PRISM Intervention Toolkit

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Tool prepared by Emily Cyr, Patricia Colaco, Sarah Myint, Kayla Robinson, Shyamaly Vasuthevan, and the Project PRISM Team.

ENGENDERING SUCCESS IN STEM

Table of Contents

Overview

Addressing Gender Bias in Early STEM Education

Project PRISM was designed to address gender gaps in early STEM education. Despite girls and boys often achieving similar grades in math and science, girls are less likely to pursue STEM education and careers into adolescence and adulthood. We point to the pervasive effects of gender stereotypes and bias in STEM: girls are stereotyped as less interested in and capable at STEM activities, and both boys and girls tend to automatically "think STEM, think men". Further, girls often report a low sense of belonging or "fit" in STEM. This feeling of mismatch between the self and the environment is associated with a reduced likelihood of entering or staying in STEM.

Through two distinct interventions, we tested how to make early STEM education more inclusive. Both projects were grounded in strong theory, tested in a real-world educational setting (STEM summer camps), and have easily implementable components for practitioners to plug into their existing systems. Each intervention takes the form of a semi-structured conversation lasting about 10-15 minutes.

Intervention #1 focuses on a persuasive appeal intervention aimed at improving boys' perceptions of girls' STEM ability. The intervention components include a value affirmation (to induce open-mindedness), a data-driven persuasive argument, a transformative metaphor (explaining the concept of stereotypes), and a personalized anecdote to encourage reflection. See our toolkit of methods below, as well as our results in *Cyr et al., 2023.*

Intervention #2 focuses on a diverse role model intervention aimed at improving girls' forecasted "fit" (or match between their identity and the environment) in STEM. Importantly, this intervention is tailored to girls' forecasts of their *future* fit, rather than their current fit. The intervention components include role models delivering messages related to value affordances (how pursuing STEM careers supports important values, including communal values), diversity of identities and self-concepts, and social inclusion by peers inside and outside of STEM. See our toolkit of methods below, as well as our results in *Cyr et al., in press.*

Comparison: Control conversations. The intervention conversations were contrasted against an "empty control", which mimicked a typical conversation about camp experiences.

Before Intervening

Our interventions were tailored to specific social environments and social dynamics. We provide practical suggestions for both considerations.

Social Environment: STEM Summer Camps

Participants were recruited from mixed-gender STEM educational contexts.

We took a partnership approach by working directly with Actua, an existing and highly engaging early STEM education organization.

We embedded our research projects within Actua's week-long summer camps tailored toward students starting grades 6-8. These camps focused on a variety of STEM topics, such as robotics, biology, and software engineering. We seamlessly integrated our interventions into the existing camp structure while leveraging the extensive hands-on experience and practical training of the camp counselors and staff (see next section).

Importantly, we deliberately selected camps that included both boys and girls, as this reflects typical educational settings (e.g., public schools). It also provided opportunities for participants to reflect on their relationships with same-gender and different-gender peers, all within a STEM context.

Finally, because of the "pre-post" structure of our designs (surveys administered before the intervention, then again following the intervention), a stable, long-term social environment was preferable.

We therefore suggest partnering with a social environment:

- With a focus on STEM topics
- With flexible scheduling capabilities
- Where girls and boys interact with one another in stable groups
- Where children participate over several consecutive days

Social Dynamic: Conversation Leaders

Interventions (and matched controls) were a semi-structured conversation with a role model in STEM, termed here a "conversation leader."

Conversation leaders were typically camp counselors (or another uniformed staff member already embedded in the camp). Their existing relationships with participants allowed conversations to develop naturally, grounded in baseline familiarity. Further, study-related conversations blended into the broader flow of daily conversations between campers and staff.

All conversation leaders were undergraduate or graduate students in STEM fields, allowing them to draw from a personal experience with the gendered dynamics of these environments. This background also provided a rich foundation for the personalized anecdotes woven into the semi-structured conversations, as conversational leaders could share authentic, lived experiences with participants.

Where possible, conversations were conducted one-on-one, with the conversational leader selecting an appropriate moment to pull aside their assigned participant. To minimize disruption to camp activities and reduce the likelihood that participants would feel they are missing out, conversations typically occurred during "free time" or transitional periods (e.g., drop-off).

We therefore suggest leveraging conversational leaders who:

- Are existing role models within the environment
- Are already familiar with the study participants, prior to the critical conversations
- Have experience studying or working in STEM
- Can pull participants aside for one-on-one conversations

Is This Guide for You?

This guide was designed as a helpful resource to anyone interested in early education—particularly those focused on topics related to STEM (science, technology, engineering, math). That might include educators interested in how subtle messages about who can succeed in STEM can influence students' educational and career trajectories. Parents may also be interested in understanding how they can best support their children in planning for the future, by creating safe and equitable social environments.

Intervention #1: Gender Stereotypes

Opening Boys' Minds to Girls' True STEM Ability

Intervention #1 aimed to improve boys' perceptions of girls' STEM abilities. On average, boys (and girls) tend to underestimate girls' STEM ability—meaning that girls' true potential in STEM is often hidden (or "latent"). Our multi-stage intervention successfully improved boys' perceptions of girls' STEM ability. This positive shift in boys' perceptions had broader social effects: boys with more positive perceptions of girls' STEM ability were more likely to be nominated as a "friend" or "best friend" by their female peers.

Core Objectives

1. Create a genuine connection between the STEM conversation leader and the participant
2. Facilitate open-mindedness and reduce potential defensiveness
3. Explain how societal barriers can lead to some talents being "hidden" or "latent"
4. Instill a greater appreciation for girls' (and women's) STEM ability
5. Encourage reflection on social relationships with female peers in STEM

Intervention Components

The interventions took the form of semi-structured conversations with a male conversation leader. Conversations began with introductions (e.g., exchanging names and STEM interests) and icebreakers (e.g., "If you could design a perfect day, what would it be?"). Following came a genuine personal story designed to affirm the participant, a video about the concept of latent ability, and then a personalized reflection piece. Conversations finished with a discussion about camp experiences (e.g., "What was your favourite camp activity?").

Affirming story. The conversation leader shared a genuine story that linked the participant's top-rated value (from the pre-intervention survey) to their own decision to pursue a STEM education or career.

Important note: The affirming story was based on the *participant's* top-rated value, which was often communal in nature. Most participants rated Family as their most important value (75%), followed by Friends (6%), and Education (5%). Conversation leaders prepared stories for each value. Here is one real story for the "Family" value:

> *"Growing up in a household full of STEM majors, I was encouraged to go to a middle school that specializes in STEM education. It was here where I worked side by side with my dad on a science fair project, where I created an air filter using cheap materials. Working on this project with my dad brought the two of us closer together and helped me win a gold medal at the fair. "*

Videotaped persuasive appeal. Next, a psychology professor explained the concept of latent ability in a pre-recorded video (note that the conversation leader relayed this information verbally in our first year of data collection). This professor described a scenario where two runners achieve similar speeds, yet the true ability of one runner is masked by their wearing ankle weights.

This metaphor is then used to describe how societal stereotypes can impede our recognition of others' true abilities.

Importantly, this video used a data-driven approach; drawing on real-world experimental findings (cited in the video) to support its persuasive appeal. It also featured a respected expert in the field to increase the likelihood of persuasion. The metaphor introduced by the professor was intentionally free of references to gender or STEM, allowing participants to flexibly consider the effects of societal barriers for various groups.

Personalized anecdote and reflection. After the video, the conversation leader reaffirmed the overall argument that societal barriers can lead to some groups' abilities being undervalued or underestimated. Right after this explanation, the conversation leader recalled an experience when they belatedly recognized the true ability of a female peer/mentor in STEM, such as:

> *"Thanks for watching the video! When I first saw it, it reminded me of how much I depended on my friend Anna in one of my Chemistry workgroups—I first thought she was more into theatre than science, but she stayed up really late helping me study for the exam and I couldn't have done so well without her. "*

Finally, participants were encouraged to consider a time when they perhaps underestimated the true STEM talents of one of their female peers.

Overall Recommendations

Although we allowed for minimal variations on this "kitchen sink" style intervention, given past work on this domain and extensive feedback from the conversation leaders, we suspect that maintaining these central components would lead to the best outcomes. See also the suggestions above that apply to field interventions more broadly.

1. Begin with an affirmation to induce open-mindedness
2. Leverage data-driven findings and topic experts
3. Include personalized anecdotes and real-world examples
4. Encourage reflection

Intervention #2: Forecasted Fit in STEM

Encouraging Girls' Identity Fit in STEM

Intervention #2 was focused on encouraging girls to imagine their future selves in STEM. By late childhood, girls tend to show a weaker interest in STEM than boys, despite comparable abilities in science and math. We point to a potential mismatch between their identity and the environment (a lack of "fit"): If girls expect that they cannot be their true selves within STEM spaces, they might simply decide that STEM isn't a good fit for them long-term. Through our multi-stage intervention, we improved girls' ability to envision themselves fitting in STEM pathways as an adult, with related benefits to their interest in STEM education and careers.

Core Objectives

1. Create a genuine connection between the STEM conversation leader and the participant
2. Explain how pursuing STEM can facilitate important personal values and goals
3. Demonstrate a diverse array of adult STEM role models
4. Model social inclusion by STEM and non-STEM peers
5. Encourage prospection into the future

Intervention Components

As with Intervention #1, Intervention #2 took the form of semi-structured conversations with a conversational leader--here, female. Conversations began with introductions (e.g., exchanging names and STEM interests) and icebreakers (e.g., "If you could have any superpower, what would it be?"). Following came a genuine personal story to affirm the participant, a video showcasing diverse STEM undergraduate students, and another personal story about feeling included both within and outside of STEM. Conversations finished with a discussion about camp experiences (e.g., "what was your favourite camp activity?")

Value/Goal Connection: Female conversation leaders shared a genuine personal anecdote demonstrating how they pursued each girl's top-rated value or goal (from the pre-intervention survey) by going into STEM. The majority of participants rated Family as their most important value (85%), followed by Friends (5%), and Education (3%). The participant was then asked to reflect on how they could do the same. Here is an example anecdote given for the "Family" value:

> *"When my sister was in Grade 3 and I was in Grade 2, she was always excited to teach me something she'd learned in school that day. When she learned about currency, she and I sat in our basement, and she taught me what each coin was worth and how to use them to pay for things. I remember that her excitement to repeat math and science information was so infectious that I became excited about math as well."*

Diverse Role Models: After sharing their anecdote, conversation leaders showed participants a 5-minute video of diverse undergraduate STEM students describing their projects, motivations, and future career goals. Each role model described how going into STEM allowed them to pursue personal (and often, communal) goals particularly meaningful to them--and highlighted a group of female friends in STEM. The video ended with a call to action asking participants to contemplate what they could personally achieve through STEM.

Social Inclusion: After watching the video, the conversational leader drew attention to the strong friendships between a group of young women and shared a personal story about her own sense of community. Notably, the leaders focused on their friendships with other female students in STEM--a key motivator for girls' STEM-related decisions--as well as peers outside of STEM. Here is a genuine example of a social inclusion anecdote:

> *"During my undergrad I studied with one of my friends in my program during lunch. I found out that a few of my other friends in music studied during lunch period as well. When I found this out, we started studying together during lunch periods. We studied with these girls from the music field and my friend would quiz me on the human anatomy material that I was studying at the time, and I would help her memorize her music pieces. It was comforting that we could work together even though we weren't studying the same thing. "*

Overall Recommendations

Given our past pilot work testing different variations of this intervention, we have some specific insights into which components are the most likely to support positive outcomes. See also the suggestions above that apply to field interventions more broadly.

1. Maintain focus on the future (i.e., early adulthood), but not *too* far into the future
2. Provide a diverse array of potential role models in STEM
3. Touch upon different ways of interpreting potential fit in STEM
4. Encourage reflection

Key Measures

For each of our interventions, we used self-report surveys to assess our potential outcomes.

Intervention #1

Our key measure was a composite of 3 items assessing perceptions of **girls' STEM ability**. For comparison, we asked additional questions pertaining to perceptions of boys' STEM ability and perceptions of girls' and boys' non-STEM (i.e., writing) ability. Participants responded to each of these 8 items using a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Importantly, this measure was only asked in the "post" survey, to prevent any backlash associated with questions related to potential gender bias.

- "In general, {**girls**/boys} my age are good at **math**"
- "In general, {**girls**/boys} my age are good at **science**"
- "In general, {**girls**/boys} my age are good at **computers**"
- "In general, {**girls**/boys} my age are good at **writing**"

Intervention #2

We asked participants about their **fit in STEM (current and forecasted), and interest in STEM high school courses and careers**. For comparison, we also asked matched items involving non-STEM domains (e.g., writing, English classes, journalism careers). Participants responded to each item from 1 (*not at all*) to 5 (*extremely*). Importantly, fit and interest were assessed in both the "pre" survey and the "post" survey (with an additional midweek survey for forecasted fit).

- ***Current STEM fit***: "How much do you **feel like you belong** in your **math** classes?"
- ***Forecasted STEM fit***: "How much do you **feel like you would belong** in an **engineering** major?"
- ***STEM high school classes***: "How interested are you in each of these **high school classes**?" (e.g., Advanced Math, Advanced Chemistry, Advanced Physics)
- ***STEM careers***: "How interested are you in going into each of these **careers**?" (e.g., Engineer, Scientist)

Friendship Networks

In addition to the self-report measures described above for Intervention #1 and Intervention #2, we collected friendship nominations from girls and boys in each camp. By asking each child to report which of their peers were a "friend" (or "best friend") versus "not a friend" (or "I don't know them"), we were able to construct an overall network of the genuine friendships within each camp. As described in Cyr et al. 2023, boys with more positive perceptions of girls' STEM ability were nominated by more of their female peers. Although such network measures are resource-intensive, they allow for key insights into how peer interactions are affected by individual beliefs (and vice versa). See Cyr et al., invited revision. for more details on friendship networks within these summer camps.

Talking About Complex Topics

When talking about complex topics—especially with kids—our words really matter! We've given some examples of how we define and describe some of these key terms and concepts.

Key Concepts

STEM stands for Science, Technology, Engineering, and Math. STEM education encourages the development of vital skills that can help us build and explore the world around us.

Two step persuasion is a framework that can facilitate open-mindedness toward potentially sensitive or challenging messages. Typically, it involves:
1. *Affirming the listener's personal values* to reduce defensive biases
2. *Having a trusted and expert source* present the appeal to increase persuasiveness

Stereotypes are generalized and commonly held beliefs - often incorrect ones - about a group of people with a shared identity (i.e., gender, race). When we **"stereotype"** someone, it becomes difficult to recognise the traits, interests and abilities that make them unique.

Latent ability refers to a person's true potential being obscured by external factors. For example, girls' actual abilities in STEM are often overlooked or underestimated due to persistent societal stereotypes that girls (and women) don't belong in STEM.

Role models are people who can embody an example of what others aspire to be. Having diverse role models (e.g., women, people of colour) can allow children to better see themselves and their identity reflected in STEM environments and recognize their full potential!

Double inclusion is the phenomenon of being simultaneously "included" by two different social groups. It is the opposite of "double isolation," a phenomenon characterized by girls in STEM feeling excluded by both their (predominantly male) STEM peers as well as their (predominantly female) non-STEM peers.

Identity fit is the extent to which someone's identity aligns (or "fits") with their environment - or how they perceive their environment. Fit can be assessed along three dimensions:
Self-concept fit: *Does this reflect who I am?*
Goal fit: *Will this help me get where I want to go?*
Social fit: *Do I feel like I belong here?*

Gender is socially constructed and represents a collection of culturally bound norms, behaviours, roles, and aesthetics. While gender exists on a continuum, it is often categorized using binary terms such as "girls" (or "women") and "boys" (or "men"). For narrative clarity, we occasionally use the terms "female participants" or "male participants" to refer to gender (not biological sex).

Sex is defined by a set of biological and physiological characteristics, such as chromosomes and gene expression, hormones, and reproductive anatomy. Commonly, sex is characterized as female and male. We did not directly study biological sex.

Crediting This Work

When presenting, please ensure you credit Project PRISM of Engendering Success in STEM, with funding by the Social Sciences and Humanities Research Council (SSHRC).

Reviewed Papers

Cyr, E. N., Steele, J. R., Schmader, T., Robinson, K., Wright, S. C., Spencer, S. J., & Bergsieker, H. B. (invited revision). Friendship networks predict girls' STEM fit and interest through subjective belonging. *Group Processes and Intergroup Relations*.

Cyr, E. N., Spencer, S. J., Wright, S. C., Steele, J. R., Kroeper, K. M., Colaco, P., Dennehy, T. C., Shum, P., Ballinger, J.T., Nam, H., Reeves, S. L., Wells, M., Schmader, T., & Bergsieker, H. B. (in press). Seeing women who fit: Girls' forecasted fit in STEM fosters career interest. *Social Psychology of Education.*

Cyr, E. N., Kroeper, K., Bergsieker, H. B., [...] Wright, S. C., & Spencer, S. (2023). Girls are good at STEM: Opening minds and providing evidence reduces boys' stereotyping of girls' STEM ability. *Child Development, 95*(2), 636-647. doi.org/10.1111/cdev.14007

Recommended White Papers

Designing Gender Inclusive Classrooms

Reducing Boys' Gender Bias & Improving Girls' Anticipated Fit in STEM

Reducing Boys' Stereotyping of Girls' STEM Ability

Role Models in STEM

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Engendering Success in STEM (ESS) is a research partnership of social scientists, STEM experts, and stakeholders in STEM industries and education, united by the shared goal of fostering gender inclusion and success in STEM (Science, Technology, Engineering, and Math). We use an evidence-based approach to break down the biases girls and women face on their pathway to success in STEM. Applying two decades of research, our team tests interventions that harness the power of positive social interactions to reduce the effects of implicit gender bias. These interventions target the distinct obstacles that are unique to each step along the path from early education to industry (see successinstem.ca for more information).

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