A Twin Cities Public Television Project

Funded by the National Science Foundation

Experiential Science Education
Research Collaborative

Inspiring girls in STEM.

Center for STEM Learning
UNIVERSITY OF COLORADO **BOULDER**

STEM Program Impacts...

"I enjoy STEM subjects. I just think they're a great way to reach out to new things and I think all STEM subjects can be found and applied in your everyday life. It's most often in subtle ways but it's really easy to find reasons how, like I did with my video about the science behind baking."

- SciGirls Student Journal

Executive Summary

SciGirls Strategies:

This report presents findings of the SciGirls Strategies quasi-experimental mixed methods study, investigating the experiences and outcomes of female high school students in classes taught by SciGirls-trained educators in terms of STEM-related identity construction. The STEM-related identity framework and research model used to guide this investigation is presented along with the study's research questions: 1) How does the experience of participating in all of the SciGirls Strategies project components impact girls' STEM-related identity development?; 2) What are the impacts of individual project components, with a focus on the use of role models in classroom instruction?; and 3) What modifications to the STEM identity framework are indicated by the findings?

Findings indicate female student experiences in classes led by ScigGirls-trained educators showed significant results towards the development of more positive STEM-related identities. The results of both quantitative and qualitative compo-

nents of this mixed methods study support the growth of STEM-related identity in seven of nine key composite indicators, including: Personal Relevance, Agency, Emotional Connection, Content Confidence, Enjoyment of Science, Science Career Interest, Technology Career Interest, Engineering Career Interest, Mathematics Career Interest. Case studies provided important insights of how lived experiences including those dimensions unfold in the personal lives of girls, including the importance of STEM-learning-related risk experiences and social factors as important components in forging agency and emotional connections to STEM.

The engagement of role models was revealed to be a significant and complex factor in the development of positive STEM-related identity. The use of female STEM by educators showed statistically significant advantages over no use. In-person role model interactions showed advantage over video based and/or article-reading exposure to role models. However, the case studies revealed

the concept of "role models" to be somewhat alien to girls, in favor of a broader concept of "personal influencers" in their lives. These were most often relatives or friends who had a high degree of personal relevancy for girls. These findings are discussed in terms of the need to recognize and articulate different kinds of role models in service to broadening participation in STEM for non-majority group students. Viewed through a social identity theory lens, it is argued necessary to unpack the monolithic concept of 'role model' to differentiate role, social, and personal influencers who exhibit traits and behaviors that inform these different levels of identity.

Finally, indicated adjustments to the conceptual framework and research model are discussed along with recommendations for future research. trategies quasi-experimental mixed methods study, investigating the experiences and outcomes of female high school students in classes taught by SciGirls-trained educators in terms of STEM-related identity construction.

Program Introduction

SciGirls Strategies was a National Science Foundation–funded project led by Twin Cities PBS (TPT) in partnership with St. Catherine University, the National Girls Collaborative, and XSci (The Experiential Science Education Research Collaborative) at the University of Colorado Boulder's Center for STEM Learning. This report presents the methods and findings of a quasi-experimental mixed-methods study designed to contribute to improved programming and knowledge in STEM-related identity development. The study tests the hypothesis that girls will develop more positive STEM-related identities when their educators employ research-based, gender-equitable and culturally responsive teaching practices enhanced with female STEM role models. The effort focuses on

the outcomes for girls engaging with the project's strategies and deliverables, including in-class experiences with SciGirls-trained teachers, and explores how those experiences contribute to their STEM-related identity development.

The larger context in which this study is positioned to contribute is the challenge of girls' entry into scientific and technical fields, which includes the challenge of developing a positive science identity against gender stereotypes (Notter, 2010; Brickhouse, Lowery, & Schultz, 2000) and maintaining that identity within a prevalent anti-science attitude among America's youth (Osborne, Simon & Collins, 2003). This challenge is amplified for girls as research indicates that sustained engagement of girls with STEM activities and career opportunities requires elements not traditionally included in STEM education: holistic human experiences that include emotions and social components, such as role modeling, integrated in the learning of content and process knowledge (Notter, 2010). If SciGirls Strategies can demonstrate successes (or failures) in integrating STEM into the processes of identity development for girls, it will generate knowledge important to the field for promoting positive STEM-related identities as an important precursor to STEM literacy and STEM career choices. It is hoped this study will also be important for educators attempting to reach learners who do not traditionally self-select for STEM learning; consider themselves culturally positioned for STEM; think themselves "smart" or "capable" enough to engage in STEM; or who actively seek to avoid the social stigma costs of participating in STEM beyond K12.

Role Models

The project placed particular emphasis on integrating role model strategies into the educator professional development for more gender equitable teaching. Role modeling has been shown to be an important factor in generating awareness

and expectations regarding role-based identity development within society (Stryker & Statham, 1985) and in promoting interest and self-efficacy among students, including minorities, in STEM fields (Aschbacher, Li & Roth, 2010; Buck et al., 2007; Ntiri, 2001; Greenwald & Davis, 2000). Multiple studies demonstrate that connecting students to STEM professionals can increase knowledge of, awareness and interest in STEM careers. Specifically, several studies show that role models can increase positive attitudes towards STEM subjects, improve self-concept in STEM, and increase greater self-efficacy in STEM (Fuesting, 2017; Clark, 2016; Herrmann, 2016; Shin, 2016). These psychosocial factors are thought to be key in promoting investment, engagement, and persistence in STEM.

However, programs directed at addressing gendered STEM interest and self-concept disparities have historically aimed to cultivate girls' STEM competences, skills and confidence within the classroom (Häussler & Hoffman, 2002). Less often, have they sought to provide positive female role models and other forms of support through internships, mentoring, and other research experiences (Hunter, Laursen & Seymour, 2006). One of the aims of this investigation was to better understand positive STEM identity role modelling for girls a sound theoretical research base so it may translate into better educational strategies for girls and boys alike at those critical teenage years where deterministic attitudes and decisions about STEM careers occur in concert with intense identity construction. In particular, this project sought to examine differences in how role models may be introduced, especially comparing video-based role models with in-person role models and/or no role models.

Research Model

The conceptual framework for this research is Social Identity Theory as described by Tajfel and Turner (1979) and later synthesized into Identity Theory by Burke and Stets (2000), which encompasses different types of program influences on identity development. Specifically, these include:

(1) Role identity: the meanings an individual assigns to different positions/functions they hold or perform in society;

(2) Social identity: the meanings an individual incorporates into their sense-of-self based on affiliation with or formal/informal membership in social groups (gender, age, family, class, ethnicity, interests), and;

(3) Personal identity: the meanings an individual incorporates into their sense-of-self as unique or distinct from others (what makes us different).

Together, these categories influence our ideas of who we are and who we want to (and attempt to) become, guiding our self-perceptions and our choices, including what we believe we can do (and what we cannot do) (Burke & Stets, 2009). In this investigation, the research team was especially interested in any positive STEM-related identity development, or the degree to which one integrates STEM into their sense-of-self as a result of their participation (McLain, 2012).

To guide the investigation, XSci began with a theoretical framework that identifies distinct STEM identity construction zones. Construction zones include the cognitive factors of agency, content confidence, emotional connection and personal relevance, and associates these factors with specific behavioral outcomes important in STEM-related identity development (capacity, STEM concept, attitudes and self-efficacy, future choices) (see Figure 1).

STEM Related Identity Construction Zones (Figure 1)
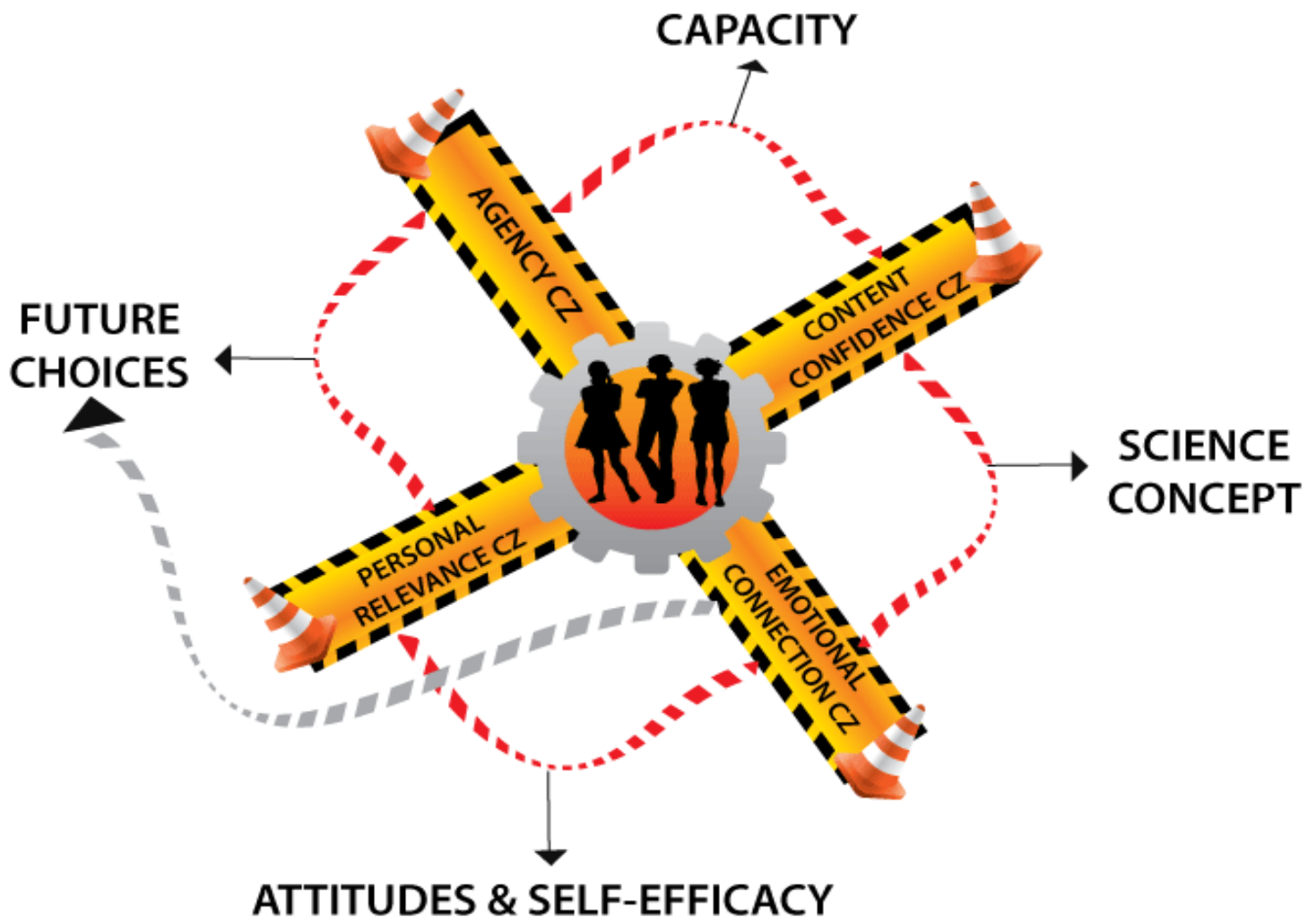
The STEM Related Identity Construction Zones

To guide the investigation of program influences (role, social and personal idenity), XSci began with a theoretical framework that identifies distinct STEM identity construction zones. Construction zones include the cognitive factors of agency, content confidence, emotional connection and personal relevance, and associates these factors with specific behavioral outcomes important in STEM-related identity development (capacity, STEM concept, attitudes and self-efficacy, future choices) (see Figure 1).

Research Questions
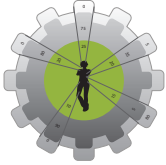
Question 1

How does the experience of participating in all of the SciGirls Strategies project components impact girls' STEM-related identity development?
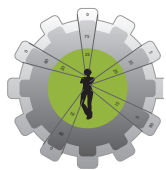
Question 2

What are the impacts of individual and project components: classroom instruction, role models, and videos and autobiographical story sharing?, with a focus on the use of role models in classroom instruction?

Question 3

What modifications to the STEM identity framework are indicated by the findings?

Case Study Highlights

Research Questions

How does the experience of participating in all of the SciGirls Strategies project components impact girls' STEM-related identity development?

What are the impacts of individual and project components: classroom instruction, role models, and videos and autobiographical story sharing?, with a focus on the use of role models in classroom instruction?

What modifications to the STEM identity framework are indicated by the findings?

In four out of the six cases, there was strong evidence of positive impacts on STEM-related identity development (see full case analysis). In two of those cases, these gains were strongly linked to in-class SciGirls-related experiences.

But in the other two cases, the positive results were not strongly linked to in-class SciGirls-related experiences, if at all. In the case one participant, there is some evidence that her STEM-related identity gains occurred in spite of some negative SciGirls-related experiences. And for two of the six cases, there were no notably positive STEM-related identity impacts linked to in-class SciGirls experiences. For one student, whose entire STEM-related identity was based in math, there was relatively little growth in broader STEM-related identity development with no major changes indicated. In the case of the one participant whose participation in SciGirls-related experiences were destructive to

> *"What is the science behind having a crush on someone? What sort of chemical reaction does your body go through when your mind decides it likes another person?"*.
>
> - SciGirl Journal

her STEM-related identity development, her overall STEM-related identity still managed to survive as positive by the end of the semester.

Based on this framework and the findings, it is necessary to unpack the monolithic concept of 'role model' to differentiate role, social, and personal influencers who exhibit traits and behaviors that inform these levels of identity.

(For full cross case analysis please see full report)

"Learning has always been a highlight of my life, but school always hasn't... I've recently come to the realization that my life is full of challenging moments. And everyone is tested on their perseverance at some point or another. And I think as long as I can stick with what I love, I'll do just fine."

- SciGirls Participant Video Narration

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