NIOST
National Institute on
Out-of-School Time

GEMS
GIRLS EXCELLING IN MATH AND SCIENCE

STEM Engagement for Girls in Rural Communities:

Research Snapshot

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Overview

This research brief summarizes findings from an observation study of GEMS (Girls Excelling in Math and Science), a STEM-focused afterschool program for girls. Data was collected during multiple observations of a program for elementary school-aged students in a rural community in the Northeast. The study investigated the behavior, engagement, and emotional state/affect of girls while participating in the program. The observations were conducted by researchers with the National Institute on Out-of-School Time in November 2019 and February 2020 and were grounded in the Science Learning Activation Framework (Dorph et al., 2016).

Background

GEMS was founded in 1994 and its mission is to increase girls' curiosity, interest, and persistence in STEM. There are more than 150 GEMS clubs around the world that operate as hands-on, activity-based out-of-school time programs. The GEMS website functions as a virtual hub. GEMS leaders and parents can access a wide range of STEM activities, information, and teaching tips and each GEMS facilitator can shape their club to respond to the unique interests, needs, and resources of the local school community.

Providing girls with opportunities to participate in enriching and fun programs that encourage long-term engagement in STEM is important.

Why STEM is Important for Girls

Providing girls with opportunities to participate in enriching and fun programs that encourage long-term engagement in STEM is important. Recruiting and retaining more women in STEM occupations will not only help individual women, but provides broader benefits to the U.S. by maximizing innovation, creativity, and competitiveness (National Academies of Sciences, Engineering, and Medicine, 2016). However, women have found it difficult to access the STEM pipeline and stay in it. As a result, despite the fact that more STEM workers are needed to fill existing and anticipated jobs, women are still underrepresented in many STEM fields, particularly engineering and computer science (National Science Foundation, 2019). Additionally, rural students have historically faced many obstacles to entering STEM fields (Versypt & Ford Versypt, 2013), such as low educational aspirations, lack of STEM role models, and difficulty accessing advanced STEM curriculum or institutions including planetariums, aquariums, nature preserves, and museums.

Theoretical Framework

This study was grounded in Science Learning Activation Theory (Dorph, Cannady, & Schunn, 2016). Learning activation in science is conceptualized as "a set of dispositions, practices, and knowledge that commonly enable success in proximal science learning experiences" (Dorph et al., 2016, p. 49). Early learning experiences that increase science learning activation and create positive associations with STEM can encourage youth to follow pathways to science. Contrarily, negative science experiences, especially at a young age, can reduce activation and discourage youth from pursuing STEM literacy and STEM careers (Dorph et al., 2016; Dorph et al., 2017). (See Figure 1.)

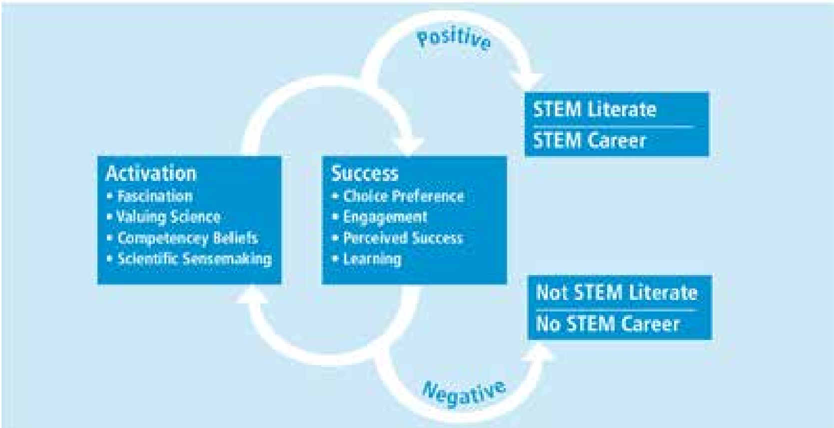

Figure 1. The Science Learning Activation Framework
Source*: Dorph et al., 2017. *Reprinted with permission.

Our research focused on two of the four elements of success in this model: choice and engagement. We observed whether or not the girls chose to participate in the activity and explored in detail the behavioral, cognitive, and affective engagement of girls with the STEM activity being offered as an indication of the success of the activity. Using this theoretical framework, the assumption was that full participation in an activity includes behavioral, cognitive, and emotional components. More engagement indicates more success; less engagement indicates less success.

Methods

Two school-based GEMS clubs for elementary school-aged girls were observed twice each by NIOST researchers in November 2019 and February 2020 using a time-sampling method and the Activation Science Engagement Observation instrument. During each visit, randomly selected girls were each observed for 10 consecutive minutes. Across the two sites and four activities, a total of 18 observations were conducted.

There were three research questions related to STEM engagement that guided club observations:

1) What types of science behaviors did girls engage in most frequently?
2) How actively involved were girls in the STEM activities?
3) What was the affect/emotional state of girls while doing the STEM activities?

Key Findings

Girls engaged in a wide variety of scientific behaviors in a hands-on way.

The type of science behaviors exhibited depended, at least in part, on the type of activity observed.

Girls were proactive in their learning.

Science learning at GEMS is a social activity.

Girls enjoyed the process of creating, innovating, and solving challenges during science learning.

The observational data tracked the variety of types of scientific behaviors engaged in by girls: ask, answer, connect, describe, discuss, experiment, explain, explore, identify, listen, observe, predict, problem-solve, read, use, and volunteer. If a type of behavior was observed at least once during the 10-minute observation, it was noted as present. A behavior was recorded as just one check-off regardless of its frequency or duration during the 10-minute observation period. Observational data also included records on the focus of cognition exhibited by the girls—whether they were thinking and talking about facts, procedures, artifacts, phenomena, ideas, challenges and problems, or metacognition.

Measures of activity level included rating each activity type during the observation period on a 4-point scale of active (takes initiative and eager to participate), passive positive (listening, attentive, alert, and ready to learn and participate), passive negative (unfocused, not on task, unprepared, giving up, or not taking initiative), and disruptive (actions interfere with self and others' learning). In addition, we collected individual ratings of the frequency of different types of behavior during the observation session based on the proportion of time and a rating of overall engagement.

Three data points were used to examine girls' affect or emotional engagement: (1) a recording of the girls' affect during each observed activity, (2) individual ratings of the frequency of different types of affect during the observation session based on proportion of time, and (3) a rating of overall affect during the observation session. Affect was measured as positive aroused (amazed, joyful, happy, enthusiastic, eager, inspired, determined), positive unaroused (alert, calm, relaxed, at ease), negative unaroused (bored, sad, drowsy, tired), and negative aroused (distressed, upset, angry, frustrated, worried, startled).

Findings

Girls engaged in a wide variety of scientific behaviors in a hands-on way. In all, a total of 112 science behaviors were recorded. Using the rubric, the behaviors viewed most often across all observations were listening, using, asking, experimenting, answering, discussing, and observing. The least common scientific behaviors observed were describing and volunteering. Observational data also included records on the focus of cognitive engagement exhibited by the girls. Findings indicated that girls were most often engaged in thinking about procedures, ideas, artifacts, and facts, and least often with challenges/problems, phenomena, and metacognition.

The type of science behaviors exhibited depended, at least in part, on the type of activity observed. At the first visit to Club 1, for example, when girls were involved in a windmill Lego project, the scientific behaviors seen most often were experimenting, exploring, reading, and using. At the same club on the second visit, when girls were also involved in a Lego project, the most common scientific behavior was asking. At Club 2, at the first visit when girls were following complicated instructions to create models of moving hands, the most commonly observed scientific behavior was listening, and at the second visit, when girls were building kaleidoscopes, it was using and connecting.

Girls were proactive in their learning. According to multiple measures, girls were actively involved in the STEM activities. For example, almost all of the 10-minute observations (17 girls) involved one or more instances of "active" behavior such as a girl taking initiative with hand raising or answering questions. Many of the observations involved one or more instances of "passive positive" behavior such as listening, being attentive, demonstrating alertness, or showing a readiness to learn and participate. Very few of the observations (3 girls) involved one or more incidences of "passive negative" behavior (unfocused, not on task), and no observations involved "disruptive" behavior. Similarly, in rating behavioral engagement on different levels of engagement as a proportion of time, 12 girls were rated as being active "a lot to most of the time" (meaning greater than 50 percent of the observed time segment), while 4 girls were rated as being "passive positive" (ready to learn and participate) greater than 50 percent of the observed time segment.

Science learning at GEMS is a social activity. Researchers noted that 17 of the 10-minute observations involved at least one interaction with an adult facilitator and 17 involved at least one interaction with a peer. When rating the extent of engagement with peers and adults, almost two-thirds of observations involved "extensive, ongoing interactions" with peers. The activities that were structured to encourage social interaction among girls seemed to help increase participant engagement in the activity. Only 3 of the observations were described as involving "extensive, ongoing interactions" with adults. Thus, it appears that while adults gave instructions and were available to the girls to answer questions and to help

out, in general, the adults interacted briefly with the girls one-on-one and let the girls take leadership in doing the activities themselves. One facilitator/teacher was explicit in telling her observer that she encourages the girls to consult with each other before asking an adult for help. Teamwork among girls is highly valued at GEMS, as is the goal of teaching the girls self-reliance and persistence.

Girls enjoyed the process of creating, innovating, and solving challenges during science learning. Girls were frequently amazed and joyful about what they were discovering. The majority of the observation sessions (15 observations) included at least one instance of "positive aroused affect" and 12 of the observation sessions included at least one instance of "positive unaroused affect." On the overall rating of affect during the observation, all girls were rated as being positively aroused or positively unaroused. None of the girls spent the majority of the time bored, sad, drowsy/tired, or distressed/upset/angry/frustrated/worried. In fact, at no time were girls observed feeling frustrated, upset, or distressed when they encountered a challenge. Rather, the girls were activated by the challenges they confronted and eager to try to solve them and to connect with each other for help when needed. They enjoyed the process of engaging in science behaviors and learning STEM content.

This preliminary evidence suggests the GEMS clubs were effectively exposing girls to new STEM activities, sparking involvement in STEM behaviors, teaching STEM content, and creating positive associations with the subject of STEM.

Conclusion

The observational data suggest that the GEMS approach stimulated girls' interest and promoted active participation and positive emotional engagement in STEM activities. Although this study is based on a small number of clubs, findings suggest that girls involved in GEMS have the chance to learn key procedures involved in the scientific process. They practiced a wide variety of science behaviors and thought about scientific issues. Girls were proactive in their participation and demonstrated positive affect. This preliminary evidence suggests the GEMS clubs were effectively exposing girls to new STEM activities, sparking involvement in STEM behaviors, teaching STEM content, and creating positive associations with the subject of STEM. All of these elements are key components of "success" in the Science Learning Activation Framework and they suggest increased likelihood that GEMS girls will continue to seek and pursue opportunities to engage in STEM. GEMS may therefore offer a promising model for how out-of-school time programs can increase engagement and interest in STEM among an underrepresented population of rural school-aged girls who may otherwise have limited opportunities to: (1) do structured STEM activities outside of school; (2) work together collaboratively with other girls and discover the fun of STEM; and (3) learn concrete information about STEM content, careers, and pathways.

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