

# Developing STEM identity: Beyond STEM content knowledge in an informal STEM club

Sue Ellen Richardson, Purdue University

Elizabeth Suazo-Flores, Purdue University, ✉ [esuazo@purdue.edu](mailto:esuazo@purdue.edu)

Michaela Rice, Purdue University

*In this study we seek to expand the boundaries of mathematics education research. We explored a group of women's experiences attending an extracurricular, informal STEM (science, technology, engineering, mathematics) club in the 1990s. Using oral history methods, we learned that women's experiences in life and the club contributed to their identity development. These women have allowed themselves to be, or keep searching for, who they want to be. As a collection, these stories evidence the potential of informal learning spaces as spaces for identity development that are usually absent in school mathematics. As identity development is crucial to develop critical and independent thinkers, this study is a call for creating spaces where underrepresented learners, like women (Wood, 2020), can reach their fullest potential.*

As mathematics teacher educators (MTEs), we have partnered with the founder of a long-running extracurricular, informal girls STEM club (GSC) on a broad research agenda to document, celebrate, and analyse the experiences of the founder, club leaders, and girls who have participated in the clubs. The GSCs were initiated in the United States in 1994 by a parent who was dismayed to hear her 10-year-old daughter opt herself out of attending a magnet school because “math is hard” (Personal communication, October 20, 2020). This mom knew that math was not hard for her daughter, who had great test scores and grades. Her daughter seemed to be sliding into not wanting to appear smart, and she wanted to do something to stop it. She started the first GSC at her daughter's school for her and her friends in fifth and sixth grades. For 25 years, this mom shared resources from robotics, engineering, science, mathematics, and computer science, as well as support for implementing activities and developing funding sources and club policies to help GSCs spread all over the world in 28 states and 9 countries (e.g., Nigeria, Vietnam, Australia, and England) to enhance girls' interest and confidence with STEM in an informal, afterschool learning environment.

Leaders run the clubs for girls in grades K-12, ages five to 18, and plan the activities, which may be completed in a single club meeting or be extended projects over a semester. Leaders are facilitators, rather than the one who holds the answers and gives grades, as they work to create environments and activities that support girls to take risks and develop

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positive feelings and dispositions towards STEM. For example, as girls, the women in our study explored activities related to the stock market, dissecting owl pellets, meeting women who work in STEM careers, and assisting a veterinarian.

In this study, we aimed to document memories of women's experiences attending the first GSC in 1994. We used oral history (Shopes, 2011) as a data collection and analysis method. We consider that these women's stories provide insights into the influence of informal learning spaces on supporting women's identities. We investigate the following questions: What stories do participants share about themselves and the GSC? What insights can we (MTEs) gain from learning about the participants' identities?

## **Perspectives and theoretical framework**

### *Mathematics education and informal learning spaces*

Mathematics education is a field that emerged at the intersection of mathematics and psychology (Kilpatrick, 2014) that has broadened its research topics and practices over time (Stinson & Walshaw, 2017). Although the focus in mathematics education research has been the "didactic triad" (Valero, 2010, p. LX) of the relationship between mathematics, teaching, and learning, researchers have called for expanding research topics outside of the didactic triad (Ernest, 1998; Valero, 2010). Examples of the expansion of mathematics education research topics are the research program called ethnomathematics (D'Ambrosio, 1985) and mathematics in informal learning spaces (Nemirovsky, Kelton, & Civil, 2017; Nunes et al., 1993).

### *Informal learning spaces and GSCs*

Extracurricular, informal learning spaces like GSCs provide opportunities that can sustain girls' early interests in STEM disciplines through their later years of schooling in various ways. Sadler et al. (2012), for example, suggested that programs designed to support school-aged girls' interest in mathematics and science can increase their interest in choosing STEM-related career paths at the end of high school. Exposing girls to a variety of female role models in STEM learning and careers allows girls to see that they are worthy of representation in STEM fields (Anderson & Cavallaro, 2002). Hands-on activities that excite, spark curiosity, and connect school-day lessons to their everyday lives can increase girls' interests and shape their identities in STEM areas (e.g., Chen et al., 2011; Holmes et al., 2012; Bell, Lewenstein, & Shouse, 2009; Tyler-Wood et al., 2012). Other positive academic impacts can include improving STEM content knowledge, enhancing motivation and engagement in STEM learning, and improving academic performance (Chittum et al., 2017; Krishnamyrthi, Ballard, & Noam, 2014; McCreedy & Dierking, 2013; Moreno et al., 2016; Sahin, 2013). Girls may also find the unique characteristics of the informal learning spaces to be beneficial, such as having freedom to follow their own interests and values, feeling less pressure from school academic requirements or standardized testing, and working in collaborative groups (McCreedy & Dierking, 2013).

### *Identity of girls*

The construct of identity can provide insights into experiences of learning mathematics in all learning contexts and for all learners. For our study of women who participated in the first GSC, we draw insight from Darragh's (2016) definition of identity

as the performance and the recognition of the self. It exists in the moment of the performance and as it is recognised. We perform ourselves—be it by telling stories, joining groups, acting in a particular way at a particular time, positioning ourselves and others within wider societal discourses...Furthermore, identity is a result of the process of identifying, whether this is self-identification or identification by others. This view of identity keeps in mind the audience at all times as the ultimate identifier and enables us to consider the ways in which power is exerted in this recognition (p. 29).

The identity that results from the process of identifying may not be desirable. The identity performance acts of the past influence the identity performance acts of the present and future.

## **Methods**

### *Oral history in mathematics education*

Oral history is a qualitative methodology that has been broadly used by sociologists, anthropologists, and historians that is linked to memory and orality (Garnica, 2011).

Oral history is understood as both an act of memory and an inherently subjective account of the past. Interviews record what an interviewer draws out, what the interviewee remembers, what he or she chooses to tell, and how he or she understands what happened, not the unmediated 'facts' of what happened in the past. An interview, therefore, renders an interpretation of the past that itself requires interpretation (Shopes, 2011, p. 452).

Although oral history methods are not widely used in mathematics education research, these methods have been used in mathematics education research to explore the history of training, practices of mathematics teachers, and teaching artifacts (Gomes, 2019). When mathematics education researchers use oral history, they carefully prepare for the interview by defining the focus of the inquiry, collecting and studying background information, and developing plans to cultivate rapport with participants (Shopes, 2011). Although the women in our study will describe the same events, the subjective nature of oral history causes each to tell a different story (Garnica, 2011).

### *Participants and research team*

Participants in this study were nine women who were members of the original GSC. Now in their mid- to late-thirties, the women participated in the first GSC in 1994-1995, when they were in fifth and sixth grades. They went to the same elementary school, which was located in a large subdivision neighbourhood outside a large metropolitan area in the United States. Seven of the participants lived in the neighbourhood when they attended GSC. All the women have obtained at least bachelor's degrees, and all are employed outside the home.

The research team consisted of one faculty member, a research associate, four doctoral students, two undergraduate students, and the founder of GSCs. While all members of the research team contributed to the development of our data collection tools, the research associate and doctoral students conducted all focus group meetings and interviews with participants. Two or three researchers were present for each meeting, which were all conducted over Zoom.

#### *Contexts that inform the oral history data collection and analysis*

We collected data in the fall of 2020, consistent with oral history methods (Shopes, 2011), which required collecting and studying background information about the time and place of the first GSC. The clubs' founder worked with a local historian to develop the local context from the mid-1990s (personal communication, October 14, 2020). The school was in a county just outside of a large metropolitan area in the United States. This school district had a reputation as having the best schools in the metropolitan area. Many people worked for the Federal government, making the population generally well-educated, middle- to upper-middle-class, and somewhat transient. The population around this school, however, was more middle- and working class, and rooted in the area, with many students graduating with friends from their kindergarten class. In the 1990s, the town's population grew 25% from 16,200 to 21,600, while the demographics shifted from 77% White, 10% Black, and 9% Hispanic to 58% White, 10% Black, and 26% Hispanic. During this time of suburban sprawl, town leaders sought to bring in more white-collar, professional office jobs, while the influx of Hispanic families brought more day laborers to the community and English language learners into the school. A large neighbourhood included family-friendly amenities such as the school and a pool, to which children could safely walk with their neighbourhood friends. However, lack of transportation for out-of-school activities prevented students who could not walk home or be picked up from participating. The school's principal acknowledged a risk of potential controversy over single-gender activities, but she gave permission for GSC anyway.

#### *Data collection activities*

Building from our understanding of the time and place of the original club, we developed a survey to elicit participants' experiences (Dewey, 1938/1998) related to their STEM learning and interests in both formal school and informal extracurricular settings, spanning their time in the club to the present. Fourteen of the original 41 GSC participants completed a survey, and nine agreed to participate in a follow-up focus group meeting and an individual interview. To accommodate participants' schedules, we arranged three focus group meetings of two, three, and four participants.

From the survey data, we created research memos to document emerging themes that influenced topics for our focus group interviews. To cultivate rapport with the women, who had never met us, we combed the survey data for details with which we resonated. For each of the three focus groups, one member of our research team found a personal photo that

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represented an area of resonance with the women in that focus group. For example, three of the four women in the first focus group had children, so we shared a photo of one of us with a daughter in the garden. The three women in the second focus group each had a son and a daughter, so the researcher shared a photo of herself with her own son and daughter. The two women in the third focus group both enjoyed being outside in nature, so the researcher shared a photo of herself by a lake.

Focus groups were scheduled based on participants' availability. One researcher welcomed the women and outlined the goals for the meeting. She introduced herself with her chosen photo. To help trigger memories from their time in GSC (Salandim, 2019), a researcher asked the participants to introduce themselves using the following prompt:

Introduce yourself to us as if you are entering the GSC so we can conjure an image of you as a girl anticipating the afternoon. I will give you an example from when I was in 5th grade. I will use some "juicy" words so hopefully you will be able to conjure me as a girl. "My name is Mary Francis, and I go by the whole name. I am thinking of when I was in 5th grade and going to the GAA Club, which is a girls' athletics club. I just came from Mr. Smith's class, have arrived at the bowling alley, and have switched out my own wood and leather clogs for the bowling alley shoes. I am looking forward to seeing my friends Lori and Nancy and hope I am on their team, but I am NOT looking forward to Molly Brooks telling me how to bowl."

Participants were encouraged to build on or add to each other's introductions. Afterward, a researcher shared our rationale and goals for the study. She described the individual interview process and asked the women to bring a photo that conveyed something related to their GSC experiences, past, present, or future. The focus group ended with the women sharing what they would say today to their little girl selves.

Focus group recordings were transcribed and reviewed as primary source research to inform each individual interview outline (Shopes, 2011). The researchers conducting individual interviews worked to develop skills in feminist oral history interview methods, learning to listen beyond the words shared and to probe for additional detail (Anderson & Jack, 1991). Prompts included the following, with specific prompts and questions developed from the survey and focus group data: (a) Tell us about the picture; (b) Tell us about the school and about being a girl in the school; (c) How did you decide to pursue your current career? (d) How were your experiences in your class and GSC similar or different? (e) How do you recognize a good math learner? (f) Would you say that you were(not) a strong mathematics learner? Two or three researchers were present for each interview, which were conducted over Zoom.

### *Analysis*

In oral history methods, analysis of primary and secondary resources is completed before the oral history interview outline is created, thus shaping the individual interviews (Shopes, 2011). Here, analysis was completed after each data collection activity to inform the next data collection activity for the oral history story findings. As we set out to understand the role of GSC in participants' lives, the founder provided background information regarding

her motivations for starting GSC. Therefore, our survey questions focused on memories of GSC, feelings toward mathematics and science both in formal and informal learning spaces, activities engaged in with families/children, post-secondary experiences, and career choices. Analysis of the survey data indicated the women are more than the sum of their formal and informal education experiences and career choices, which led the research team to develop a strategy to connect with the participants as fellow women who are also connected to GSCs, rather than as stereotypical intimidating researchers. As mathematics teacher educators, we chose to analyze the survey data for *resonances* (Conle, 1996) in order to find correspondences on a very personal level, that might evoke an emotional dimension, as we needed to quickly develop a trusting relationship with these women to whom we were strangers. Focus group transcripts were analyzed using a feminist oral history listening framework (Anderson & Jack, 1991) to find areas to probe further in the individual interviews, such as missing or incomplete information, feelings and understandings of experiences, and our own areas of confusion or discomfort. After transcribing the individual interviews, we read the transcripts and lightly edited them to document the stories the women told (Shopes, 2011). While each woman defined the plot of her own story, we shaped their stories initially through questions we asked and the prompts we posed, as well as through our editing process.

In oral history research, the stories that emerged from the lightly edited transcripts are the findings. Next, we used Darragh's (2016) identity definition to understand instances of self-identification and identification of and by others in the stories.

### **Preliminary findings**

We share preliminary story findings for two of the women, Jo and Amanda. To respect the space limit, we represent each women's findings using three paragraphs. The first paragraph is a summary of the woman's story, and the following paragraphs are excerpts of their stories.

#### *Jo's story: A continuous search for confidence and a career path*

Jo is a white middle-class mother, wife, and daughter who portrayed herself as searching for a career path, wanting to help people, and working on her confidence. When referring to others, Jo would make explicit her value for others' opinions; Jo will always listen and learn from observing others while running, playing with her children, or interacting with her husband. Jo remembered enjoying being with other girls at GSC as she could be herself. In a mathematics classroom, she would not raise her hand and would lead the boys to respond to the teacher's questions. Although, as an adult, she reported feeling confident around male colleagues, Jo sees value in girls being with only girls in clubs such as the GSC, especially to boost their confidence.

I think it's such a positive, like has such a positive impact on these girls' lives, like they you know, maybe they are shy like I was and, and don't speak out a lot in class or because, because I was never one to raise my hand and answer a question. And so maybe it helps them with, you know, their confidence.

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Two of her role models are women, her mom and sister, and she sees them as strong and successful women who allowed themselves to search for career paths that made them happy. Yet, Jo sees herself as opposites to her role models in terms of personality. Despite her shyness and lack of confidence, Jo never gives up on her career dreams. Across her adult life, Jo has had different jobs and been in places where she was the only woman and in other places where women have surrounded her. She has never felt inferior with males, but recognized differences when in predominately women's spaces. Jo valued being with other girls at GSC, and she wants her daughter to experience something similar.

Jo is afraid of failing people. Jo does not know where she got so scared of failure; rationally, she has never failed, but thinking of failing is always in her mind. "I don't want to fail, but sometimes you have to; how else would you learn?" Jo's inside voice tries to rationalize a feeling that overwhelms her. Her memories of being at GSC are pleasant as she felt confident in those spaces. As an adult, she is glad she has her running friends, husband, and role models alongside her. Their voices become an umbrella she opens and uses as a shelter to shake off her shyness in her pursuit of a career path that fulfills her.

### *Amanda's story: Living the present moment and loving people*

Amanda is a white middle-class woman and daughter who told the story of being comfortable with uncertainty, living with minimal possessions, and feeling fortunate with her life. In her search for a career path, she was attracted to theatre, yet others let her know that she was not good enough to be an actress. However, she enjoyed the theatre people. Amanda was fortunate to have a female teacher who helped her see herself in the theatre field but doing a different job: Stage manager. She graduated from a very competitive program and loved her job. Her social network in her hometown and job was diverse; Amanda enjoyed being with people with different backgrounds, cultures, and identities. Amanda portrayed herself as a passionate worker, and a human being who enjoys nature and few possessions.

Amanda's stories portrayed her as an optimist and someone who lived a minimalist life: "I don't own anything; I don't even have an apartment [...] I literally own what I can fit in my car." Her lifestyle has prepared her to be grateful for whatever life brings her. For instance, during the pandemic, she has enjoyed family and the nature surrounding her. Although she does not know if she will have a job in the future, she still plans to enjoy what she has in the present moment. Amanda's low needs and passion for life contrast with typical ways in which women are positioned by society. Amanda does not manage a house or children, but rather people in the performance industry. "I basically manage. I manage people and I manage what's happening in the show."

Managing people could sound as though Amanda's heart is cold and selfish. Yet, Amanda is full of love. Her parents encouraged Amanda's love for people since she was little. They supported her, exposed her to people from different parts of the world, and showed so much trust in her, that in middle school, she was often by herself in her parents' house with a group of male friends. Amanda recognized gender differences as a girl and an adult. For instance, when answering a teacher's question at the school, she described how girls would stop

themselves from responding, “I just think like stereotypically they [girls] were like ‘oh the guys are gonna know it’ or whatever.” As an adult, Amanda felt confident enough to address any issue or question, in front of a male or female audience; she showed herself sure enough to be whoever she wanted to be, silencing societal demands.

## **Discussion**

We aimed to answer the following research questions: What stories do participants share about themselves and the GSC? What insights can we (MTEs) gain from learning about the participants’ identities? These women had non-traditional roles in society and told hopeful stories of themselves. They are both searching or performing themselves to others in a way that makes them feel fulfilled. Jo is still searching for her career path, while Amanda is proud of performing a role that could be considered by society as non-traditional for women. As MTEs, we learned from their stories that informal learning spaces have the potential to allow girls to perform an identity different from the one they perform at school. The two participants showed evidence of performing different selves in different places: Being quiet and shy in school, while chatty and confident in the GSC. For instance, in school, both participants perceived themselves as not needing to answer the teacher’s questions as they portrayed the boys in class as capable of doing it. This was different in the GSC where, as girls, the women felt confident enough to raise their hands and speak up. Now adult women, they comfortably contribute, lead, and work with male colleagues in their work lives. Although we cannot claim any strong relationship between the participants’ confidence as adults and their GSC experiences, there is something MTEs can learn from pedagogical approaches used in informal learning spaces. Participants enjoyed their experiences in the club, seeing their experiences as confidence boosting. Because the participants described themselves as performing other selves in such spaces, we think that informal learning spaces allow for identity development.

As MTEs, we found the process of collecting and creating the women’s stories, and then analyzing the stories for self-identification and identification by others, to reveal complex relationships between factors that we had not previously considered to play a role in mathematics learning. Because MTEs usually study the relationship between mathematics, teaching, and learning (Valero, 2010), we have joined others who have claimed that informal learning spaces seem to promote identity development (Krishnamyrthi, Ballard, & Noam, 2014; McCreedy & Dierking, 2013). We see a need for MTEs to study practices that others use in informal learning spaces and then bring those practices into academic contexts. We envision school spaces as nurturing all learners’ identities, in addition to nurturing their content knowledge. We are eager to continue this work.



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