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Centering a Triangle of Affirmation for Equity in STEM

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ABSTRACT

As the demographics of US schools continue to diversify, STEM leaders, educators, and researchers must continue to work to address the inequities present in STEM classrooms, programs, and fields. One crucial step towards equity in STEM is an intentional mindset shift that centers the affirmation of all learners as valuable contributors to STEM. This article introduces the Triangle of Affirmation, a framework that addresses the interrelatedness of identity, positioning, and belonging. While exploring each individual affirmation element, their connectedness to one another, and actionable educator steps, this article calls to shift mindsets in STEM to center inclusive diversity through a framework of affirmation, a relational triangle, to address the inequities in STEM.

Keywords: Belonging, Equity, Identity, Math, Positioning, Science, STEM

INTRODUCTION

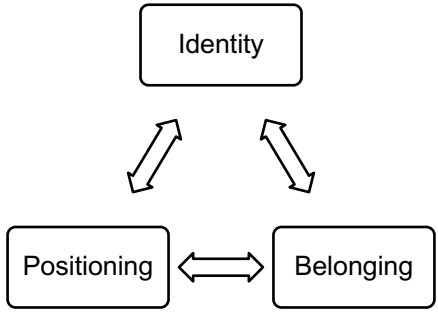
As the demographics of schools continue to shift and become more diverse, representation within STEM (science, technology, engineering, and math) fields does not proportionately reflect this same shift (National Science Foundation, 2023, 2024). Researchers and educators must continue to look at the inequities present in STEM education classes, programs, and fields (Fry et al., 2021) to combat this lack of representation. It is well researched that barriers continue to

remain in STEM for marginalized groups, and educators must shift to have inclusive diversity at the center of STEM learning (Asai, 2020). This centering of diversity in STEM requires a shift to affirming the individual's experience in STEM and viewing the diversity of the individual as an asset. Research highlights the importance of focusing on identity and positioning of each individual learner so that students envision themselves in STEM (Dou & Cian, 2022; Kayumova & Harper, 2020), and research has linked the sense of belonging to feeling connected to STEM (Peterson et al., 2024; Van Herpen et al., 2020). Educators must shift to focus on identity, positioning, and belonging in STEM spaces to affirm all learners within STEM. However, these concepts are often separated from one another, and a lack of professional development emphasizing these three elements leads to the ideas being researched but not embedded into practice.

Rather than looking at identity, positioning, and belonging in isolation or in pairs, the three elements of affirmation should be combined into a relational triangle. I posit that this lens, a Triangle of Affirmation (See Figure 1), connects identity, positioning, and belonging as a framework for all work in STEM spaces. This focus on identity, positioning, and belonging shifts the focus of the STEM space to the individual and is a necessary shift for creating more equitable STEM experiences for students of diverse backgrounds. Professional development opportunities and preservice teacher programs must then train STEM educators to address these inequities within STEM spaces through this lens; this article seeks to explain the elements of the triangle, their interconnectedness, and possible steps that can be taken by educators.

Figure 1

Triangle of Affirmation



LITERATURE REVIEW

Identity

STEM identity is defined as the beliefs and dispositions that students develop about their own ability to both perform and participate in STEM contexts (Aguirre et al., 2013). An individual's STEM identity is developed and reinforced, both positively and negatively, throughout students' formal and informal STEM experiences. People who identify positively with STEM, thus having a positive STEM identity, are more likely to persevere through challenging contexts and problems in STEM as well as continue in and pursue STEM fields (Bishop, 2012; Gholson & Wilkes, 2017; Miller-Cotto & Lewis, 2020). Furthermore, possessing a positive STEM identity directly affects achievement, retention and participation in STEM (Fernandez et al., 2024). When students feel recognized as scientists and experience a positive classroom STEM climate, their STEM motivation, identity, and career aspirations increase (Bodnar et al., 2020; Starr et al., 2020). Therefore, to address the inequities in STEM spaces, educators must center the intentional inclusion of the development and strengthening of a student's STEM identity.

Students' STEM identities are intertwined within their other identities, for example, gender, race, language, etc. (Miller-Cotto & Lewis, 2020). Moreover, learning is a social process, so a student's experience is affected by their interactions with others around them, and these interactions involve the whole student, including their multiple individual identities. As a result of both positive and negative perceptions of these individual identities, a student's recognition as a person of STEM is often limited by both themselves and those around them (Dou & Cian, 2022). Additionally, teacher and parental stereotypes, attitudes, and beliefs toward specific genders and ethnicities in STEM are strongly related to the development of a student's STEM identity (Fernandez et al., 2024) and thus impact students' perceptions of themselves as people of STEM.

As educators, we must re-envision the inclusion of all elements of a student's identity to break down these biases and perceptions of which identity types are more apt to be successful in STEM. Carlone and Johnson's (2007) framework, which includes three major factors impacting a person's development of a science identity, can be used as a tool in STEM classrooms to intentionally focus on identity. This framework includes science-related social performances, their science related knowledge and competence, and sense of belonging/recognition as a science person. While often classes focus specifically on the second component of the framework, science related knowledge and competence, a higher emphasis must be placed on the first and third components to fully implement this framework. This relies on educators focusing on the social experiences of all individuals in STEM, such as in group work/class discussions, and students seeing themselves as a STEM person through intentional integration of their other identities and their personal backgrounds/experiences. Furthermore,

science identity and its reinforcement is impacted by a student's sense of community and affiliation, their own attitude toward science (both intrinsically and extrinsically), and the match between science at school and their applied science (Sandrone, 2022). Without shifting mindsets and pedagogical practices to embrace all learners' backgrounds and experiences, learners from nondominant communities are forced to assimilate into the dominant culture or be left out/excluded from STEM learning (Kayumova & Strom, 2023). Thus, educators must connect all students' experiences, communities, and usage of STEM to develop and reinforce their STEM identities.

Possible Teacher Actions:

- Incorporate a student's Funds of Knowledge.
  Funds of Knowledge refers to the knowledges, skills, and cultural practices passed down to individuals through their families (Esteban-Guitart & Moll, 2014).
- Go beyond a surface level of culture.
  Consider Edward T. Hall's iceberg analogy when thinking on culture in which 90% of culture is not visible. Surface levels of culture (10%) include elements that are observed, such as clothing, names, and music. Examples of deeper levels of culture that need to be embedded into STEM classrooms are ways of interaction (i.e., Collaboration vs Individualism), relationship norms, thought patterns, cocreation of knowledge, etc.
- Center STEM leaders and include posters with diverse cultural and linguistic representations.
- Embrace a translanguaging stance.
  Translanguaging refers to the ability to move fluidly between languages without adhering to the political boundaries of named languages (García et al., 2017). Encouraging the use of all the languages in a multilingual learner's linguistic repertoire affirms their identity as a multilingual person in STEM.

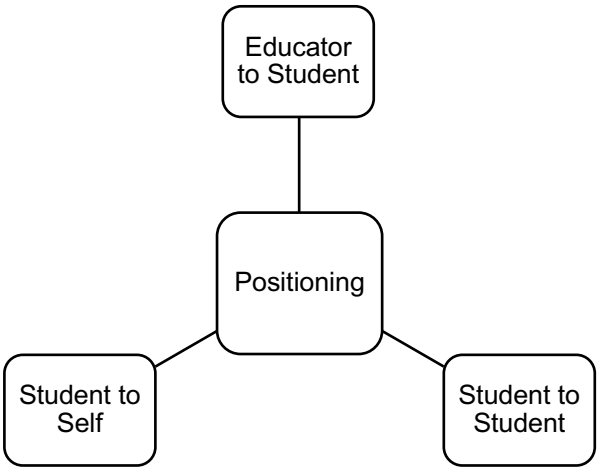
Positioning

When one engages in different spaces with others, the individual naturally formulates ideas about themselves and others around them. These perceived ideas about themselves and others, also known as assumed positions, play a role in how students interact within the classroom space. Positioning refers to the way in which people negotiate their identities through others (Chval et al., 2021; Zangori & Pinnow, 2020). These positions or roles placed upon students are a result of three relationships: student to self, student to student, and teacher to student (See Figure 2). Put simply, some students may position themselves as leaders, others may position them as leaders, or the teacher may position them as leaders. The opposite

scenario also occurs in which a student feels as though they are not a leader, and they are not positioned as leaders by others. This positioning of oneself and those around them plays a role in one's success in STEM (Chval et al., 2021). Furthermore, biases, stereotypes, and prior experiences in STEM affect the initial and continuing positions placed upon learners from diverse backgrounds (Brockman, 2021). Educators must take intentional steps to position all students as leaders and participators in the STEM space by focusing on these three relationships.

Figure 2

Position Relationships



Positioning theory is centered around three key tenets: positioning, storylines, and social acts (Felix & Ali, 2023; van Langenhove & Harré, 1999). Positioning refers to the role that is assigned to a person, whether intentional or not, in that space. Storylines refer to the situations (stories) that occur within the space that reinforce or negate that positioning, and acts refers to the actions that take place within or after this situation. For example, a student may see himself as a strong leader in math (self-positioning); the student raises his hand continuously and solves the problems in front of the class (storyline), and his friend says, "you are so good at math!" (act). This student's position is reinforced as a leader in math. In contrast, a student may think that he has never been good at math (position); he

puts his head down and shuts down due to not understanding the context of the problem (storyline), and another student giggles when the student is called on to respond to a question (act). This student's self-assigned position as not being a math person, is reinforced and thus, he continues to see himself as not being able to excel in mathematics.

Within every conversation and interaction a person positions others as well as themselves, both unintentionally and intentionally (van Langenhove & Harré, 1999); therefore, there is a constant positioning and repositioning of students. During each positioning and repositioning, the students affirm, adjust, and negotiate their identities in the STEM space (Kayumova et al., 2022). This gives educators multiple opportunities to reposition students as leaders and participators in STEM by intentionally focusing on how they position students, what classroom scenarios and narratives they help develop (storylines), and the ways in which they respond to the scenarios (acts). This requires educators to actively consider the role positioning plays in their environments. Furthermore, by analyzing the social forces that construct and impact students' positions, storylines, and acts, educators center social justice within the STEM classroom (Varelas et al., 2024) as they deconstruct and reconstruct these positions to include all learners as leaders and active participants in STEM.

By centering positioning, especially through empathy, students transcend the boundaries of STEM as they position their experiences and connections at the center of STEM work (Edelen et al., 2023). This centering switches the lens from content and teacher-driven to relational and student-driven; this lens shift transforms learning for students of all backgrounds as they connect to STEM through their own lenses. Therefore, valuing and centering positioning in STEM recognizes that each student comes with a diverse perspective that is necessary and valued within the STEM space.

Positioning students' cultural and linguistic assets as strengths results in a positive development of their science identities, an increased engagement in learning STEM, and a sense of belonging and well-being (Kayumova & Tippens, 2021). Therefore, educators must be mindful of the ways students are positioned (self, others, and teachers) in their classrooms. Additionally, they must actively build upon the assets each individual brings to the STEM space and then must intentionally position each student as both a leader and participator in the classroom.

Possible Teacher Actions:

- Assign roles to intentionally place different students in distinct roles that change regularly, such as group leader, discussion leader, group presenter, etc.

- Provide linguistic and academic supports and scaffolds during discussions and throughout classroom discourse so that all students can be seen as active and successful participants.
- Actively call on all students and find opportunities for all students to share ideas with supports readily available, such as sentence frames, bilingual dictionaries, etc. as needed.
- Be prepared to disrupt storylines that reinforce stereotypes and biases.

Belonging

Belonging has been defined in different ways as it gains more attention in education. Broadly speaking, having a sense of belonging means possessing a feeling of contentment, mattering, and importance within a space (Ovink et al., 2024). Mathematical belonging, which can be extended to the other STEM fields, refers to someone feeling safe and valued within their learning community and feeling seen as a contributor to the development of the ideas, values, beliefs, and knowledge (NCTM Publications, personal communication, 2024). An additional explanation of STEM belonging is feeling comfortable and safe in the STEM space (Dost, 2024). Simply put, belonging means to feel both welcomed and needed within a group. For a student to feel a sense of belonging in the STEM space, they must feel valued, feel they can grow, and feel seen by themselves, other students, and teachers (Watson, 2023).

Feeling a sense of belonging impacts one's persistence, motivation, and academic success in STEM (Tandrayen-Ragoobur & Gokulsing, 2021; Van Herpen et al., 2020). In their research study focusing on belonging, Hansen et al. (2024) found that participants in programs centered around belonging had higher persistent rates in STEM, and this centering of belonging resulted in more equitable STEM environments and a higher rate of continuation in STEM for low-income, underrepresented STEM students. Social stereotypes and biases, within both academic capabilities and abilities, highlight the belonging of males in STEM rather than females resulting in females feeling as though they need to conform to the masculine default to feel they 'belong' in STEM (Schmader, 2023). This lack of sense of belonging continues to perpetuate the lack of representation of females within traditionally male-dominated, STEM fields. As belonging is one of the psychological needs that impacts intrinsic motivation (Ryan & Deci, 2016), there must be a greater emphasis placed on belonging for all populations, especially marginalized populations in STEM.

For students to begin to feel STEM belonging, students must feel that they have unique perspectives and experiences that they need to share within the STEM space. Furthermore, they must feel as though they can achieve by intentionally adding in opportunities for students to grow and contribute by building upon their academic, linguistic, and cultural assets. Educators must also add in scaffolds that

build all students up rather than simplifying the curriculum and watering down the STEM experiences of students. They must also see examples of individuals and contexts that reflect their own cultural experiences and identities regularly in both the classroom setting and in the curriculum. By centering the individual as a needed and valued part of the STEM space and group, students' STEM belonging is reinforced.

Possible Teacher Actions:

- Add linguistic and academic supports and scaffolds that elevate rather than water down curriculum.
- Make sure the classroom space includes posters, languages, and curricular material that centers students of all backgrounds.
- Make classroom/group roles and norms so that all students feel a sense of purpose and belonging in the classroom.
- Include culturally diverse contexts so that all students see their background valued.

The Interrelatedness of Identity, Positioning, and Belonging

Individually, identity, positioning, and belonging have been shown to impact an individual's connectedness and continuation in STEM. Research also connects pairs of these affirmation elements to one another. Master and Meltzoff (2020) connect the importance of belonging and identity in the persistence in STEM; in their STEMO (STEreotypes, Motivations, and Outcomes) developmental framework, they highlight the usage of belonging as an intervention for identity development. In their book focusing on STEM identity and belonging, Howson and Kingsbury (2024) curated articles connecting identity and belonging as essential interrelated components for STEM connections in both classrooms and non-disciplinary spaces. Individuals who feel they are valued and needed within the space (belonging) are more likely to persevere and feel they have a role and place in STEM (identity).

Positioning has also been connected to identity development. Within their study of multilingual learners, Kayumova et al. (2022) argues that positioning theory can be used as the lens in which to connect learners' identities to the STEM space to transform their learning space to one of affirmation. Furthermore, in their STEM identity model, Dou and Cian (2022) connect social positioning, via recognition in STEM, as a critical component of the development and reinforcement of one's STEM identity. Put simply, if one feels seen as having a positive position within the STEM space, their identity as a person of STEM is reinforced not only to themselves but also to the other individuals in the space.

Positioning and belonging also have a direct relationship with one another. Thereby, when positioned as a leader or as a valued participant in STEM (positive positioning), one feels a sense of belonging (positive belonging). Within their research study with multilingual learners, Tripp and Waight (2024) found that having robust, affective relationships between classmates in which all are valued and heard (positioning) within STEM spaces led to a space of comfort and belonging for learners; this focus on the relationships is essential for an inclusive learning space. In contrast, persistent negative stereotypes and lower numbers of underrepresented minorities and females in STEM result in a lack of positive positioning of these individuals and lead to a lack of sense of belonging within that STEM space (Brockman, 2021). This combined lack of belonging and positioning impacted their continuation and persistence in STEM.

DISCUSSION AND CONCLUSIONS

The Triangle of Affirmation

To affirm our students in STEM, educators must center identity, positioning, and belonging as a complete framework to fully affirm all students as leaders, thinkers, and participants in STEM. Despite the clear connections in research between pairs of these affirmation elements and these elements individually, there lacks a framework looking at the interconnectedness of all three elements. Due to the overlap and relationship among identity, positioning, and belonging, the three should be seen as integrated and woven together when we emphasize the student as an individual in STEM. For example, positioning affirms identity, having a sense of belonging affirms a positive positioning, and feeling a sense of belonging affirms a positive identity; therefore, we should view these three elements as a relational triangle in which each element reinforces and affirms the other elements. Focusing on one element separate from the others is a missed opportunity for continued affirmation of all three critical elements of affirmation.

In contrast, by connecting and centering all three elements as a relational whole, educators reframe their classes to connect pedagogical practices, classroom environments, and curriculum to an element of affirmation. For example, focusing on positioning involves engagement, supported discourse and leadership, focusing on identity involves cultural relevancy and building upon the Funds of Knowledge of students, and focusing on belonging involves adding in meaningful scaffolds to build upon the assets of students and having curriculum that includes diverse leaders in STEM. The classroom elements within each part of the triangle overlap and reinforce one another, and the educator's mindset shifts toward affirming the individual in STEM. Centering and supporting all three elements reframe the STEM classroom to affirm students of all backgrounds, focuses on inclusive

diversity in STEM, and addresses inequities in STEM, especially for marginalized populations.

IMPLICATIONS

Although professional development efforts focus on equity and support in STEM, often efforts focus on specific curricular elements, such as adding linguistic scaffolds and making STEM content more comprehensible. These efforts fail to address the necessary mindset shift needed to center the whole student in the STEM space, especially for marginalized groups. Innovative professional development (PD) is a critical component on meeting the ever evolving needs of STEM educators (Joseph & Uzondu, 2024) and improves educators practices and self-efficacy in STEM (Brand, 2020; Kelley et al., 2020; Zhou et al., 2023); this PD is critical to avoid a theory to practice gap. However, a lack of access to high quality STEM PD persists (Mohamad Hasim et al., 2022).

Pair the separation of identity, positioning, and belonging with a lack of professional development emphasizing the three elements, and there remains a continuation of the status quo within STEM. Professional development opportunities and preservice teacher programs must train STEM educators to address inequities within STEM spaces through this affirmation lens. By centering the Triangle of Affirmation, educators shift the focus of classroom supports, design, and practices to align with affirming and developing the students' connectedness to STEM. Teacher education programs and professional development providers must reframe the way that they teach educators within STEM fields to intentionally connect elements of their teaching and classroom environment to the three dimensions of the triangle. This mindset shift intentionally incorporates identity, positioning, and belonging as a lens for STEM equity. This shift is necessary to center all individuals as people of STEM.

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Note: The authors did not use OpenAI's ChatGPT or any other AI tools in the drafting, editing, or refining of this manuscript. All content was generated, reviewed, and refined solely by the authors.
