BOARD # 190: A Call to STEM Exposure: Reinforcing Young Women and Planting Seeds

Madeleine Mickle, MoLSMAP

As an Afro-Latina women , I have always been interested in math and science and I wish to see young women especially those of color to take education seriously and learn how to grow for a lifetime. Therefore I try to be a leader and mentor in the field not only helping those on my College campus but children in Highschool and Middle school through nonprofit organizations.

Dr. Tayo Obafemi-Ajayi, Missouri State University

Dr. Tayo Obafemi-Ajayi is an Associate Professor of Electrical Engineering at Missouri State University in the Engineering Program, a joint program with Missouri University of Science and Technology (S&T).

A Call to STEM Exposure: Reinforcing Young Girls and Planting Seeds

Madi Mickle [1], Amber Lewis [2], Tayo Obafemi-Ajayi [1]

[1] *Missouri State University, Springfield MO 65897*
[2] *A Girl Like Me Mentoring Network, Springfield MO*
mm3737s@missouristate.edu, ambylewis@aglmn.org, tayoobafemiajayi@missouristate.edu

Abstract:
Expanding STEM opportunities for females is crucial not only to address longstanding gender disparities in science, technology, engineering and math (STEM) fields, but also to unlock a broader spectrum of innovation, foster inclusive economic growth, and ensure that future advancements reflect the diverse needs of society. Systemic barriers contributing to the gender gap in STEM disciplines are deeply embedded in societal norms, institutional structures, and cultural expectations, particularly for people of color. Race tends to amplify the gender gap in STEM for women of color by layering unique stereotypes, cultural expectations, and systemic exclusions. Addressing the gender gap in STEM without considering race will inevitably leave many of the most marginalized women behind. The intersection of race, gender, and socioeconomic status even further uniquely intensifies these barriers, compounding systemic disadvantages and creating distinct challenges not experienced by females from more privileged economic backgrounds. Empowering marginalized communities necessitates systemic efforts to expose young girls of color to STEM education in environments that affirm their identities and foster sustained engagement.
This study introduces the Affirmation Wheel, a pedagogical project activity, designed to teach girls key STEM concepts across various stages of the engineering process while simultaneously fostering positive self-esteem and affirming identity. More than a simple educational exercise, the Affirmation Wheel serves as a daily reminder of individual potential and resilience. The project seeks not only to cultivate STEM interest but also to empower young girls of color with critical life skills such as perseverance, determination, and self-sufficiency. By affirming that opportunities exist despite challenges, the initiative aims to dismantle negative societal stereotypes associated with women of color in STEM and inspire participants to pursue bright and successful futures. To evaluate its effectiveness, pre- and post-assessments are administered before and after the activity.

Introduction

While systemic biases and social constructs have historically limited opportunities for marginalized groups—particularly women of color—in science, technology, engineering and math (STEM) disciplines [1], there is growing recognition of the need to dismantle these barriers. Despite comprising half of the overall workforce in the United States, women represent just over one-quarter of employees in STEM fields, highlighting the ongoing persistence of the gender gap [2]. The intersection of race, gender, and socioeconomic status contributes to distinct barriers experienced by women of color in STEM fields, amplifying the effects of multiple, overlapping forms of bias [3–5]. These intersecting factors result in experiences that differ qualitatively from those of white women, men of color, or individuals from more advantaged socioeconomic backgrounds. Contemporary society is shaped by a continuously evolving, self-reinforcing social framework, informed by individual experiences and subjective observations [6,7]. Beginning in early childhood, children demonstrate a keen ability to recognize societal cues regarding gender norms and expectations [8]. As they progress from elementary to middle school, their awareness of gender-based stereotypes in STEM increases, often showing a moderate correlation with their personal acceptance of these beliefs. Empirical studies have shown that many children adopt the belief that brilliance is a predominantly male attribute at a young age. Once internalized, this stereotype begins to shape their interests and can significantly constrain the range of careers they consider in the future [9, 10]. When, from an early age, girls are exposed to the pervasive stereotype that men possess superior abilities in mathematics and science; this can negatively impact their experiences and opportunities across multiple stages of their lives [11]. This usually

results in girls exhibiting diminished interest in STEM related fields and are less inclined to pursue them.

To mitigate the effects of this "STEM is for guys" stigma, it is imperative to expand access to as well as engagement with technology and STEM fields within these communities. Our aim is to promote familiarity through increased knowledge and a deeper understanding of technological functions. It is hypothesized that such exposure may foster more positive attitudes, gradually diminishing resistance and mistrust, thereby contributing to a more inclusive and collaborative environment for future generations. Within this context, affirming learning environments play a critical role in counteracting negative perceptions and fostering a sense of belonging that encourages girls of color to engage meaningfully in STEM disciplines.

This study introduces an innovative approach, the **Affirmation Wheel**, designed to convey STEM concepts to middle and high school girls of color in a manner that both affirms their capabilities and promotes a sense of empowerment. The Affirmation Wheel is intended to serve as a daily reinforcement of the attainability of a successful future, while simultaneously introducing STEM concepts to young girls in an accessible and non-intimidating manner. While it may initially appear to be a simple educational activity, the Affirmation Wheel embodies a deeper pedagogical function grounded in the principles of Community Cultural Wealth [12]. It draws upon and affirms the existing aspirational and resistant capital of girls of color by framing challenges not as barriers, but as opportunities for growth and self-actualization. This approach leverages students' lived experiences and strengths to promote sustained motivation, empower agency, and cultivate a supportive environment that inspires both individual perseverance and collective advancement. Qualitative data analysis of the Affirmation Wheel as an educational activity illustrates its effectiveness in serving as a means of self-esteem booster as well as motivating students to further explore STEM related activities.

Background and Setting

This project is rooted in the theoretical Community Cultural Wealth (CCW) framework [12]. CCW challenges deficit-based perspectives that often view communities of color as lacking the cultural capital necessary to succeed in educational settings. It highlights the diverse forms of capital that these communities possess, including familial, aspirational, social, linguistic, resistant, and navigational capital. These forms of capital are critical assets that our young girls of color can leverage to navigate and resist systemic barriers within educational systems, particularly in STEM fields where they are underrepresented. Given the unique intersection of race, gender, and socioeconomic status, we draw from Acevedo and Solorzano's adaptation of CCW [13] as a protective factor against racism. The overall aim to create an educational environment that not only acknowledges the systemic barriers faced by our girls, but actively works to dismantle them by harnessing the strengths of these girls and their communities. By engaging the girls in meaningful STEM experiences and activities, such as the Affirmation Wheel, and connecting them with mentors who recognize and value their cultural capital, we can foster a supportive and inclusive learning environment that enhances their academic readiness, persistence in STEM pathways, and overall sense of belonging.

This project was conducted in partnership with A Girl Like Me Network (AGLMN, www.aglmn.org), a local non-for-profit mentoring organization in Springfield, Missouri, whose mission is to empower women and young girls in grades 5^{th} to 12^{th}. The local non-for-profit organization has been in existence and working with young girls in the region for five years. Living in a predominantly white environment, girls with low socioeconomic status tend to face an uphill battle to overcome struggles and negative influences in relationships from diverse aspects of life, including home, school, and the community. To address these challenges, AGLMN seeks to create a safe environment by offering meaningful mentorship based on connecting participants with individuals who share their experiences and fostering a trusted supportive community. Dedicated to equipping young girls for success in the real world, they promote a diverse set of skills such as leadership and innovation, while actively engaging them with stimulating projects and opportunities from STEM fields. A significant observation is that many of these young girls have experienced failure on various levels multiple times, resulting in a reduced perception of their own self-efficacy.

Self-awareness is one of the foundations that is an important step in understanding yourself and changing yourself [14]. Thus, to spark their interest in STEM concepts and empower them to overcome negative stereotypes regarding the abilities and potential of girls of color in this field, it is essential to address and bridge the gap in their self-perception of ability. In accordance with the guiding principle of "Affirmation", the Affirmation Wheel was subsequently developed to facilitate a substantial transformation that prioritizes a holistic approach to cultivating self-esteem, with the overarching objective of further advancing the skill sets of the participating young girls. Note that the Affirmation Wheel, a tangible engineering design project, is distinct from the Triangle of Affirmation [15], which serves as a conceptual framework addressing the interrelatedness of identity, positioning, and belonging. This initiative seeks to cultivate the confidence necessary to engage with unfamiliar subject matter that societal norms and pressures might otherwise dissuade exploration of. By establishing a supportive foundation rooted in encouragement and a strong sense of identity, the Affirmation Wheel project aims to reframe STEM

not as an intimidating domain, but as an accessible and inviting opportunity. Ultimately, the goal is to inspire participants to confront and embrace increasingly complex challenges, thereby fostering enhanced self-confidence and a strengthened belief in their own capabilities.

Methods

A prototype of the Affirmation Wheel is shown in Fig. 1. The objective of the project is to create a free-standing rotating wheel designed to systematically release ping-pong balls, one at a time, with each full rotation. Each ping pong ball contains handwritten affirmations crafted by the young girls. The wheel is connected to a button that initiates a single full rotation, allowing a ball to be dispensed and come to a resting stop for the girls to read and reflect upon. The wheel is designed to hold enough ping pong balls to provide 14–15 daily affirmations, covering a two-week period. Its compact size ensures it can easily fit on a bedside table or dresser, allowing the girls to seamlessly incorporate it into their daily routine. Through craftsmanship and innovation, a single sheet of cardboard is transformed from 2-D shapes into 3-D structures, symbolizing the process of turning abstract ideas into tangible, functional creations with our own hands. The addition of a motor brings the Affirmation Wheel to ”life,” representing the drive for determination and motivation.

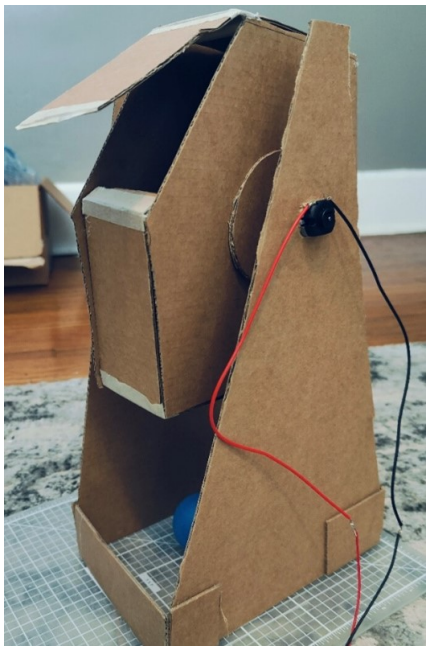


Fig. 1: An initial prototype of affirmation wheel

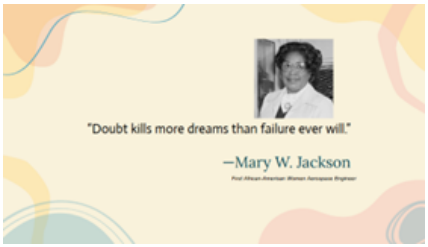
Our approach centers on the individual’s development within a collaborative and supportive team-based environment. While each participant is individually responsible for executing and completing the project, she receives encouragement and guidance from her peers throughout the process. This structure is intentionally designed to underscore the importance of affirming each participant’s capability to independently initiate and successfully complete the project.

Guided by the Community Cultural Wealth (CCW) framework, the construction of the affirmation wheel was intended to nurture three key forms of social capital among the girls—encouragement, resilience, and individuality—as expressions of their existing cultural assets and experiential knowledge.” These qualities are integrated into the project through the way it is presented and taught to the girls. This pedagogical approach (Fig. 2) ensures that the Affirmation Wheel was not merely an activity, but a transformative and affirming experience. It functions as a daily site of reflection and resistance, reinforcing the importance of staying committed to one’s goals and aspirations in the face of structural and personal challenges.

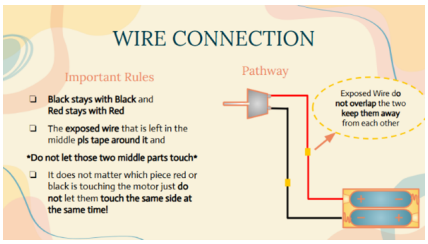
The teaching presentation is structured into sequential segments, each highlighting a distinct component of the Affirmation Wheel. The transition slides feature reflective questions about the future, affirmations, and inspirational quotes from women of color in STEM fields. This approach not only allowed us to observe the real-time application of affirmations but also emphasized their role in fostering resilience throughout the activity. To further cultivate inspiration among the participating girls, each affirmation was paired with visual representations of women role models, offering tangible embodiments of their own potential. Additionally, the reflective questions

were deliberately crafted to foster a sense of autonomy, encouraging the girls to critically engage with their aspirations and envision the possibilities they seek to realize. By integrating these components into a cohesive project, the Affirmation Wheel activity, aims to ignite a sustained sense of inspiration—motivating participants to envision ambitious futures and pursue their goals with confidence, agency, and determination.

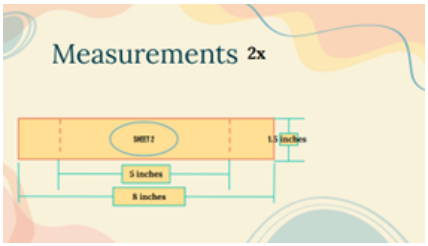
(a) Examples of easy everyday affirmations



(b) Quotes from (and pictures of) inspirational women of color



(c) Digital diagrams of step-by-step procedures



(d) Dimensional sketch of components of the wheel

Fig. 2: Presentation highlights

For our young girls of color, image and fashion are a very important aspect of their identity [16]. Usually in life, we each possess our own personal style, which is expressed outwardly through how we carry ourselves and the way we dress. Style does not only convey expression of how we see ourselves or the world, but a bold outward reflection of experiences that shape us. Thus, it was important for the Affirmation Wheel to be a mean through which each girl could reflect their unique personality and style. This was attained by allowing them to personalize their wheels with embellishments, decorative tapes, and creative coloring on different sections, making each project a true expression of their individuality.

The act of placing self-written affirmations into the wheel is designed to embody the process of manifesting personal goals and aspirations. As the famous saying goes, ”Your body is your temple,” or in this case, your ”wheel.” The visual act of the affirmation emerging from the Wheel symbolizes the realization of one’s aspirations or serves as a powerful reminder to continue striving and putting in the necessary effort to achieve them.

Qualitative Analysis and Evaluation

To assess the impact of the Affirmation Wheel, we conducted pre- and post-assessments to gather data on the emotional fluctuations experienced by the girls during the process, with a particular focus on self-confidence and motivation, both internally and in their interactions with others. We were interested in assessing their interest in STEM activities, personal growth, and holistic development. The pre-assessment survey was based on a Likert scale to establish a geneal baseline of emotions [17]. The post-activity assessment was designed as a reflective survey featuring open-ended questions. Its purpose was to encourage the girls to express their thoughts openly and in greater detail, providing insights on their personal growth and experiences throughout the project.

We also incorporated a post-activity group discussion session. Activities that relied heavily on behavioral observations, particularly within similar age groups, proved to be more effective in eliciting inner thoughts by allowing participants to express how they felt verbally rather than in writing. To ensure the success of these group discussions, we established criteria based on the concept of ”classroom etiquette”. Commonly referred to as self-monitoring, this approach emphasized the importance of individuals being mindful of their behaviors. The reflective group discussion exercise helped convey effective cooperation, accountability for achieving goals, and maintaining engagement throughout the activities. These qualities are also essential for persistence in STEM learning.

Pre-activity assessment questions included:

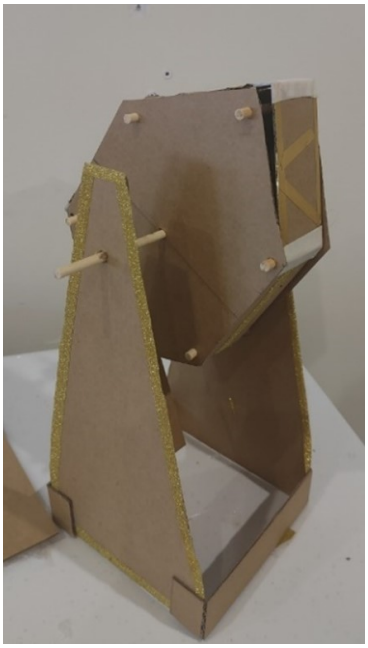
- How well do you understand your own emotions and what triggers them?
- On a scale of 1 to 10, how confident do you feel in your abilities and talents?
- Do you feel empowered to take control of your future and make positive changes in your life?

Examples of some of post-activity assessment questions are:

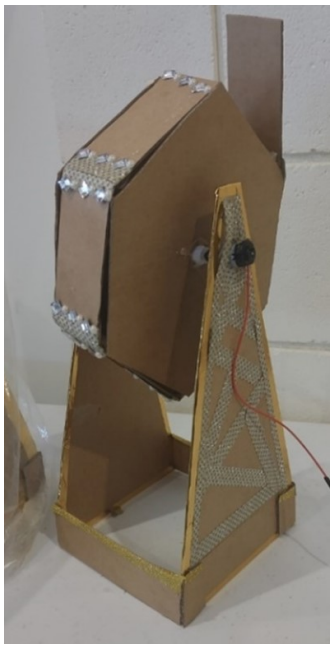
- What new concepts or skills did you learn and how do you feel they will benefit in the future?
- Did you notice any changes in your mindset or outlook because of practicing affirmations?
- What specific lesson or experience from the camp do you feel will have a lasting impact on you?

(a) Girls taking measurements

(b) Laid out components of the wheel



(c) A completed project



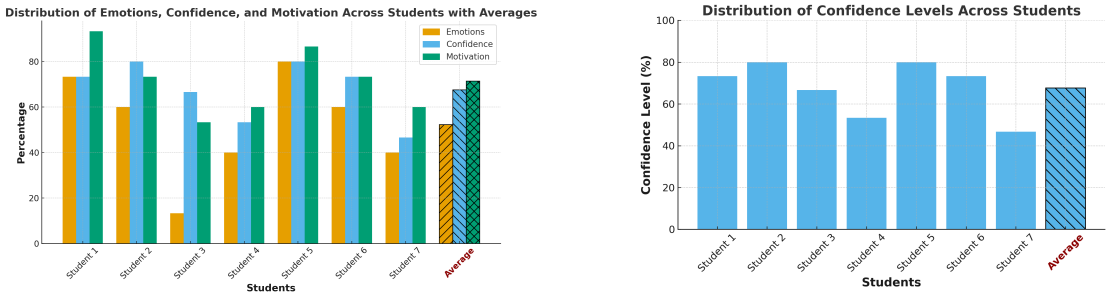
(d) Another completed project

Fig. 3: Pictures from the trial run of the Affirmation Wheel project.

Results and Discussion

The preliminary trial run of Affirmation Wheel activity was conducted during the annual one week long summer camp organized by AGLMN for their constituents. The camp usually consists of various activities designed to empower the girls with life skills (such as Cardiopulmonary Resuscitation (CPR) certification), friendships, sense of belonging, and introductory to STEM-related activities. It also included reflective activities designed to enhance self-awareness by helping to understand the factors that influence or trigger them, both emotionally and externally.

We had ten girls participate in the Affirmation Wheel activity. The sequential aspects of the design process of of the affirmation wheel exercise in action are illustrated in Fig. 3. The girls demonstrated a great deal of enthusiasm in contributing to their success in the project. Even when they encountered challenges, there was a drive to complete the step and eagerly move on to the next. The difficulty of the project seemed to be on par with the given grade level. The challenges were just enough to where if they focused well and gave their best effort, results were possible. On the topic of engagement, most girls started the project without much persuasion. Those who were hesitant saw their friends enjoying themselves and felt inspired to give it a try too. More than half of the students completed the wheel project. Both qualitative data analysis from group discussions and the Likert scale questionnaire offered valuable insights into the young girls' thoughts and the internal conflicts they faced while approaching the challenge. From the pre-assessment Likert-scale questionnaire (completed by 7 out of 10 girls), 28.6% of the students demonstrated good emotional well-being, 28.6% average emotional well-being, and the remaining 42.9% had poor emotional well-being. The confidence and motivation levels were low across the board (See Fig. 4a). From the post-assessment surveys, students expressed an average of 9.2 out of 10 rating satisfaction with the exercise and how they felt about themselves. The outcome of the pre and post assessments, from the Likert scale, are also illustrated in Fig. 4. The predominant STEM skill that they reported as useful and most likely to be beneficial in future was "building" and "learning how to use measurement tools".



(a) Outcome of Pre-activity assessment.

(b) Post-activity assessment of confidence levels.

Fig. 4: Outcomes of pre- and post activity assessments based on Likert-scale questionaire.

Their responses highlighted the probable sources of their insecurities prior to beginning the task and allowed reflection on their emotions and confidence after successfully completing it. In addition, the assessments explored moments when the girls felt that they had overcome the learning curve and were fully engaged with the experience. This process effectively captured their growth and the mindset shifts that occurred throughout the activity.

The feedback received from the group discussion was predominately positive. The group also discussed how to incorporate affirmations into daily aspects of their life in the future. Many girls agreed to become more social and confident in themselves and their abilities. One girl stated, "by being my true self, and being more honest with myself". Another key takeaway from the concluding discussion questions was "In STEM, what new concepts of skills did you learn?". One girl stated "building, it was more fun than expected". When asked for suggestions or feedback on the Affirmation Wheel many responded with "none", while a few suggested "more building projects".

Conclusion and Future Work

The outcome of the data analysis demonstrated that factors such as self-affirmations, the enhancement of self-confidence through group encouragement are very instrumental in dismantling insecurities of STEM activities. The confidence of the girls was increased by being able to start and complete an engineering design project on their own. Although the trial run involved only 10 girls, it provided valuable constructive feedback on aspects they enjoyed and areas that could be improved to enhance the project's success in the future.

One challenge encountered during the preliminary run was the uneven weight distribution of the ping pong balls in the Wheel. Participants who wrote more affirmations were able to load all their balls into the Wheel but faced difficulties spinning it consistently. To address these issues, rather than limiting the number of affirmations, we are exploring the use of stronger motors and lighter materials for constructing the Wheel. Apart from minor feedback concerning the physical design elements, there was minimal critique regarding the overall process or pedagogical approach. As evidenced by the participants' responses, the activity was perceived as intellectually engaging and emotionally resonant, with many expressing heightened motivation and enthusiasm as they progressed through each phase. The evolving construction of the Affirmation Wheel served not only as a vehicle for demonstrating their existing knowledge and cultural strengths, but also as a means of rendering their efforts visible and

meaningful. In alignment with the principles of the CCW framework, this process affirmed the girls' aspirational, resistant, and navigational capital—highlighting their agency and reinforcing their capacity to shape and visualize their futures.

Future iterations of the activity will incorporate extended sessions spanning multiple days, as opposed to the preliminary short-format model. This expanded structure is designed to facilitate deeper engagement, enhance participation, and allow for more comprehensive instruction and experiential learning. By affording participants increased time for reflection and active construction, these efforts aim to counteract prevailing deficit-based narratives that often undermine young girls' perceived potential in academic and professional contexts. Through the intentional creation of exploratory and empowering learning environments, the Affirmation Wheel project seeks to foster a sense of agency, positioning participants as future innovators, leaders, and equitable contributors to societal advancement."

Acknowledgment

This work was partly supported by the National Science Foundation award (1619639), Show-Me STEM: The Missouri Alliance for Minority Participation (MoLSAMP).

References

1. D. W. Carbado and D. Roithmayr, "Critical race theory meets social science," Annu. Rev. Law Soc. Sci. **10**, 149–167 (2014).
2. D. Kinkopf and H. Dack, "Teachers' perceptions of increasing stem self-efficacy among female middle grades students," RMLE Online **46**, 1–21 (2023).
3. L. Charleston, R. P. Adserias, N. M. Lang, and J. Jackson, "Intersectionality and stem: The role of race and gender in the academic pursuits of african american women in stem," J. Progressive Policy & Pract. **2**, 273–293 (2014).
4. D. M. Sparks, S. D. Przymus, A. Silveus, Y. De La Fuente, and C. Cartmill, "Navigating the intersectionality of race/ethnicity, culture, and gender identity as an aspiring latina stem student," J. Latinos Educ. **22**, 1355–1371 (2023).
5. L. Perez-Felkner, K. Erichsen, Y. Li, J. Chen, S. Hu, L. Ramirez Surmeier, and C. Shore, "Computing education interventions to increase gender equity from 2000 to 2020: A systematic literature review," Rev. Educ. Res. p. 00346543241241536 (2024).
6. L. Foster, X. Uribe-Zarain, and T. Obafemi-Ajayi, "Microaggressions in the heartland "flyover" region: history, progress, lessons learned and challenges," Equal. Divers. Inclusion: An Int. J. **43**, 531–550 (2023).
7. S. E. Bibri, "The social shaping of the metaverse as an alternative to the imaginaries of data-driven smart cities: A study in science, technology, and society," Smart Cities **5**, 832–874 (2022).
8. A. Master, "Gender stereotypes influence children's stem motivation," Child Dev. Perspect. **15**, 203–210 (2021).
9. L. Bian, S.-J. Leslie, and A. Cimpian, "Gender stereotypes about intellectual ability emerge early and influence children's interests," Science **355**, 389–391 (2017).
10. J. Jaxon, R. F. Lei, R. Shachnai, E. K. Chestnut, and A. Cimpian, "The acquisition of gender stereotypes about intellectual ability: Intersections with race," J. Soc. Issues **75**, 1192–1215 (2019).
11. R. Knasel, "Reducing gender bias against women in stem through self-affirmation and persuasive arguments," Ph.D. thesis, The Ohio State University (2019).
12. T. J. Yosso*, "Whose culture has capital? a critical race theory discussion of community cultural wealth," Race ethnicity education **8**, 69–91 (2005).
13. N. Acevedo and D. G. Solorzano, "An overview of community cultural wealth: Toward a protective factor against racism," Urban Educ. **58**, 1470–1488 (2023).
14. D. L. Rajagukguk, A. Salim, Y. Muhammad, and T. Ramadhanis, "Training to build students' self-awareness to improve qualities in facing the digital era," Indonesian J. Community Serv. Cel **2**, 92–99 (2023).
15. H. Brandon, "Centering a triangle of affirmation for equity in stem," Am. J. STEM Educ. **4**, 75–89 (2025).
16. J. Bettie, *Women without class: Girls, race, and identity* (Univ of California Press, 2014).
17. R. Magalhães, F. S. Marcondes, D. Durães, and P. Novais, "Emotion extraction from likert-scale questionnaires: –an additional dimension to psychology instruments–," in *International Conference on Intelligent Data Engineering and Automated Learning,* (Springer, 2023), pp. 166–176.