some studies have questioned the relationship between interest and identity. For example, Archer et al. (2010) found in their research that many young people reported being interested in science but did not see themselves as science people or wanting to do science in the future. Even when this relationship might not be straightforward, interest in STEM continues to be one of the widely used personal constructs in the research focusing on understanding students' relation with STEM, which justifies considering it when studying STEM identities in the present study. We, further, recognize that interest can be relative and context driven, and asking young people's interest in both STEM and non-STEM areas is valuable to better characterize engagement in STEM educational activities (Musavi et al., 2018).

2.3 | STEM competence

The next important construct used to characterize how students identify with STEM topics, activities, or areas, is their competence. Individual competence is one of the three key constructs described in the model of identity proposed by Carlone and Johnson (2007), which has been widely used in the literature and applied to other identity models, such as in Hazari et al. (2010) who used it in the form of reported competence. Competence has been defined as the demonstration of meaningful knowledge and understanding of STEM content (Carlone & Johnson, 2007), and in the literature, has been usually related to achievement or academic scores.

Literature reports complex findings about how STEM competence relates to students' self-identification as STEM people, and what role gender plays. Despite there being little or no difference in the actual competence between boys and girls, as shown by the results of PISA 2018, it has been found that there was a small but significant difference in students' scores of different STEM areas on average across OECD countries: while boys slightly outperformed girls in mathematics, girls slightly outperformed boys in science (OECD, 2019). However, not only were these differences only significant in half of the participating countries, but the variation in the scores was larger among boys than the variation in girls' scores (OECD, 2019). In the case of Spain, for example, differences between boys and girls were only significant in mathematics, where boys slightly outperformed girls, but not for science. Similar results were found in other quantitative investigations, as in Else-Quest et al. (2013).

Hence, although these variations of competence in the individual STEM subjects between boys and girls may not be relevant, it does not mean that competence is not one of the key constructs used to explain why someone might relate to STEM. The reason is that competence, besides being usually related to achievement, is also connected to how students interpret their achievement which, in turn, is significantly gender biased (Schunk & Pajares, 2002), as described in the next subsection. Because of this mediated effect, we argue that young people's STEM competence is a relevant construct to include when studying STEM identities of boys and girls.

2.4 | Self-efficacy in STEM

Self-efficacy, also called competency beliefs, has been defined as beliefs in one's ability to successfully perform a task (Bandura, 1995). In different identity models, such as in Flowers and Banda (2019), Hazari et al. (2010), and van Aalderen-Smeets et al. (2019), self-efficacy has been defined as a key construct to understand students' self-identification as STEM people. Self-efficacy has been also widely used in other frameworks, such as the Eccles et al.'s (2015) expectancy-value theory of motivated behavioral choices, as well as in other related studies. Andersen and Ward (2014), for instance, have argued that students' confidence about their ability to master or complete a particular task/activity is a key construct or factor to explain the probability of an individual selecting a specific activity.

Despite the discussion in some studies that differences in students' self-efficacy in STEM practices according to gender may not be relevant in primary school, it is widely agreed that in the transition to middle or junior high school (ages 10–14), girls typically show a significant decline in their self-efficacy beliefs in STEM (Schunk & Pajares, 2002). Lower levels in female students' self-efficacy in high school are also described for mathematics (Goldman & Penner, 2016), computer sciences (Huang, 2013), and for some specific science disciplines, such as physics (Sheldrake et al., 2019).

2.5 | STEM-related aspirations

Aspirations in STEM, understood as expressions of people's hopes or ambitions regarding further STEM studies and career (Archer et al., 2020), have also been widely studied in the literature in relation to identity frameworks. STEM-related aspirations have mostly been related to a positive STEM identity. For example, Macdonald (2014) and Wong and Kemp (2018) have

evidenced a relationship between students' aspirations and their recognition as "STEM people," and Hazari et al. (2010) have reported a strong correlation between students' physics identity and their reported likelihood of choosing a career in physical sciences. Moreover, aspirations have also been widely studied in numerous other studies based on different frameworks, such as expectancy-value models, as in Gottlieb (2018). Therefore, students' aspirations represent a key construct in characterizing how students identify with STEM areas, not only because of their relevance within the literature but also as an intrinsic and future-oriented element of students' self-identification as STEM people that facilitate their understanding, in line with the studies of academic possible selves of Oyserman et al. (2004).

There are gender differences in students' STEM-related aspirations, that is, how women and men see themselves within the different STEM areas. Thus, boys are significantly more likely than girls to agree that they would like to become a scientist (Archer et al., 2020) and pursue studies related to computer sciences and engineering (OECD, 2019); girls are more interested than boys in pursuing studies related to health sciences (Sáinz et al., 2017). From an identity perspective, social stereotypes (Archer et al., 2016) play an important role in explaining gender differences in career aspirations, as well as other factors, such as learning experiences (Starr et al., 2020) or home support (Sheldrake et al., 2019). These gender differences, which show high consistency with previous constructs, justify not only the importance of considering aspirations as a relevant construct related to identity.

In sum, previous studies evidence that students relate differently to the individual STEM areas (science, technology, engineering, and mathematics), and that differences exist even within the individual disciplines within these areas (e.g., physics, biology, computer science). These relations can be explained by using a constellation of motivational and cognitive variables, including students' interest, self-efficacy, competence, and aspirations in relation to STEM school subjects, activities, or careers. From an identity perspective, the four constructs that we presented in this section can provide relevant insights into understand how students self-identify as STEM people, and how these constructs are connected to other ones related to students' identity for the different STEM and non-STEM areas. Understanding these relationships can, further, contribute to understanding and addressing gender differences which manifest in persistent inequities in STEM participation.

3 | RESEARCH QUESTIONS

This article aims to characterize how 12- to 16-year-old students self-identify with the STEM area "as a whole" and how their self-identification relates to their interest, competence, self-efficacy, and aspirations toward different STEM as well as non-STEM areas, differentiating also between STEM activities, subjects, and careers. Specifically, we address the following questions:

- What are the different groups of 12- to 16-year-old students when considering their interest, competence, self-efficacy, and aspirations in specific STEM activities, subjects, and careers, as well as in relation to non-STEM areas? (Q1)
- How do students in these profiles self-identify as STEM people? (Q2)
- What gender differences can be observed in students' profiles regarding the different constructs (interest, competence, self-efficacy, and aspirations)? (Q3)

- How do interest, competence, self-efficacy, and aspirations toward specific STEM and non-STEM areas relate to the profiles of students who self-identify as STEM people? (Q4)

4 | MATERIALS AND METHODS

The data for this study came from a questionnaire completed by 12- to 16-year-old students from 237 different high schools in and around Barcelona (Catalonia, Spain), as part of a larger project. The focus of the larger study was to investigate how students' self-identification as STEM people, characterized by personal constructs (such as interest, competence, self-efficacy, and aspirations), changed through their participation in a large STEM festival aimed at high-school students (12- to 16-year-old), which was held in Barcelona in 2019. In the larger study, other demographic variables were considered (apart from the students' gender), such as their socioeconomic level and type of school. Then, 2019, when the data were collected, was the first year of the implementation of a national STEM education program, making it particularly relevant to understand how students self-identified as STEM people. The term STEM was relatively new for students, and it was thus particularly pertinent to understand what could be done to better support students going forward. Our work in this paper focuses on the characterization of students' initial self-identification based on their answers *prior* to their participation in the festival.

4.1 | Participants

A convenience sampling was used for this study. All schools that attended the festival were invited to participate in our study, with a priority booking for the festival as an incentive. A total of 1004 secondary school students (12- to 16-year-old), from 64 schools, completed the questionnaire. Of the total sample, 622 students (62%) were from public schools, and 382 students (38%) were from private or semiprivate schools. Then, 487 students (49%) identified themselves as boys, 461 students (47%) as girls, and 38 students (4%) did not identify as boys or girls. We considered that, as teachers and school principals were the ones who signed up for the festival on behalf of their students and they, as a class, were to participate in the festival within the regular school schedule (not as a voluntary out-of-school activity), this might introduce some bias in terms of how students might feel toward the STEM area. However, as the data were collected before the festival and most students had not previously participated in this or similar event, we believe that the festival context did not influence their responses.

In order to check the representativeness of the data collected by the convenience sampling compared to the total population, a chi-square test of goodness-of-fit was performed. In particular, we sought to determine whether the distribution of students by gender and type of school was similar to the total population of Catalonia (the region of Spain where Barcelona is located). Data for the population of Catalonia was obtained from the Statistical Institute of Catalonia (IdesCat), where with the most recent data at the time we began our analysis was from 2017.

Results of the goodness-of-fit analysis showed that our study sample was broadly representative in terms of gender and type of school (Catalonia, Spain). That is, based on the significance level, no differences in the distribution of the gender and type of school were found in

TABLE 1 Results of the chi-square test of goodness-of-fit between the sample obtained and the population

Variable considered	χ^2 value	p-Value
Gender	0.01	.9509
Type of school	0.21	.6464

Note: In both contrasts, the level of significance was fixed at .05. DF were calculated as $k - 1$, where k equals the number of groups or categories (“boy” and “girl” for gender and “public” and “private” for type of school). Therefore, for all contrasts $DF = 1$. Data of the population were obtained from IdesCat (2017).
Abbreviation: DF, degrees of freedom.

comparison with the population (see Table 1). The proportion of students in our study who did not identify as neither boys nor girls was not considered, since corresponding data were not available in the official database.

4.2 | Questionnaire design

We drew on previous studies to develop a questionnaire to measure students' self-identification as STEM people from their interest, competence, self-efficacy, and aspirations in different STEM activities, subjects, and careers, as well as in relation to STEM and non-STEM areas. Being aware that complex constructs like identity or learning cannot be directly measured, the questionnaire design was based on different self-identification measures to develop an indicator of students' identities, following the approach of Hazari et al. (2010). The different variables used were hypothesized to be related to the constructs (identity, interest, competence, self-efficacy, and aspirations) and allowed us to elaborate conclusions and concrete implications regarding students' relationship between STEM “as a whole” and the different STEM areas.

4.2.1 | Measuring students' self-identification as STEM people

Students' self-identification as STEM people (one item) was adapted from Dou et al. (2019) single item for STEM identity indicator (i.e., “I see myself as a STEM person”) and Hazari et al. (2010) (i.e., “Do you see yourself as a physics person?”). Students were asked to select between the following statements which best described their relationship with the Science, Technology, Engineering and Mathematics area: *i) Science, Technology, Engineering and Mathematics (STEM) are not for me: I am definitely not a scientific/technological person.* *ii) If I can, I prefer to avoid doing STEM activities, or talking about those themes. I do not consider myself a scientific/technological person.* *iii) I enjoy STEM and I do have some personal qualities that can be good for a scientific/technological person.* *iv) I identify myself as a scientific/technological person.* This single item acted as a target variable in the analysis, as described below.

4.2.2 | Measuring interest

Interest (17 items) was measured in relation to students' ratings on a 6-point Likert scale of their interest in five concrete STEM-related activities (*To what extent are you interested in*

the following activities? i) Discuss about the human brain, e.g., some areas that can be damaged and their consequences in the nervous system; ii) Speak about how the universe was formed and what we expect in a future; iii) Print in 3D a small object, e.g., a keyring; iv) Construct a big structure which can support different weights; v) Identify some of the mathematics behind some card tricks), and the extent to which they were interested in five different STEM subjects: i) biology, ii) geology and environmental sciences, iii) chemistry and physics, iv) technology and computer sciences, and v) mathematics subjects. Both items for STEM-related activities and for STEM subjects were defined according to post-compulsory STEM-related subjects, which provided more nuanced options for science, and technology and engineering. The text for the items for interest in STEM activities and subjects was adapted from OECD (2017) (i.e., *to what extent are you interested in the following topics?*) and Obra Social “la Caixa”, FECYT, and Everis (2015)) (i.e., *to what extent are you interested in each of the following subjects?*), respectively.

In addition, students were asked to select what were the three most interesting areas for them by choosing from all seven knowledge areas of the Spanish secondary school curriculum: i) Languages, for example, read texts in Catalan, Spanish or English, produce written texts....; ii) Mathematics, for example, solve a mathematical problem, doing calculations....; iii) Science, for example, design or carry out an experiment, analyze data, provide a scientific explanation to natural phenomenon....; iv) Social Sciences, for example, investigate how the place where you live was in the past, know how other people live in other places in the world....; v) Arts, for example, learn to play an instrument, draw or paint....; vi) Sports, for example, play a team game, participate in a dance....; vii) Technology and Digital area, for example, design a prototype or a device, use computers or mobile phones to search the internet for information... The name of the areas was followed by some examples to help students to choose.

4.2.3 | Competence

Students' reported attainment for the different STEM subjects was measured as a proxy for competence in STEM. Specifically, students were asked to provide their average marks of the past term for the subjects of science, technology, computer sciences, and mathematics (i.e., *which was your mark of the following subjects in the last term?*), following Hughes et al. (2013) and using the Spanish grading system, which is formed by four categories of achievement (1 = fail, 2 = between 5 and 6, 3 = between 7 and 8, 4 = between 9 and 10 (four items)). In the Spanish curriculum, engineering practices are promoted within the subject of technology and are not an individual subject. Being aware of the limitations that using self-reported attainment has, as some students might overreport their achievements and introduce some bias in the results, we decided to keep this self-reported item drawing on previous studies. For example, Hughes et al. (2013) used self-reported grades as an item to explain students' self-concept within STEM areas, and Wong (2016) checked that most students reported similar grades across science and mathematics compared to the ones reported by their teachers. As the results of students' reported attainment were to be analyzed together with interest, self-efficacy, and aspirations, using a multivariate analysis, we interpreted that the possible bias introduced by students' self-reported grades would mostly affect students who had more trouble identifying themselves as STEM people. As competence is one of the key constructs constituting identity (Carlone & Johnson, 2007), those students might present the lowest scores, which might not be comfortable information to share. However, as this paper focuses on students' who self-identify as STEM

people, we assumed that the deviations between reported attainment and real grades could be negligible, although in further studies, it would be more appropriate to verify these alleged achievements.

4.2.4 | Self-efficacy

Self-efficacy was measured in relation to beliefs in one's ability to perform different tasks, following Bandura (2006), and in relation to self-beliefs regarding academic outcomes and STEM activities, following Fouad and Smith (1997). A total of 17 items formed the self-efficacy scale. These items were defined in relation to the same STEM activities presented in the interest scale (e.g., *Speak about the human brain, print in 3D a small object*, etc.), in which students were asked to rate how confident they were that they could do the specific activities, using a 6-point Likert scale. Students were also asked to rate how confident they were that they could succeed studying STEM subjects presented in the interest scale (e.g., biology, geology and environmental sciences, chemistry and physics, etc.), using a 6-point Likert scale. Self-efficacy items also included students' selection of the three areas in which they thought they were more able to perform successfully an activity, from the areas of the Spanish curriculum, as described above (e.g., *Languages, e.g., read texts in Catalan, Spanish, or English, produce written texts...*, etc.).

4.2.5 | Aspirations

We measured students' aspirations in STEM subjects, for the same subjects as we described above (i) biology, ii) geology and environmental sciences, iii) chemistry and physics, iv) technology and computer sciences, and v) mathematics subjects). Items relating to aspirations in STEM subjects were adapted from Archer et al. (2014) items on science aspiration (i.e., *I would like to study more [subject] in the future*). Similarly to Archer et al.'s study, students were asked to rate the statements according to their level of agreement, using a 6-point Likert scale. Aspirations in different areas of knowledge (including beyond STEM) were also recorded, asking students to choose three areas in which they thought they would like to work in the future from the seven knowledge areas of the Spanish secondary school curriculum.

For aspirations in STEM careers, an open question was used, and students were asked to write a brief description of what they would like to be when they grow up. The responses to this question were coded using the International Standard Classification of Occupations (ISCO-08) (International Labor Office (ILO), 2012) and recoded to identify if students expressed STEM aspirations or not, following Cairns and Dickson (2021). Although the total number of items for the aspiration scale was smaller (12 items in total), we considered that it was more accurate reporting students' real aspirations, as students in high school sometimes have difficulties knowing which jobs are related to STEM areas and which are not.

4.2.6 | Demographic information

In addition, demographic data were collected, including gender, parents' jobs (as a proxy of socioeconomic level), and school name. The question about gender was formulated according

to the guidelines of The GenIUSS Group (2014), in which adolescents' current gender identity is assessed to identify gender minority respondents (i.e., *how do you identify yourself?* i) boy, ii) girl, iii) *do not identify as boy or girl*). As it is highly controversial to ask about race or ethnicity in the Spanish context (see Estévez Hernández, 2015 and other studies), these data were not collected to avoid discomforting the participants.

4.2.7 | Validity and reliability

Construct validity of the questionnaire was established by theoretically grounding all the constructs and through a revision by experts in STEM areas and educational researchers in relevant disciplines. The questionnaire was extensively pretested using focus groups and was piloted with an equivalent sample ($n = 1058$) and same contextual conditions in 2018. The validity of the final instrument was assessed with Cronbach's alpha values, showing appropriate values for interest ($\alpha = 0.86$), competence ($\alpha = 0.83$), self-efficacy ($\alpha = 0.86$), and aspirations ($\alpha = 0.75$). A *post hoc* exploratory factor analysis was conducted as a complementary analysis. As mentioned above, external validity was assessed by comparing gender and students' school with the population. Results are presented in the next subsection.

4.3 | Analysis

Drawing from Ng (2021) and others, we used a two-step hierarchical cluster analysis to address the research questions. We aimed to characterize the different profiles regarding the ways in which students related to the STEM areas (based on their interest, competence, self-efficacy, and aspirations) and further examine these profiles by looking at students' self-identification as STEM people and their gender. Cluster analysis was considered to be an optimal analytical strategy because it allowed us to consider multidimensional profiles within a complex data set. Students' self-identification and gender were not included in the cluster analysis, as they were considered as target variables, according to our framework.

In the first step, a multiple correspondence analysis was performed to group together answers of interest, competence, self-efficacy, and aspirations on the basis of their similarity and obtains a simplified representation of them in a smaller number of dimensions, following Greenacre (2017). In the second step, a hierarchical cluster analysis was performed to identify students with similar responses in this smaller number of dimensions. Distance between clusters was calculated with Ward's method to display the differences between the groups or clusters formed in each grouping step and the subsequent one until all answers were merged in a hierarchical way. To select the optimal number of clusters, a compromise was made between the largest number of clusters and the largest distance with the subsequent set of clusters. We applied criteria including cubic clustering criterion, pseudo F, pseudo T-squared, and semi-partial R-squared difference, following the methodological approach of Everitt et al. (2011). Based on these criteria, we concluded that the optimal number of clusters was six.

After the clusters were established, the main traits of each cluster were identified by comparing the distribution of the values of each variable in each cluster with all the respondents' answers, considering a hypergeometric distribution of each value and $p < 0.0001$, following the approach of Lebart et al. (2000). This comparison allowed us to find which variables displayed significantly high or low values in each cluster. All the analysis presented in this paper was carried out with the software SAS v9.4, and significance level was fixed at 0.0001.

5 | RESULTS

In this study, the analysis of students' responses relating to the four constructs measured (interest, competence, self-efficacy, and aspirations; in relation to STEM and non-STEM areas) generated six clusters: C1 (234 students, 23% of the sample), C2 (158 students, 16%), C3 (359 students, 36%), C4 (73 students, 7%), C5 (137 students, 14%) and C6 (43 students, 4%).

5.1 | Profiles of 12- to 16-year-old students (Q1) and their self-identification as STEM people (Q2)

Overall, more than half of participating students in the study expressed a very positive or fairly positive identification with STEM (56%, first column of Figure 1). Only 15% of students expressed an identification toward STEM that interpreted as very negative, while 29% of students expressed an identification we interpreted as mildly negative.

A closer look at the answers of students' self-identification for each of the six identified clusters provided a more nuanced picture. Self-identification with STEM among students in C1 and C2 was overwhelmingly positive at a $p < 0.0001$, with over half of the students in each cluster reporting that they identified as a STEM person. We interpreted self-identification of students in clusters C3 and C4 as intermediate since, although a significant proportion of negative statements (i.e., students not identifying with STEM) were found, the proportion of the negative statements was relatively low compared to clusters C5 and C6, and positive statements were still present at a significant level. We interpreted students in clusters C5 and C6 as displaying a negative self-identification as STEM people, since their answers were concentrated at a significant level within the most negative end for both groups of students ($p < 0.0001$).

Based on these results, we interpreted and classified the six clusters into three groups: students with positive self-identification with STEM (C1 and C2, 39%), intermediate self-identification with STEM (C3 and C4, 43%) or negative self-identification with STEM (C5 and C6, 18%) (Figure 1). This result was of particular interest because, although self-identification was not used to build the clusters, but rather as a target construct, how students in each cluster self-identified as STEM people suggested a connection between a possible sense of STEM identity and participants' interest, competence, self-efficacy, and aspirations. More details of the attributes of these clusters can be found in Grimalt-Álvaro and Couso (2019) and Grimalt-Álvaro and Couso (2021).

5.2 | Gender differences in students' profiles (Q3)

Overall, a similar proportion of boys and girls completed the questionnaire (49 and 47%, respectively). The proportion of boys and girls, however, varied between the clusters (chi-square = 96.17; $p < 0.0001$). Students who did not identify as a boy or a girl represented the 4% of the sample; there were no statistically significant differences in the proportion of students who did not self-identify as a boy or a girl in the clusters, with the proportion ranging from 2 to 6% (chi-square = 4.23, $DF = 5$, p -value = 0.5167). Distribution of gender in the overall sample and in each of the clusters is presented in Table 2. As the number of students who did not identify themselves as a boy or a girl was lower than 15 in each of the clusters, contrasts were only carried out between students who identified themselves as a boy or a girl, as inclusion of the small third group would violate the assumptions of chi-square test, following Pagano (2009).

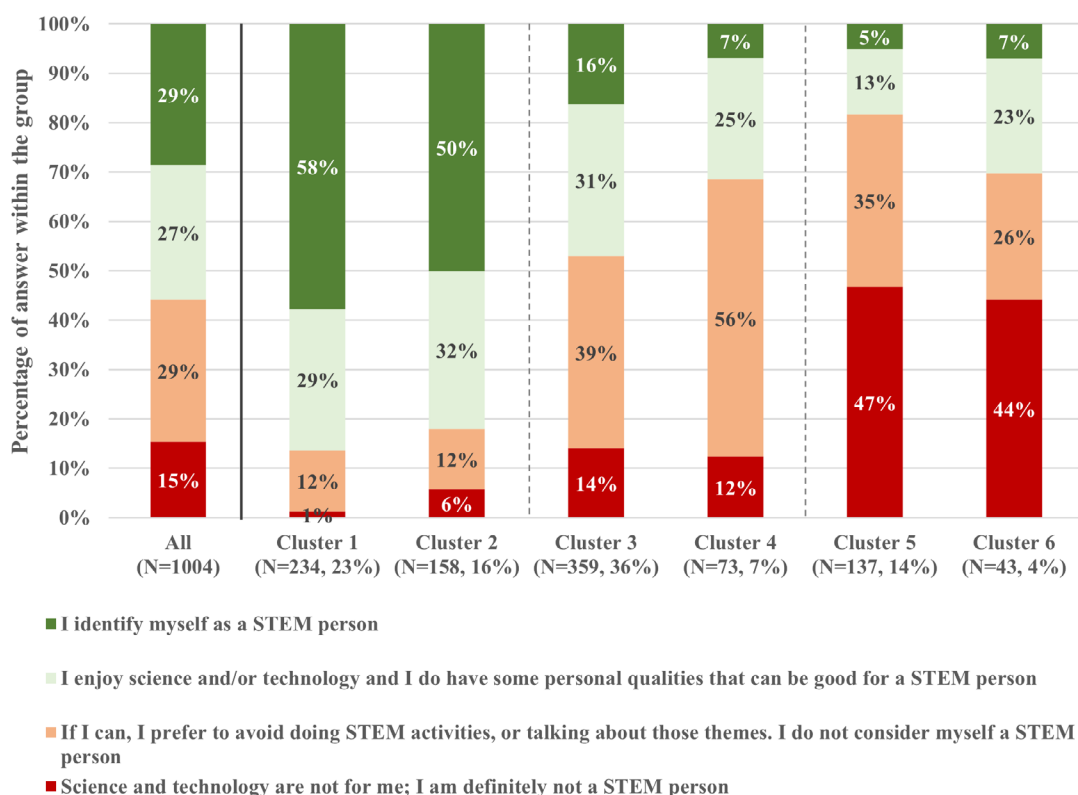


FIGURE 1 Students' responses on their self-identification as STEM people for all participants and for each cluster. Results are displayed in percentage of responses for each answer

From the two clusters that we interpreted as displaying positive self-identification as STEM people, C1 was overrepresented by students who self-identified as boys, whereas C2 was overrepresented by students who self-identified as girls. In the clusters displaying intermediate self-identification with STEM, there were no significant differences between boys and girls in C3, whereas C4 was overrepresented by students who self-identified as girls. Finally, in the clusters we interpreted as displaying negative self-identification with STEM, there were no significant differences between boys and girls in C5, while C6 was overrepresented by students who self-identified as boys.

5.3 | Understanding students' identification as STEM people in relation to their interest, competence, self-efficacy, and aspirations (Q4)

The analysis of students' responses about their interest, competence, self-efficacy, and aspirations toward STEM and non-STEM areas provided an enriched picture of how students related to STEM. In this paper, we want to focus particularly on the analysis of the students who self-identified as STEM people (clusters C1 and C2), who displayed high levels of interest, competence, self-efficacy and aspirations toward STEM-related activities, subjects, and careers. Focusing on these two clusters of students allowed us to investigate different ways in which students who self-identified with STEM relate to different STEM areas in terms of their interest, competence, self-efficacy, and aspirations. By analyzing the commonalities and the differences,

TABLE 2 Results of chi-square test for a single variable of the contrasts between the distribution of students who identified themselves as a “boy” or “girl” within each cluster

Cluster	Boy (%)	Girl (%)	Chi-square statistic	p-Value
C1	72	28	45.34	<0.0001
C2	40	60	5.80	0.0160
C3	50	50	0.01	0.9131
C4	14	86	36.63	<0.0001
C5	46	54	0.92	0.3365
C6	73	28	8.10	0.0044

Note: DF were calculated as $K - 1$, where K equals the number of groups or categories (“boy” and “girl”). Therefore, for all contrasts DF = 1.

Abbreviation: DF, degrees of freedom.

we expected to unpack and problematize the often unacknowledged complexity behind students' notion of self-identification with STEM.

The levels of interest, competence, self-efficacy, and aspirations of students in C1 (Figure 2) appeared to be strongly coherent within STEM areas, as they were found at similar levels between constructs when the same STEM area was considered (e.g., when we considered the levels of interest and the level self-efficacy for technology and engineering). This group reported the highest levels of interest among STEM-related activities in technological activities (i.e., *Print in 3D a small object...*) and engineering activities (i.e., *Construct a big structure...* see the description of the questionnaire design section). Their interest in STEM subjects was, similarly, particularly high for technology and computer science. Students' reported attainment in this cluster was highest for technology and computer science subjects. These students also displayed the highest levels of self-efficacy toward technological activities (i.e., *Print in 3D a small object...*) and engineering activities (i.e., *Construct a big structure...*), as well as for technology and computer science subjects. Similarly, students in C1 displayed the highest levels of aspirations toward technology and engineering subjects of all clusters. Finally, when considering STEM versus non-STEM areas, technology and engineering was the most selected area in which these students had more interest in, felt more capable of, and aspired to. Surprisingly, aspirations toward science as an area were low. Regarding non-STEM areas, these students showed a top preference for sports, which appeared at similar levels as in interest, self-efficacy and aspirations toward mathematics and science areas. In sum, all values for technology and engineering were significantly higher compared to the overall values of all participants ($p < 0.0001$).

Students' in C2 reported the highest levels of interest in science activities, as well as in science subjects among all the clusters (Figure 3). Although these students' reported attainment was the highest for science subjects, their reported attainment for mathematics and technology and engineering subjects was also high. Similarly, while self-efficacy levels of students in C2 were the highest for science activities and subjects, their self-efficacy for mathematics and technology and engineering activities and subjects was much lower. Aspirations to continue studying STEM subjects in this cluster focused on science subjects. When asked in relation to STEM and non-STEM areas, values of interest, self-efficacy, and aspirations for the science area were found at the highest levels and statistically significant, compared to the average of all participants. Aspirations toward mathematics as well as aspirations and self-efficacy in technology and engineering were found at low levels for this cluster, although only at significant level for aspirations in technology and engineering. In particular, aspirations toward technology and

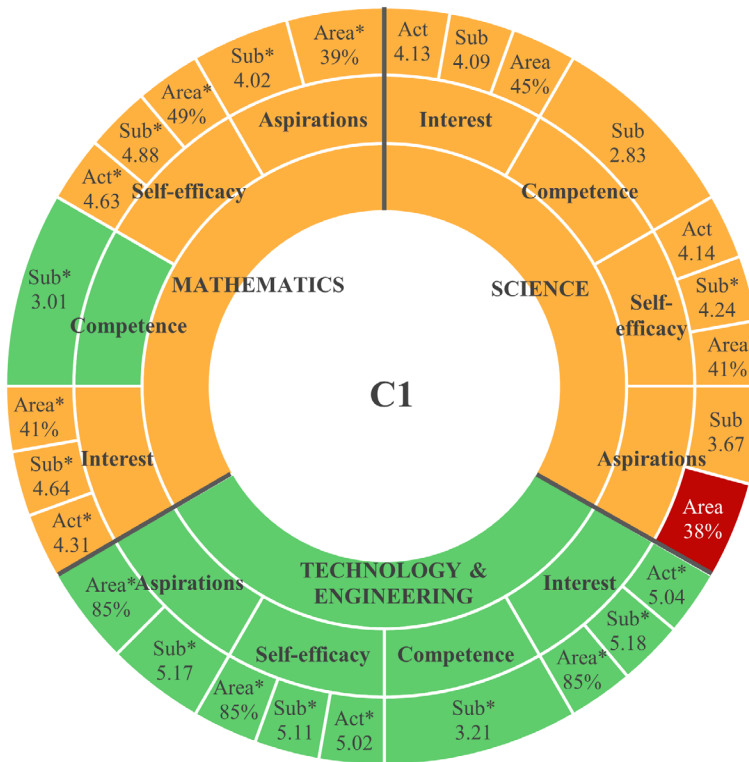


FIGURE 2 Mean values of interest, competence, self-efficacy, and aspirations for students in C1 regarding science, technology and engineering and mathematics activities (act), subjects (sub), and as an area (area). Green, orange, and red display the authors' interpretation of the C1 responses for each variable in terms of high, medium, or low levels, respectively. Asterisks indicate those values which are significantly higher compared to responses from all participating students at $p < 0.0001$. Mean values of interest and self-efficacy in activities and subjects are reported using a Likert scale from 1 (none) to 6 (very). Interest and self-efficacy in areas of knowledge are reported as the percentage of students who chose science, technology, and engineering and/or mathematics as one top three areas. Competence is displayed according to the Spanish grading system (1 = fail, 2 = between 5 and 6, 3 = between 7 and 8, 4 = between 9 and 10). Aspirations regarding subjects are reported using a Likert scale from 1 (none) to 6 (very), and regarding areas of knowledge, as the percentage of students who chose science, technology and engineering, and mathematics as one of the top three areas in which they would like to work in the future

engineering were found to be significantly lower compared to the overall sample. Looking at non-STEM areas, levels of students' aspiration toward social sciences were found to be at similar levels as in technology and engineering areas. In sum, results for all variables related to science were significantly higher compared to the overall sample ($p < 0.0001$).

Overall, for students in C1, interest, competence, self-efficacy, and aspirations concentrated on technology and engineering. In other words, students' relationship to technology and engineering appeared to be significantly stronger, when compared to other clusters. For students in C2, the highest values about their interest, competence, self-efficacy, and aspirations were concentrated on science. Therefore, we suggest that although both clusters of students expressed a positive self-identification as STEM people, they identified differently with the different STEM areas. We interpret this finding as there being different ways of being STEM people. For instance, students who self-identified as STEM people were inclined either toward the areas of

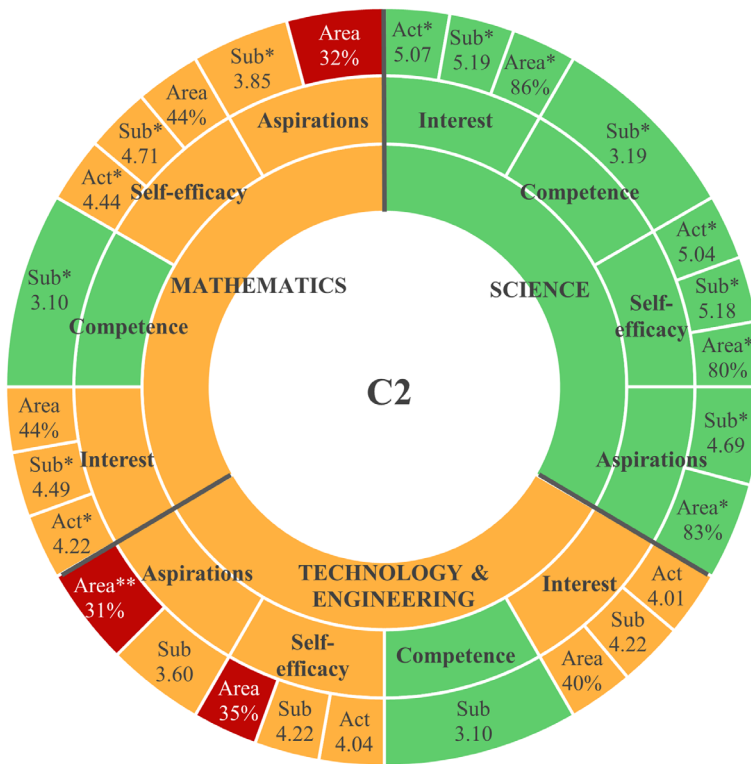


FIGURE 3 Mean values of interest, competence, self-efficacy, and aspirations for students in C2 regarding science, technology and engineering and mathematics activities (act), subjects (sub), and as an area (area). Green, orange, and red display the authors' interpretation of the C2 responses for each variable in terms of high, medium, or low levels, respectively. *Values significantly higher compared to responses from all participating students at $p < 0.0001$. **Values significantly lower compared to responses from all participating students at $p < 0.0001$. Mean values of interest and self-efficacy in activities and subjects are reported using a Likert scale from 1 (none) to 6 (very). Interest and self-efficacy in areas of knowledge are reported as the percentage of students who chose science, technology, and engineering and/or mathematics as one top three areas. Competence is displayed according to the Spanish grading system (1 = fail, 2 = between 5 and 6, 3 = between 7 and 8, 4 = between 9 and 10). Aspirations regarding subjects are reported using a Likert scale from 1 (none) to 6 (very), and regarding areas of knowledge, as the percentage of students who chose science, technology and engineering, and mathematics as one of the top three areas in which they would like to work in the future

technology and engineering, or toward science, with mathematics appearing to play a secondary role for both of these groups of students.

6 | DISCUSSION OF RESULTS: UNDERSTANDING HOW YOUNG PEOPLE IDENTIFY WITH STEM

6.1 | Students' self-identification as STEM people

This article reported findings of how 12- to 16-year-old students self-identified as STEM people, what gender differences can be observed in this self-identification and how the way young people see themselves as STEM people can be further interpreted from the perspective of their

interest, competence, self-efficacy, and aspirations toward different STEM and non-STEM areas. The instrument designed to assess how students identify themselves as STEM people based on their relationship with different STEM and non-STEM areas showed appropriate levels of construct validity for each construct. Yet, we also acknowledge some limitations of the instrument, especially regarding the inequality in the number of items per scale in the final version of the instrument and the wording of the question used for students' self-identification as STEM people, which might have to be reviewed and improved in further work.

Results of how students self-identified as STEM people showed similarities with previous studies as, for example, between the percentage of students who self-identified very positively toward STEM "as a whole" in our study (29%) with the percentage of students who display aspirations to the STEM area reported in Archer et al. (2020). Moreover, our findings allowed us to delve further into these previous results, identifying six clusters of students who self-identified with STEM very differently, ranging on a scale from positive (C1 and C2, comprising 39% of participating students), intermediate (C3 and C4, comprising the 43% of participating students), to negative identification as STEM people (C5 and C6, comprising the 18% of participating students). Variations within students' self-identification and similarities with previous findings suggested that the possible bias introduced because of our sampling method is unimportant. Moreover, although the levels of representativeness of the sample in this study in terms of type of school and gender distribution are sufficient, further work would have to consider using a larger sample, which might provide additional nuance to the clusters and help to better interpret how students identify themselves as STEM people.

The analysis of students' responses on their self-identification with STEM suggests the existence of a conscious, explicit "sense of STEM identity" for 12- to 16-year-old students, since these students appeared to be able to indicate their preferences toward it. Furthermore, these preferences seemed to be coherent within each cluster, even though the clusters were only constructed from students' interests, competence, self-efficacy and aspirations toward STEM and non-STEM areas and not from their self-identification toward STEM. For instance, 87% of students belonging to C1 expressed a positive self-identification with STEM whereas only 18% of students in C5 identified this way. This finding aligns with previous investigations using different methodological approaches that have also referred to self-identification as an evidence of the existence of a STEM identity (identifying with STEM "as a whole"), as in Kim et al. (2018), King and Pringle (2019), and McDonald et al. (2019). However, even though students' self-identification expressed something about how students relate to the STEM area "as a whole," the interpretation of the different ways in which a student can positively or negatively identify themselves as STEM people—and even the interpretation of the meaning of STEM—remains unclear from the use of a single item. The integration of different constructs (in our case, interest, competence, self-efficacy, and aspirations toward the different STEM areas, as well as other non-STEM areas) allows for a more in-depth interpretation of how students relate to STEM and, especially which meaning they might be attributing to the term STEM. As such, we consider the self-identification of students toward the whole of STEM an interesting but not a definite variable to focus on for research purposes.

6.2 | Understanding positive identification with STEM from the perspective of how students relate to different STEM and non-STEM areas

Students grouped in C1 and C2 clusters self-identified as STEM people. However, when closely considering factors that the literature suggests strongly related with students' STEM identity,

such as their interest, competence, self-efficacy, and aspirations toward different STEM areas, we observed two notably different ways of how students self-identified as STEM people. Students were either more inclined toward technology and engineering (C1) or science (C2), particularly in relation to their aspirations. Moreover, and interestingly, the students in C1 and C2 reported good competence in mathematics but medium levels of interest, self-efficacy, or aspirations toward it, possibly showing the instrumental view given to mathematics by these STEM-identifying students. A similar trend was found in students' non-preferred STEM areas (science for C1, technology and engineering for C2), while competence levels were found at high levels, interest, self-efficacy, and aspirations toward these non-preferred areas were moderate or low, highlighting how the different constructs contributed and are needed to understand students' relationship with STEM.

Our findings suggest that each of these two groups of students (C1 and C2) might be giving a different meaning to STEM, based on their preferences toward STEM areas, raising questions about the existence of a single and unified meaning of STEM. In addition, and because the proportion of students who self-identified as STEM people within is bigger in C1 than in C2, we also cautiously interpret that there might be more students who lend a meaning to the construct of *STEM* more related to the engineering and technology areas than other meanings which would give preeminence to different disciplinary areas, such as science, in line with McComas and Burgin (2020).

From our perspective, this bias in students' understanding of STEM could reflect and be reinforced by how STEM activities are usually designed in school contexts. Although the number of educational projects, activities, and/or programs labeled as STEM has considerably increased in recent years (Martín-Páez et al., 2019), literature findings suggest that technology and engineering have a preeminent role in the majority of STEM activities, compared with other areas, and that mathematics takes a less important role in the design and delivery of STEM education (McComas & Burgin, 2020).

The preeminence for technology and engineering would be found for both S/T/E/M educational approach (a main domain with focus on any of the four elements) (McComas & Burgin, 2020) and I-STEM (integrated perspective) (Pleasant, 2020). In general, there is an emphasis on the use of robotics, and the use of engineering design and engineering-based problems (e.g., through the extensive use of design thinking strategies) (Martín-Páez et al., 2019; Pleasant, 2020). We agree with these authors that this emphasis on technology and engineering areas is a potentially problematic trend, as not only the other STEM areas or disciplinary practices might potentially be relegated to secondary roles, but in addition, such emphasis is not conducive to generating inclusive learning environments, as it would only be engaging for a small proportion of students (C1).

Therefore, we suggest that there is a need to overcome the dominant view of "STEM education" as a synonym for "technology and engineering" or a synonym for "science," and opt for a more inclusive perspective, balancing the weight of the different areas, and especially emphasizing the role of mathematical reasoning and other STEM-related disciplines, such as life or environmental sciences. In addition, considering that C1 and C2 students also showed preferences toward other non-STEM areas such as sports and social sciences, an approach that emphasizes the role not only of the different STEM areas but also those non-STEM ones would be interesting for these students and beneficial for all, including those students who might not identify as STEM people. An example could be the concept of STEM-relevant problems (Pleasant, 2020), where complex real-world problems are used as a point of entry into component problems aligned with science, technology, engineering, and mathematics and others, as there are also

many dimensions to the problem that are aligned with non-STEM areas. These complex real-world problems, which would include social, political, and other non-STEM dimensions would certainly be more aligned with socio-scientific issues traditional instruction, as Zeidler (2016) points out. From our perspective, their added value for STEM education is that they can provide more opportunities for students to engage in different ways of attempting to design a solution for a designated problem, instead of a sole focus on engineering design.

6.3 | Might a focus on STEM identity contribute to reproducing gender stereotypes?

A final comment needs to be made in terms of the gender distribution within the two clusters of students who self-identified as STEM people. Our results showed that these two clusters are strongly gendered: C1 was dominated by boys and C2 by girls. Therefore, results of our study suggest that the common approach within STEM education that is centered on technology and engineering would engage not only a smaller number of students, but might be negatively affecting girls' participation—and contributing to gender stereotypes and biases within STEM.

This stereotyped relationship between boys and technology/engineering and between girls and science, mostly within the health disciplines, has previously been reported in the literature that focuses on aspirations (Sáinz et al., 2017; UNESCO, 2017). The novelty of our results is showing that using an identity framework, we can portray a more complex profile to interpret gender differences in how students negotiate their STEM identities. For instance, we found that students in C2, who were predominantly girls, show especially low self-efficacy and aspirations toward the technological and engineering areas, but moderate interest and actually good competence. That is, these students do not appear to be “anti-technology,” but they seem to think they are not good enough and do not see their professional future in this area. This signals particular aspects that could be addressed in more targeted, future actions in STEM education.

7 | IN CONCLUSION: HOW CAN WE TALK ABOUT AND RESEARCH STEM IDENTITY?

In this article, we presented a study on how 12- to 16-year-old students identified as STEM people, drawing on data from 1004 high-school students. We focused on two clusters of students who we interpreted as self-identified as STEM people, and examined how they related to different STEM areas, through looking their interest, competence, self-efficacy, and aspirations toward these areas. Throughout our data collection and analytic process, we considered what it meant to focus on and work with the concept of STEM identity—and what insights our data could offer for thinking about the usefulness and the challenges of using this concept.

Our findings suggest an existence of an explicitly stated “sense of STEM identity” and that STEM does have some meaning for students, which we inferred from i) students being able to self-identify as STEM people when directly asked about it and ii) how groups of students who mostly self-identified as STEM people also showed high levels of interest, competence, self-efficacy and aspirations toward particular STEM areas (which we considered as indicative of students' relationship with STEM), whereas groups of students who did not self-identified as STEM people showed low levels on any of these four constructs when related to STEM areas.

Our findings are in line with previous studies that can be found in the literature in which STEM identity or identification with STEM is studied as a “whole” construct (e.g., Dou et al., 2019; McDonald et al., 2019).

However, our results highlight a complex relationship between agreeing with a statement like “I see myself as a STEM person” and displaying strong interest, competence, self-efficacy, and aspirations across the STEM areas. In fact, our results show that there are different ways of relating to STEM, but at least two different ways of feeling as STEM people, as indicated by the characteristics of two clusters who both exhibited positive identification with STEM yet differed notable in other ways. A general “STEM identity” umbrella term is complex and cannot be clearly understood without considering students’ level of alignment between interest, competence, self-efficacy, and aspirations in relation to each of the different STEM areas (particularly, science on the one hand and technology and engineering on the other). Our study suggests that there is an ambiguity in the meaning that students attribute to STEM, a point that has previously been acknowledged by Dou et al. (2019). These authors, despite using STEM identity as a concept, state that it is not clear what students interpret by STEM—whether STEM to them was a specific term or industry, a broad term that captured the specific academic discipline, or something else. Hence, although students appeared to be able to relate to STEM, our results bring into question the suitability of studying STEM identity as a “whole” construct.

Although there is evidence that some students might feel more or less inclined toward STEM activities, for example, in the classroom, we argue that it is questionable to consider the existence of an actual and defined *STEM identity* (STEM identity as a whole construct), at least from our current social and historical moment. Literature suggests that social identities are commonly based on “prototypes,” that is, social meanings of what a *STEM person* would be and do (Burke & Stets, 2009). Yet, there currently does not seem to be a clearly defined STEM prototype, but rather, only prototypes related to the individual STEM areas (e.g., prototypes of what a science or engineering person is and does) or specific subjects and professions within the individual STEM areas (e.g., prototypes of what a physicist, a computer engineer or a health professional is and does). Thus, it is difficult to compare these socially but unclear constructed meanings of STEM as a whole area with the personal self. Therefore, although a general notion of being a “STEM person” can technically be measured, we would discourage the use of STEM identity within research without sufficiently problematizing the concepts and critically addressing its limitations.

The idea that “general” STEM identity, or identifying with STEM “as a whole”, is problematic, and the ways in which students identify with STEM varies has implications for pedagogy. In STEM education, there have been ongoing discussions about the level of interdisciplinarity (e.g., multi-, inter-, trans-, and meta-disciplinary approaches to how STEM disciplines fit together) and about the concrete educational approaches to follow to increase competence and spark interest and aspirations in STEM (e.g., integrated STEM focused on design-thinking, STEAM on including the Arts, STREAM meaning a focus on robotics or the integration of religion and ethics with science ideas). Within this diversity of frameworks, one could argue that integrative STEM is often a preferred approach (see, for instance, the last Handbook of Research on STEM Education (Johnson et al., 2020). However, regardless of the suitability of this approach, the fact that a STEM activity or a STEM curriculum is designed from an integrative STEM perspective does not necessarily mean that such an approach has the potential to promote an integrative, “general” STEM identity. In fact, the two clusters we identified in our study (of students positively identifying as STEM people) could be seen as reflective of how integrative STEM activities are commonly

designed in the school context, in which technology and engineering have a preeminent role compared with other STEM areas, and mathematics would be relegated to a merely instrumental role (Couso & Simarro, 2020). We suggest that to overcome existing gender inequalities, we need to reconsider how STEM education is defined, portrayed, and put into practice, in order to avoid reinforcing one way of being “a STEM person.” Based on our findings, we would suggest that it could be beneficial to support students to actively engage in multiple ways of doing, thinking, talking, and valuing the different STEM as well as different non-STEM areas in a non-stereotypical and balanced way, such as for instance through the use of complex, real-world problems where different STEM and non-STEM areas are needed depending on the problem, where problems are meaningful to students and all students can have a say in the activities (Pleasant, 2020). This diversity of practices might contribute to build a broader definition of what is STEM and who is allowed in it.

Finally, while in this paper, we have focused on the two students who positively identified with STEM, we believe that to better understand the relationship between STEM identity and the relations with individual STEM areas, it would be beneficial to also consider students who displayed a negative or an intermediate identification with STEM. Knowing how these students’ interests, competence, self-efficacy, and aspirations toward the different STEM and non-STEM areas interplay with their STEM identity could help bring to light additional ways of how young people might view and relate to STEM. The increased understanding of these issues can be helpful for designing STEM education that works for everyone. In particular, such insights might foster more effective ways to work with students who are “in the middle” (those who show some interest in STEM but who do not aspire to it). As we discuss in Grimalt-Álvarez and Couso (2021), the students “in the middle” often tend to be left out from interventions, which (at least in the Spanish context) tend to predominantly focus on those students most interested in STEM or those who most need additional educational support (and report the lowest interest). We invite readers to continue exploring different understandings and interpretations of STEM identity, what this concept means and how it might vary among different people, while also critically considering how specific interpretations of STEM in research and practice might risk reproducing and reinforcing gender inequalities. It is through increased understanding and critical reflection that we can advance our research and practice in STEM education.

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