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Science Identity and Its "Identity Crisis": On Science Identity and Strategies to Foster Self-Efficacy and Sense of Belonging in STEM

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The word identity etymologically derives from the Latin expression *identitas*, from *idem*, which means *same*. But the identities each of us has in the same moment and across life stages can be multiple and continuously changing, and are influenced by internal (i.e., personal) and external (i.e., environmental) factors. In this manuscript, I reviewed the existing literature on the theoretical and practical aspects of science identity across school levels. I explored how it can be measured and shed light on the links between science identity, professional identity, mentoring and sense of belonging. Then, I analysed strategies to foster self-efficacy and sense of belonging in Science, Technology, Engineering, and Mathematics (STEM), with the aim of creating a scientific community that is genuinely inclusive and diverse. A set of recommendations to build a community with shared goals and enhanced diversity, with beneficial effects at several societal levels, has been included.

Keywords: identity, science, STEM, self-efficacy, mentoring, community, inclusivity

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FROM IDENTITAS TO IDENTITY THEORY

The word identity etymologically derives from the Latin expression *identitas*, from *idem*, which means *same*. But the identities each of us has in the same moment and across life stages can be multiple and continuously changing, and are influenced by internal (i.e., personal) and external (i.e., environmental) factors.

Identity theory (Stryker, 1968, 1980; Stryker and Craft, 1982) postulates that "*every individual in modern society has multiple role identities which correspond to the different social roles they fill*" (Burke and Stets, 2009; Merolla and Serpe, 2013, p. 576) and tries to explore why individuals choose to embody, or enact, a particular role identity (Merolla and Serpe, 2013). It differentiates role identities based on social roles vs. group identification, social characteristics (Tajfel and Turner, 1986) and personal traits (Burke and Stets, 2009; Hazari et al., 2010; Merolla and Serpe, 2013). Role identities follow a hierarchical structure. The choice of one over another depends on identity salience: the higher the hierarchical salience rank, the higher the probability of choosing a specific identity role and keeping it across situations and over time (Stryker, 1980; Serpe and Stryker, 1987, 2011).

But salience is also a function of commitment to a specific identity, where commitment represents the cost (perceived) due to leaving a specific social role because of the loss of the associated relationships in the social context (Merolla and Serpe, 2013). According to this theory, individual behaviour is linked to social structures as "*individuals with more satisfying social ties to a particular social role will be more likely to enact that role identity in situations when there is a choice*" (Serpe and Stryker, 2011; Merolla and Serpe, 2013, p. 577). A hierarchy of social structures has been defined: *large* and *intermediate* structures provide boundaries that define the likelihood that individuals will enter a *proximate* social structure, which, in turn, affects the likelihood that specific social relationships will develop (Serpe and Stryker, 2011; Merolla et al., 2012). Therefore, social relationships lead to higher identity salience of a specific role, making enactment of *that* role more likely (Merolla et al., 2012).

Interestingly, at the beginning of the millennium, a landmark paper by Stets and Burke (2000) compared and contrasted identity theory and social identity theory (reviewed by Scheepers and Ellemers, 2019), with the aim of developing a general theory of self. Minor differences among the core components of these theories exist, especially on the different bases of identity (category/group or role), salience and the activation of identities, cognitive/motivational processes in relation to category/group and role. However, these differences are more nominal than factual, and have been compared to nuances of emphasis; moreover, "*linking the two theories can establish a more fully integrated view of the self*" (Stets and Burke, 2000, p. 224). In the same years (and even more so in the last 15 years), educational research has factually surpassed this theoretical division in favour of exploring both self-related aspects and social-related aspects, pragmatically intended as part of the same phenomenon to be described. This was parallelled by a growing interest in the study of science identity in Science, Technology, Engineering, and Mathematics (STEM) disciplines, triggered by policy papers and governmental recommendations in favour of an increase of STEM students in many countries worldwide, including the United Kingdom (HM Government, 2017) and United States (White House Press Secretary, 2010). While in the late 1990s/early 2000s the main aim was to involve more female learners in science (Brickhouse et al., 2000; Barton and Brickhouse, 2006; Ford et al., 2006), in the late 2000s/early 2010s the focus shifted toward a non-binary involvement and the topics of diversity and inclusion, especially BAME learners and students from disadvantaged background (Carlone and Johnson, 2007; Barton and Tan, 2010; Hazari et al., 2013; Rodriguez et al., 2017; White et al., 2019).

SCIENCE IDENTITY AND ITS IDENTITY CRISIS

The theoretical context of science identity is based on identity theory and subsequent developments (including self-concepts, self-meanings and individual perception scientific roles as theorised by Burke, 1991; Burke and Reitzes, 1991; Lee, 1998). Science identity identifies science type people (Vincent-Ruz and Schunn, 2018), namely learners across school levels whose interests and inclinations are within the scientific remit *broadly defined*. Studies (mostly, but not only) performed in pre-higher education environments demonstrated that science identity is driven by three factors: (i) sense of community and affiliation (Carlone and Johnson, 2007); (ii) attitudinal factors (both extrinsic and intrinsic) (Aschbacher et al., 2010) and (iii) alignment (match) between science at school and applied science (Archer et al., 2010). Science identity (and its development) are postulated to be constructed from experiences internalisation via a social construction with others, in certain contexts, thanks to the "*socialisation of individuals into the norms and discourse practices of science*" (Brown, 2004; Vincent-Ruz and Schunn, 2018, p. 2), and includes exposure to scientific experiences, enculturation and career entry (Christidou, 2011) via formal and informal learning experience and scientific exposure (Rodriguez et al., 2017).

The criticism toward the concept of science identity is related to two main aspects. The first aspect is the vagueness of its definition, such as "*developing an interest in*" or an "*intention to pursue a STEM career*" (Stets et al., 2017, p. 2), and of the related outcomes used to explore it. This is chiefly due to the perceived "*amorphous nature of the concept*," which renders the concept of science identity itself "*slippery and difficult to operationalise in a way that provides solid methodological and analytic direction*" (Carlone and Johnson, 2007, p. 1189). The second aspect is linked to the outcomes chosen to define it (and its impact). In fact, until the early 2000s, science identity has been diffusively perceived as a personal/subjective construct. In other words, a concept refractory to a quantitative categorisation as opposed to the objective outcomes that are part of the academic experience (i.e., if students with solid science identity chose a STEM subject as a university course and which academic results they obtain).

By analysing some of the key studies across the educational levels that have been published over the last 15 years, it seems that, from 2007 onward, many reports went beyond the second limitation by adopting quantifiable outcomes. These went well beyond academic matrices, ranging from a single-item scale for STEM identity (McDonald et al., 2019) to longer scales (Vincent-Ruz and Schunn, 2018). Several works even explored the factors associated with science identity, from the probability of entering a science occupation to its role in reaching academic success (Stets et al., 2017). Developing a strong science identity has been linked to improvement in science major persistence (Chang et al., 2011) and can provide a stronger sense of directionality to students' trajectories in STEM (Carlone and Johnson, 2007). More recently, studies showed that science identity could also be instrumental toward favouring a widened access of female BAME students in STEM at the college level (Rodriguez et al., 2017).

Nevertheless, this situation led to the opposite problem: the presence of a plethora of quantitative measures. In addition to this, there are many inconsistencies between scales and findings from different studies, from inconsistent conceptualisation as in science identity being a latent or an independent construct (Vincent-Ruz and Schunn, 2018) to its dependency on students' perceptions (Hazari et al., 2013) and science experience (Barton and Tan, 2010; Trujillo and Tanner, 2014). Furthermore, inconsistencies regarding the methodologies used to assess identity, from the quantification of the actions taken by the students (Archer et al., 2010) to their retrospective internalisation (Barton et al., 2013; Vincent-Ruz and Schunn, 2018), are also apparent.

SINGULAR OR MULTIPLE SELF-EFFICACY?

A third line of study had the merit of revamping the definition of *measurable* science identity as an "*individual's competence, performance, and recognition in a STEM-related field*" (Williams and George-Jackson, 2014, p. 99). This contributed to giving a solid, quantifiable boundary to a multifaceted, qualitative and abstract phenomenon. By anchoring science identity to the *performance* aspect, the revised definition had two main advantages. On the one side, it brought the concept of science identity closer to the one of professional identity, which, for scientists, revolves around the "*mastery of a discipline and the development of research skills*" (Ullrich et al., 2014, p. 1). On the other side, it put science identity in direct relation with the concept of self-efficacy.

Self-efficacy is the set of "*beliefs in one's capabilities to mobilise the motivation, cognitive resources, and courses of action needed to meet given situational demands*" (Wood and Bandura, 1989, p. 408). It is an individual's perception of the "*ability to perform designated tasks to accomplish a particular goal or identified outcome*" (Williams and George-Jackson, 2014, p. 99). It is rooted in social cognitive theory, which sees achievement based on a bidirectional interaction between the environment, behaviour and personal factors (affective, biological, cognitive) (Bandura, 1986; Flowers and Banda, 2016). Self-efficacy beliefs vary on three factors: (i) level/magnitude of task difficulty; (ii) strength (i.e., the certainty of performing a task successfully), and (iii) generality (how the first two factors can be generalised across different situations). In Bandura's earlier works, self-efficacy was primarily situation-specific (Bandura, 1986). Consequently, many of the seminal works tended to emphasise the first two factors and not the third one, highlighting the task-specific nature of self-efficacy.

But in 1997 Bandura wrote:

> "*Powerful mastery experiences that provide striking testimony to one's capacity to effect personal changes can also produce a transformational restructuring of efficacy beliefs that is manifested across diverse realms of functioning. Such personal triumphs serve as transforming experiences. What generalises is the belief that one can mobilise whatever effort it takes to succeed in different undertakings*" (Bandura, 1997, p. 53).

Consequently, the focus shifted from specific situations to a more generalisable context. The construct of General Self-Efficacy (GSE) entered the research arena (Eden, 1996) and was used to define "*individuals" perception of their ability to perform across a variety of different situations*' (Judge et al., 1998a, p. 170). This happened even though Bandura wrote, just some pages before, that GSE measures "*bear little or no relation either to efficacy beliefs related to particular activity domains [i.e., SSE] or to behaviour*" (p. 42). The act of ignoring (or not correctly reading) this warning led to a rise of GSE-related publications, which has been reportedly linked to self-esteem (Judge et al., 1998b, 2000), in a series of works replicated in STEM in more recent years, as we will explore in the next paragraph.

MEASURING SELF-EFFICACY

The GSE Scale has been historically used to measure GSE (Sherer et al., 1982; Sherer and Adams, 1983). More specifically, it has been the most widely used GSE measure from its conception to the early 2000s; despite being devised for research on clinical and personality aspects, it has also been extensively used within organisational settings (Chen et al., 2001). In 2001, the New General Self-Efficacy Scale (New GSE) was validated for organisational research and advised for studies on "*macro-performance that transcends specific situations*" (Chen et al., 2001, p. 79). The psychometric properties of the New GSE include higher content reliability and higher predictive validity (Chen et al., 2001). Moreover, the New GSE is unidimensional, shorter (8 items vs. 17), has a better predicted specific self-efficacy for certain tasks (Chen et al., 2001), and is now the most widely used measure for GSE.

Although both science identity and self-efficacy impact positively on doing science at a higher-university level, it is self-efficacy that plays a more prominent role in sustaining the *using science* and *doing science* concepts over time, according to a regression model reported in a study that recruited more than 1,800 undergraduate students (Williams and George-Jackson, 2014). This finding has been replicated more recently: self-efficacy promotes the formation (*cultivation*) of science identity, and even more so for minority students; as such, these aspects should be further investigated to widen participation and recruitment of BAME students and students from a broader range of socioeconomic statuses at university level, but also specifically for high-ranking/academically selective institutions (Flowers and Banda, 2016). Considering that the stronger the self-efficacy persuasion regarding occupational choice, the higher the certainty of that choice (Tracey, 2010), it follows that exploring self-efficacy within and outside the academic environment on both the alumni and the faculty side will deepen our understanding of this relationship.

SELF-EFFICACY IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

Self-efficacy influences task performance via goal-setting and self-regulation (self-monitoring, self-assessment and outcome-monitoring) during the performance (Bandura, 1991; Pintrich, 2003). Research on self-efficacy in STEM labelled self-efficacy beliefs based on "*mastery experience, an individual's task-specific experiences, and interpretation of those experiences*" (Rittmayer and Beier, 2008, p. 2). It also predicts the level of motivation for a specific task and task performance (Bandura and Locke, 2003; Abbas and North, 2018) and job performance

(Stajkovic and Luthans, 1998; Carter et al., 2018). Since the late 2000s, it has been used to predict STEM performance and perseverance (Rittmayer and Beier, 2008; Jungert et al., 2019).

Individuals with high STEM self-efficacy perform better and persist longer in STEM disciplines than those with lower self-efficacy (Rittmayer and Beier, 2008). High-school students, including underrepresented students, with a high sense of STEM self-efficacy are more likely to express an interest in pursuing a STEM degree (Byars-Winston et al., 2010). Additionally, a gender difference between men and female has been reported in pre-academic and academic STEM self-efficacy, which projects the chances of success in STEM (Schunk and Pajares, 2002; Tellhed et al., 2017). According to the earlier studies on self-efficacy, while mastery experience seemed to be the most critical source of STEM self-efficacy for young male learners, vicarious experience and social persuasion are the main driver for young female learners in mathematical, scientific and technological careers (Zeldin and Pajares, 2000; Pajares, 2005). In a large group of upper primary students, the students' stereotypical beliefs about STEM careers predicted negatively the expectations linked to careers and self-efficacy in STEM, and the latter predicted STEM career interest (Luo et al., 2021). Another large study conducted on more than 600 university students across two institutions showed a sort of mitigation of STEM self-efficacy imbalance (Wilson et al., 2015), probably due to the number of programmes introduced in early 2000 to recruit more young female learners in STEM, but exceptions still exist (Raelin et al., 2015). Asians, regardless of gender or specific area of STEM study, reported lower levels of self-efficacy than other major ethnic groups (Wilson et al., 2015). Instead, African American and Hispanic students demonstrated a higher level of GSE than Caucasian and Asian peers (Wilson et al., 2015). Whether this is a *localised* effect, which does not necessarily reflect the global picture, or a more widespread phenomenon is still an open question. Further investigations are needed to plan local and global interventions.

FOSTERING SELF-EFFICACY IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS WITH MENTORING

With targetted intervention, STEM self-efficacy can be improved across each school level. Increases in self-efficacy and STEM over time have been recorded longitudinally after hands-on training from public elementary school - with a high proportion of STEM underrepresented learners (Schlegel et al., 2019)- to higher education. For example, a 3-year longitudinal study with almost 400 undergraduate engineering students enrolled at four United States universities (Virginia Polytechnic Institute and State University, Rochester Institute of Technology, Northeastern University and the University of Wyoming) demonstrated that self-efficacy is a critical factor in student persistence and is influenced by three components: work, career, and academic self-efficacy (Raelin et al., 2015). However, there might be a hidden cultural correlation: the results may not necessarily apply to other prominent educational sectors. Still, they could be highly impacted by the fact that the sample was solely United States-based.

Assessing the academic self-efficacy at the beginning (i.e., at the admissions stage) and the end of the academic journey demonstrated that female students perceived themselves as academically weaker than men (despite similar academic performances); still, thanks to a mentoring programme, the equivalence in academic self-efficacy was reached by graduation (MacPhee et al., 2013). Similarly, students with double STEM-minority status (i.e., ethnicity and socioeconomic) had lower academic self-efficacy and performance than students with single STEM-minority status, but implementing a mentoring programme successfully increased the academic self-efficacy (MacPhee et al., 2013).

Recent works focussed on social/interactive aspects, well beyond the three components of work, career, and academic self-efficacy, and even discussed self-efficacy as a "*mobile construct to be re-achieved as students' progress toward advanced STEM degrees*" (Charleston and Leon, 2016, p. 152). Conducted in a cohort of 23 African American graduate students and faculty in computing, this report highlighted the importance of parents, teachers, mentors and peers on the two dimensions of *level* of self-efficacy and *persistence* in STEM studies (Charleston and Leon, 2016).

Another study conducted on students and teachers discovered a fundamental role of teachers' self-efficacy (in driving effective teaching and student learning) and teachers' awareness of STEM careers as they positively impact students when considering potential career choices (Knowles, 2017). Another recent work by John Geoff Knowles showed that science teachers' self-efficacy increased after 70 hours of professional development activities delivered over 3 years, the *Teachers and Researchers Advancing Integrated Lessons in STEM* (TRAILS) training (Kelley et al., 2020). Science teachers deeply benefitted from learning within a community of practice, which we will examine in the following paragraph, as shown by pre-test vs. post-test vs. delayed post-test survey assessments, engaging with real science and using their knowledge to solve authentic, real-world problems (Kelley et al., 2020). As many of these studies have been conducted in the United States and considering that local influences on attitudes and beliefs can play a key role in shaping self-efficacy, it would be interesting to explore the existence and the extent of inter-generational and intra-community roles in other countries. On this note, surveying and interviewing alumni and academics might give further information on how self-efficacy develops, its relationship with mentoring and how professional identity evolves within a community of practice.

MEASURING THE DEVELOPMENT OF PROFESSIONAL IDENTITY

Within a community of practice, a concept introduced in 1991 by the anthropologist Jean Lave and the educationalist Étienne Wenger (Lave and Wenger, 1991; Wenger, 1998, 1999), members learn from each other and, while doing so, they develop on a personal and professional level thanks to the sharing of knowledge, practices and experiences (Sandrone et al., 2021). Core characteristics of the community of practice are *becoming* and *belonging* (Wenger, 1999; Sandrone et al., 2021), which are key aspects of professional identity. Professional identity is defined as the set of "*attitudes*, *values*, *knowledge*, *beliefs*, and *skills*" shared with others within a professional group (Worthington et al., 2013, p. 187). It often affects how people interact and compare themselves to other professional groups (Adams et al., 2006; Crossley and Vivekananda-Schmidt, 2009). Professional identity is a dynamic process. Such development of professional identity, often accompanied with the development of interpersonal and communication skills, is reached via interaction and socialisation, but also engagement and observation of colleagues (Plack, 2006), and has been studied within communities of practice. A series of steps have been highlighted from graduating to being hired for a job, including relationships, responsibility and continued learning (Deppoliti, 2008).

After assessments with qualitative measures (Ohlen and Segesten, 1998; Cook et al., 2003), in 2006 a 9-item, quantitative tool called Macleod Clark Professional Identity Scale (MCPIS-9) was devised to map professional identity in interprofessional healthcare education (Adams et al., 2006). However, at a deep critical analysis, I noted this scale was largely derived from two previous scales. While the first one, originally on intergroup differentiation within an industrial setting (5-item scale, Brown et al., 1986) was explicitly cited in the article, the other one, on attitudes, stereotypes and social identity (10-item scale, Cinnirella, 1998), was not referenced by Adams et al. (2006).

In the same years, a 12-item professional identity scale was used in the New Generation Project Longitudinal Study (NGPLS): in addition to the 9 questions from Adams et al. (2006) three additional items have been included; two, slightly modified, from the aforementioned scales, namely Brown et al. (1986) ("*I am a person who criticises the profession for which I am studying*") and Cinnirella (1998) ("*I think of myself as a typical example of an average member of this profession*"), and a third one devised by Rebecca Foster and colleagues ("*When I hear someone who is not a member of this profession criticising this profession, I feel personally criticised*"). Over the years, the psychometric properties of these largely overlapping scales have been validated, showing good internal consistency, validity and reliability (Worthington et al., 2013; Matthews et al., 2019). Very importantly, they demonstrated to be good predictors of student retention and an ideal tool to explore the concept of identity within an academic context (Worthington et al., 2013; see also Cowin et al., 2013).

A more recent study conducted with a large cohort of undergraduate and recently graduated STEM students showed that science self-efficacy and science identity could be considered *fundamental* and *universal* mediators of commitment to a STEM career (Syed et al., 2019). No differences across ethnic groups or gender exist, and its mechanism of action occurs via support experiences, which can be modified within the academic environment (Syed et al., 2019). On a pragmatic note, given the substantial imbalance of BAME students in STEM programmes in many universities, exploring self-efficacy and professional identity can help create new targetted schemes to widen participation and support students while creating their STEM professional identity. Another study demonstrated that the key factors in supporting and sustaining the professional identity development of a group of Asian international STEM graduate students are "*previous work experiences, disciplinary skills acquisition, English proficiency, and socialisation with peers and faculty advisors*" (Park et al., 2018, p. 145), many of them labelled under the umbrella term *academic socialisation* (Park et al., 2018).

SENSE OF BELONGING IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS, FROM THE CLASSROOM TO THE COMMUNITY

Another fundamental aspect in defining science identity is the sense of belonging, the "*sense of being accepted, valued, included, and encouraged by others* (. . .) *in the academic classroom setting and of feeling* (. . .) *an important part of the life and activity of the class*" (Goodenow, 1993, p. 80, cited by Rainey et al., 2018, p. 2).

The higher the sense of belonging, the higher the chances of having successful academic careers as a student (i.e., retention rate and marks received) (Master and Meltzoff, 2020). Several factors impact the students' sense of belonging. Some of them are inside the classroom, such as the interactions with fellow students (Johnson, 2012) and academics (Ramsey et al., 2013). In contrast, others are outside the classroom, such as engaging/contributing to discussions with peers (Espinosa, 2011). Both sets of factors are correlated to the creation of support networks (Rainey et al., 2018). Importantly, these factors can be fostered: academic and environmental interventions reportedly improved women's and minorities' sense of belonging (Smith et al., 2013; Walton and Cohen, 2011).

However, at a deeper analysis, differences in STEM seem to be even more accentuated (Master and Meltzoff, 2020): fostering contextual factors can be at least equally, if not more impactful (Rainey et al., 2018), in STEM disciplines, where a higher sense of belonging has been measured for white men but lower rates for women and BAME learners (Good et al., 2012; Smith et al., 2013). This can be exacerbated within the "*highly selective predominantly white institutions*" (Dortch and Patel, 2017, p. 202) and in relation to the low representation that women and BAME learners have at the hierarchical levels of STEM disciplines (Murphy et al., 2007), to the extent they are left wondering whether they fit in the study environments or not as they are less likely to feel they belong (Rainey et al., 2018). BAME and underrepresented groups lacking representation may struggle to strengthen their sense of belonging in any STEM programme. Nevertheless, sense of belonging can be fostered, and its impact seems more pronounced in learners from disadvantaged backgrounds and BAME students (Rainey et al., 2018; Strayhorn, 2018). Although the literature on this is still in its infancy, this constitutes one more reason why investigating the concept of identity can help design strategies to support identity development.

FUTURE PERSPECTIVES

Over the last 20 years, scholars and analysts, including in the United States (Atkinson and Mayo, 2010; Hoeg and Bencze, 2017; National Academies of Sciences, Engineering, and Medicine, 2018) and the United Kingdom (Smith, 2011; Hutchison, 2012; Smith and White, 2019), have underlined the importance of increasing the number of students (and teachers) entering and staying in science. Women and BAME students have historically been underrepresented in STEM: by 2045, the BAME population in the United States will be around 40% (United States Census Bureau Report, 2012), but represented only 10% of the STEM PhD awarded during the past decade (National Science Foundation, 2015). According to a projection of the Bureau of Labour, STEM jobs would have been highly sought after and linked to higher earnings than humanities jobs Statistics (United States Census Bureau Report, 2012). In the United Kingdom, "*the number of STEM undergraduates has been increasing over the last few years*" but "*a shortage of STEM graduates*" still exists and represents a "*barrier in recruiting appropriate staff*" (HM Government, 2017, p. 97). A report from the Royal Society showed that less than 20% (19.2%) of STEM academic staff under the age of 34 is from an Asian background, and less than 2% (1.8%) is made of black scientists (Joice and Tetlow, 2020). The situation might be further exacerbated by the consequences of the COVID-19 pandemic, which reportedly hit BAME and under-represented learners more than other groups (Lynch, 2020; Spacey et al., 2020).

We need to recruit talented people, sustain them during the academic journey, and give them the possibility to interact with the next generations of scientists.

(1) *Signposting hard work vs. being born scientists*. At each school level, teaching staff should signpost the importance of hard work over inner talent and brilliance. In the words of Lewis et al., (2016, p. 020110–7), "*emphasising that*" certain skills "*are not fixed, but instead expandable with effort and hard work, might neutralise the negative ability stereotypes*" people can come across. For example, discussing famous and less known examples from the history of science can help to demystify the natural talent for science. This can be impactful across several levels. Moreover, this can be reinforced by schools wanting to attract "*STEM teachers with instructional expertise, leadership, and who are interested in gaining leadership in advocacy*" (Velasco et al., 2022, p. 451).

(2) *Promoting and showing diversity (topics-wise and careers-wise)*. Scientists within and outside academia can discuss insights from their careers and take questions in dedicated *Meet the scientist* events, which can work very well from high school onward. As shown by Sax et al. (2018) in a computing course, simple events can contribute to increasing the sense of belonging. Planned interventions demonstrated that students' identities shifted toward a more relevant STEM interest and increased the perceived competence within a single semester, especially among underrepresented minorities (Robinson et al., 2019). At the undergraduate and post-graduate levels, other actions can include showing slides with research done by scientists from diverse backgrounds, which increased sense of belonging in a neuroscience course at Brown University (Linden et al., 2020), and reminding students of the importance of citing research from diverse groups of people in the reference list to neutralise the citation bias (Dworkin et al., 2020; Zurn et al., 2020).

(3) *Integrating active learning in the curriculum for an authentic learning journey*. As explained above, active learning nurtures sense of belonging and becoming (Sandrone and Schneider, 2020; Sandrone et al., 2021), and its integration into the curriculum can lead to benefits on different levels. Moreover, students should be encouraged to learn how different scientific subjects "*can be integrated for application in real-world problems*" (Kareem et al., 2022, p. 1).

CONCLUSION

As "*unfamiliarity can contribute or exacerbate existing social inequality*" (Wong and Chiu, 2021, p. 499), integrating some of the strategies mentioned above might mitigate the stress or the insecurity around embodying new identities. It is fundamental to sustain and support science identity development across all career stages. Championing diversity can support students from disadvantaged backgrounds in identifying themselves with a series of possible and potential science-related identities. We have the duty to facilitate every possible way for students to identify as scientists and embrace science identities. Now it is time to act.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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