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Exploring the Link Between STEM Activity Leader Practice and Youth Engagement

Findings from the STEM IE Study

DECEMBER 2018

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The study described in this report was funded by the National Science Foundation's Advancing Informal STEM Learning (AISL) program under Grant No: DRL-1421198. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not reflect the views of the National Science Foundation.

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Executive Summary

The STEM Interest and Engagement (STEM IE) Study was a four-year project funded by the National Science Foundation under the auspices of its Advancing Informal STEM Learning (AISL) program that was designed to better understand what types of practices, supports, and opportunities afforded to early adolescent youth:

> *(1) Are especially effective in helping youth experience in-the-moment engagement while participating in ISL activities, and*
> *(2) Serve to support growth in STEM interest and aspirations.*

The study was undertaken between 2014 and 2018 by a research team at American Institutes for Research, Michigan State University, and Northern Illinois University.

Where was the study conducted?

The study was conducted in a total of nine, STEM-oriented, summer learning programs serving early adolescent youth from low-income communities supported by Boston After School and Beyond (BASB) and the Providence After School Alliance (PASA), two well-established afterschool intermediaries working in Boston, MA and Providence, RI respectively. Programs selected for inclusion in the study ranged from 4 to 6 weeks in duration, offering STEM-oriented programming daily for 3.5 to 4 hours, four days a week. Data were collected from study programs in the summer of 2015.

What about this study made it unique?

In order to answer the study's research questions, steps were taken to collect data on youth's in-the-moment experiences using the Experience Sampling Method (ESM). During the second, third, and fourth week of summer programming at each of the study programs, the research team selected two of the four programming days to collect youth experience data. This was done by giving each of the 203 youth enrolled in the study a mobile phone. At up to four random times during the STEM portion of programming, youth were signaled by a member of the research team to stop what they were doing, take out their phone, and complete a brief survey about what they were experiencing at that moment in time.

In addition, while ESM data were being collected, steps were being taken to videotape the programming being offered at the time the signal was issued. Overall, approximately 180 hours of video was collected across the nine programs in question. With the ESM and video data in hand, we were able to compare the type of learning environments being provided to youth as well as the practices and approaches being employed by activity leaders with the direct, in-the-moment experiences of participating youth, allowing for a very direct and real-time assessment of the relationship between practice and youth experience.

What did we find?

From a practice standpoint, episode ***quality*** as measured by the Classroom Assessment Scoring System (CLASS), statements made by activity leaders to demonstrate the ***relevance*** of STEM content, and providing youth with opportunities to experience a sense of ***agency*** while undertaking program activities were all found to be related to a set of in-the-moment experiences reported by youth conducive to supporting engagement.

Some of these practices were also found to be especially supportive of getting youth who were not particularly motivated to attend STEM programming at the start of the summer session to have key experiences associated with engagement, experiences that otherwise didn't occur when the use of these practices was absent. Both the CLASS-derived quality score and the more frequent use of relevance statements by activity leaders were found to be especially effective in this regard.

Field-based settings were found to be effective in helping youth feel challenged, perceive what they were doing as relevant, and learn more about the STEM content being addressed. However, it also appears that these settings may be more effective when activity leaders afford youth a greater degree of ***autonomy*** in undertaking field-related tasks and using time set aside after the activity to reflect on session activities, discuss findings, and supplement what youth garnered from the activity with additional information.

> *The more youth experienced in-the-moment engagement in programming during the span of the summer, the more likely they were to report growth in STEM interest and future aspirations.*

As anticipated, the more youth experienced in-the-moment engagement in programming during the span of the summer session, the more likely they were to report growth in terms of interest and future aspirations related to STEM. This finding seems to reinforce both the importance of focusing on practices that will support momentary engagement while participating in programming and the viability of assessing changes in interest and future aspirations related to STEM when youth are engaged in programming. As the ISL field continues to explore ways to assess youth outcomes, this set of findings may be of particular import as part of a larger strategy to document how youth may benefit from these types of programs.

STEM IE Toolkit

Finally, a key component of the STEM IE study was to take what we learned about practices that seem to support youth having positive in-the-moment program experiences and constructing a free online toolkit that can be accessed by program practitioners to learn more about how to design and deliver STEM programming in a manner that incorporates these practices. The toolkit identifies practices that support youth engagement. It also contains video clips that demonstrate what a given practice looks like in live programs and professional development materials, including PowerPoint slides and facilitator guides. These resources can be used by training facilitators that would like to use the toolkit to further cultivate the capacity of STEM program activity leaders to adopt these practices when designing and delivering ISL programs for early adolescent youth.

> *The toolkit can be found at https://www.niu.edu/stemie.*

Introduction

With ever increasing interest in preparing today's youth for the jobs of tomorrow in science, technology, engineering, and mathematics (STEM), out-of-school time (OST) and informal STEM learning (ISL) programs that seek to expose youth to STEM content and potentially plant the initial seeds of interest in the STEM fields have proliferated during the span of the past decade (Afterschool Alliance, 2016). Such programs may be especially important for reaching youth from low-income communities, providing an opportunity for youth to engage with STEM content in ways that otherwise may not be readily available to them. When these programs are of high quality, it is hoped that these offerings will help youth from such communities:

- Make better sense of the world in which they live;
- Have a more expansive set of prior knowledge they can draw upon when attempting to connect with, understand, and process school-day content related to STEM;
- Develop skills and competencies that will be important for STEM careers; and
- Help form a STEM identity as they refine their interests and aspirations through participation in a variety of activities, while building social capital by connecting with mentors within and outside the program which makes their aspirations seem attainable.

In this sense, out-of-school time and informal STEM learning programs may be in a position to help bridge the equity gap between lower and higher income communities by giving youth access to these experiences.

However, in order for out-of-school time and informal STEM learning programs to reach their full potential, there is a need to further provide the activity leaders designing and delivering these programs with additional information on what types of practices, supports, and opportunities afforded to participating youth:

- Are especially effective in helping youth experience in-the-moment engagement, and
- Serve to support growth in STEM interest and aspirations.

Providing this kind of information for the OST and ISL communities was a key goal of the STEM Interest and Engagement (STEM IE) Study, a four-year project funded by the National Science Foundation under the auspices of its Advancing Informal STEM Learning (AISL) program. The study was undertaken between 2014 and 2018 by a research team at American Institutes for Research, Michigan State University, and Northern Illinois University, in partnership with two afterschool intermediaries, Boston After School and Beyond (BASB) and the Providence After School Alliance (PASA).

A key facet of the STEM IE study was the collection and analysis of both data on what early adolescent youth were experiencing while participating in STEM-oriented, summer learning programs and how these experiences were related to both attributes of the learning environment and staff practices documented by videotaping the STEM programming being delivered. This resulted in a unique dataset that allowed for a careful examination of what programmatic features were related to higher levels of youth-reported engagement in programing and how these experiences translated to changes in how youth perceived STEM during the span of the program. The purpose of this report is to outline key findings from the STEM IE study and provide recommendations regarding what these results mean in terms of both further supporting the efforts of STEM OST and ISL practitioners to design and deliver programs that support youth engagement and efforts to measure the manner in which these programs may be contributing to positive youth outcomes.

When and where was the study conducted?

The study was conducted in a total of nine, STEM-oriented, summer learning programs serving early adolescent youth from low-income communities during the summer of 2015 supported by Boston After School and Beyond and the Providence After School Alliance, two well-established afterschool intermediaries working in Boston, MA and Providence, RI respectively. Programs selected for inclusion in the study ranged from 4 to 6 weeks in duration, offering STEM-oriented programming daily for 3.5 to 4 hours, four days a week. Some, but not all, of the programs offered additional enrichment or recreation programming as part of their summer program that were not studied as part of this project. In addition to providing youth exposure to STEM content and building interest and skills in STEM, each of the programs were oriented at further developing the academic content knowledge of participating youth and cultivating positive social and emotional outcomes. A short description of each program identified by pseudonym can be found in Appendix A.

What did we hope to learn from the study?

The STEM IE study was crafted to answer the following set of research questions:

- How are instructional practices in STEM summer programs related to perceptions of challenge, relevance, learning, and engagement for participating youth?
- How is the relationship between STEM practices and perceptions of challenge, relevance, learning, and engagement moderated by youth characteristics at program entry?

- Is situational (momentary) engagement in STEM activities across several weeks associated with changes in: (a) individual (sustained) interest in STEM and (b) future goals and aspirations related to STEM?

The initial two research questions were designed to explore how specific types of instructional practices were related to youth-reported, in-the-moment experiences that resulted in youth interest and engagement. This set of questions is particularly relevant to the OST and afterschool fields given the effort that has been dedicated during the span of the past decade to developing continuous quality improvement systems that have focused on supporting the development of activity leaders to better offer supports and opportunities that lead to developmentally appropriate, high quality learning environments at the point of service delivery (see Yohalem, Devaney, Smith, & Wilson-Ahlstrom, 2012 for additional information on these efforts). This set of questions represents the core purposes we were hoping to achieve when conceptualizing the STEM IE study.

The third question, in comparison, could be deemed more exploratory in nature given the limited sampling frame associated with the collection of point-of-service data used to answer the initial two research questions. In this sense, the data we collected to examine both practices and youth experiences at particular moments in time only represented a small proportion of the total time youth spent in the summer STEM programs being studied, suggesting there may have been much about a youth's overall experience in programming that we were not able to directly observe. As a result, we are more cautious about these results.

What about this study made it unique?

> *The Experience Sampling Method (ESM) is a data collection method designed to obtain repeated snapshots of youth experiences in STEM programming that allows for an understanding of what youth are thinking and feeling in different program circumstances.*

In order to answer the study's research questions, steps were taken to collect youth in-the-moment experience data using the Experience Sampling Method (ESM) (Hektner, Schmidt, & Csikszentmihalyi, 2007). During the second, third, and fourth week of summer programming at each of the study programs, the research team selected two of the four programming days to collect youth experience data (so six days in total per program). This was done by giving each of the 203 youth enrolled in the study a mobile phone. At up to four, randomly-selected times during the STEM portion of programming, youth were signaled by a member of the research team to stop what they were doing, take out their phone, and complete a brief survey about what they were experiencing at that moment in time. Survey questions largely fell within three primary categories:

- Youth perceptions of the activities they were participating in (e.g., to what extent did they find activities interesting, challenging, important to them, etc.);
- Youth experiences in these activities (e.g., to what extent did they feel in control of the activity; feel that they were learning something or getting better at something; enjoy what they were doing, etc.);
- Emotions they experienced (e.g., to what extent were they bored; excited; happy; frustrated; stressed, etc.)

The full survey can be found in Appendix B, along with other measures used to conduct the study[1]. During the course of the study, a total of 2,970 surveys were completed by participating youth in relation to 248 discrete programming moments or what we refer to as ESM episodes throughout this report. In addition, while ESM data were being collected, steps were being taken to videotape the programming being offered at the time the signal was issued. Overall, approximately 180 hours of video was collected across the nine programs. With the ESM and video data in hand, we were able to compare (a) the type of learning environments being provided to youth and the practices and approaches being employed by activity leaders with (b) the direct, in-the-moment experiences of participating youth, allowing for a very direct and real-time assessment of the relationship between practice and youth experience.

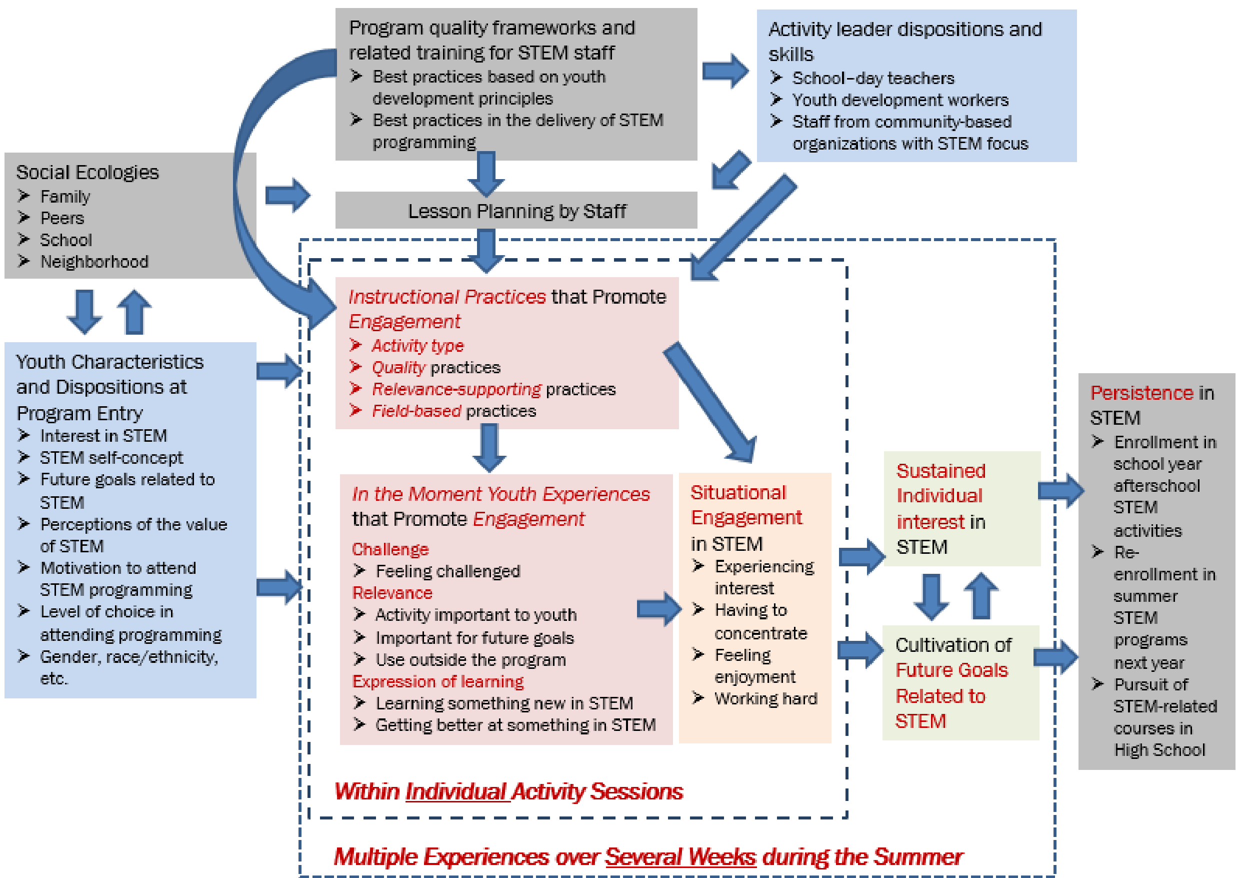
Change Model and Connection to Study Components

The STEM IE study was built upon a change model developed by the research team that outlines how we see participation in STEM programs potentially leading to both in-the-moment engagement in programming and changes in youth perceptions of STEM (see Figure 1). In the sections that follow, we briefly describe the key components of the change model and provide an overview of how a given component of the model looked among programs and youth enrolled in the STEM IE study. The goal of this section of the report is to explain why key variables were important to examine as part of the study and where we hypothesized variables would be related, connecting activity leader practices to youth experiences in programming to changes in youth perceptions of STEM.

[1] Including pre- and post-program youth surveys; an activity leader survey; an interview protocol for activity leaders; and video scoring protocols related to key youth development supports and opportunities and activity leader relevance statements.

It is important to note that there are some components of the change model we did not formally investigate as part of the STEM IE study, including the influence of social ecologies, program quality frameworks, processes for designing offerings and lesson planning, and youth persistence in STEM (all shaded gray in Figure 1). We wanted to acknowledge the importance of these elements in the change model, but formal examination of their contribution to the development of youth was outside the scope of the STEM IE study.

Figure 1. Change Model for STEM Summer Programming



Youth Characteristics and Social Ecologies

As shown in Figure 1, the proposed change model begins with youth themselves and what they bring to the STEM learning activity in terms of their background and an initial interest in STEM, STEM self-concept, the extent to which they have future goals related to STEM, and their baseline level of motivation to participate in programming.

Youth Characteristics

Each program enrolled in the STEM IE study primarily served rising 5th to 9th graders from low-income households and youth that were primarily Hispanic- (48 percent) or African-American (35 percent). Enrolled youth were evenly split between male and female youth. Early adolescence is a particularly exciting time in the development of young people, because they are gaining a new set of cognitive capabilities, including higher order reasoning, the capacity to understand the dynamics of complex systems, and enhanced executive control of one's own thought processes (Larson & Angus, 2011). This both expands the types of opportunities that can be afforded to youth and raises the bar from a cognitive perspective on what activities need to be able to do in order to engage participants. Additional information about the demographic make-up of the STEM IE population can be found in Appendix C.

Youth Motivation to Attend Programming

While enrollment in programming was largely voluntary, anywhere from 11 percent to 84 percent of youth, depending upon the program, indicated on a youth pre-survey that it was their idea to sign up for programming, while the remainder of participating youth indicated they were attending because their parents, friends, school-day teachers, or afterschool activity leaders wanted them to sign up. We also learned well into the project that a small percentage of youth were largely being compelled to participate in programming to address deficiencies in academic performance demonstrated during the preceding school year.

When asked how much they were looking forward to the summer program, a total of 11 percent of pre-survey respondents indicated that were not looking forward to it and really didn't want to be there, while another 47 percent indicated they were sort of looking forward to it. Just 42 percent of youth responding to the pre-survey indicated they were really looking forward to attending. In this sense, youth varied fairly substantially in their baseline level of motivation to attend the STEM programs enrolled in the study.

Youth Interest, Self-Concept, and Perceptions of STEM Value

Scales were also included on the pre-survey that were meant to assess youth interest, self-concept, and perceptions of the value of STEM content areas. Separate scales were included for each of the three primary STEM content areas addressed by the STEM IE programs: (1) science, (2) mathematics, and (3) building/engineering. Examples of questions asked on the pre-survey included *I am interested in science/math/building* (interest); *I am good at science/math/building* (self-concept); and *What we study in science class/math class/about building things is useful to know* (value). Youth responded to these types of items using a four-point rating scale: (1) Not at all true; (2) A little true; (3) Somewhat true; and (4) Really true. On almost all scales across each of the three content areas, the overall average score among youth enrolled in the study fell predominantly in the *somewhat true* range of the scale. The lone exception was the mathematics interest scale where the average score fell within the *a little true* range of the scale. In this sense, while youth were not necessarily always motivated to be attending the STEM summer programs in question, they were on average at least somewhat interested in the content areas being addressed by study programs at the time of program entry.

These baseline youth characteristics can have a meaningful impact on how youth experience engagement in programming. For example, work done by Durik and Harackiewicz (2007) demonstrated that both youth's level of baseline interest in and self-concept pertaining to STEM content areas can impact how youth respond to different instructional practices meant to support youth feeling engaged in STEM activities. More specifically, youth with a poor self-concept in STEM content areas were more apt to disengage from an activity which involved an activity leader describing how important that content will be for their future. In addition, several findings that will be highlighted in this report outline how youth motivation to attend at the start of the program impacted the relationship between key instructional practices and youth in-the-moment experiences.

Each of these youth-level characteristics are also influenced by the youth's family, peers, school, and neighborhood, and while we acknowledge this in the change model outlined in Figure 1, we did not examine the influence of these ecologies on the experiences or outcomes associated with the youth enrolled in our study. In some respects, the existence of these programs was in direct response to these ecologies in the sense that they were constructed to partially fill the STEM exposure and opportunity gap that youth from low-income communities would otherwise experience relative to youth from more affluent backgrounds.

Program Quality Frameworks, Program Design, and Activity Leaders

Program Quality Frameworks

A key determinant of what youth experience in STEM programs is driven by how activity leaders go about the process of designing program activities. During the span of the past decade, significant effort has been undertaken by the afterschool field in particular to create quality improvement systems anchored to formal assessment tools that provide detailed criteria for what constitutes quality within program offerings. Both BASB and PASA have used these types of quality assessment tools to guide the design and delivery of STEM programming, including the Youth Program Quality Assessment (YPQA), the Assessment of Program Practices Tool (APT-

O), and the Dimensions of Success (DoS). While these quality tools and frameworks certainly influenced the domain of activities offered by the programs enrolled in the STEM IE study, we did not explicitly study how the manner in which these tools were used by each intermediary impacted program design and delivery as part of this study. However, it is quite possible use of these tools may have influenced how program offerings were designed and delivered given that each tool contains examples of supports and opportunities that activity leaders can provide that are theoretically linked to cultivating youth engagement in programming.

Offering Design and Lesson Planning

There were a number of similarities between how PASA and BASB supported the summer programs enrolled in the study and some important differences. Each intermediary was under contract with the city's school district to administer the summer programs and managed the process of formally enrolling youth. In addition, both PASA and BASB established guidelines for how the programs would operate; outlined goals for the provision of academic content and support for social and emotional learning; and provided training and professional development for program staff aligned with the quality criteria and tools used by each intermediary.

However, PASA was much more closely involved than BASB in the provision of summer programming at each of its five programs enrolled in the study. PASA's model was predicated on programming being delivered by a trio of staff that co-designed and co-implemented the activities provided during the span of the program – (1) a school-day teacher employed by the district; (2) a community educator employed by a community-based organization responsible for providing the field experiences for participating youth; and (3) an educator employed directly by PASA. In addition, PASA also had more direct decision making authority around what staff were to be hired to staff each program team.

Each program team at PASA needed to submit a detailed backwards plan outlining specific learning goals and objectives and a day-by-day curriculum plan for the entire summer program. Each of these documents were reviewed by PASA staff responsible for ensuring program quality who provided feedback and guidance to enhance the quality of program offerings. PASA staff were responsible for recruitment of youth, assigning them to specific programs, and managing transportation and meals.

The five PASA programs also alternated between having youth in a classroom setting at one of two middle schools one day and having youth in the field the next, either at the community-based organization represented on the team for a given program or at another location pertinent to the program. In this sense, there was a very large focus in providing youth with field experiences outside the classroom setting.

In comparison, BASB was not involved in the day-to-day running of individual programs, with decisions related to staffing and activity design left to the four individual summer programs. Programs supported by BASB separated activities with more of an academic focus into specific program offerings taking place in the morning at each program led by a certified teacher, with STEM-oriented enrichment occurring in the afternoon. The degree to which the content being addressed in the academic sessions was linked to activities taking place in the enrichment offerings varied by program.

Overall, the STEM focal point varied across programs. Four of the nine programs primarily focused on local ecology and habitat stewardship and conservation, spending significant amounts of time outside the classroom exploring and learning about local ecosystems. Each of these four programs had adopted formal goals oriented at cultivating a sense of stewardship for these ecosystems on the part of participating youth. Three programs contained components that were oriented at building or engineering, focusing on building and coding robots, designing and building an outdoor classroom space, and constructing simple machines. Finally, two programs contained components that were oriented at exploring the intersection between STEM content and the arts, exploring the technical components of dance and the process of recording songs.

Activity Leader Dispositions and Skills

As previously noted, a variety of different types staff were involved in leading the domain of activities provided in the STEM IE programs. Activity leaders were surveyed before the summer sessions started and were asked a series of questions about what they perceived their role to be in the program and their past experiences delivering similar types of programming. The most substantive differences in response patterns occurred between activity leaders that were community educators employed by a community-based organization and other activity leaders involved in the provision of programming. Community educators were more apt to indicate that a large part of their role in the program was to help youth:

- Learn basic sets of laboratory, technology, or engineering skills;
- Develop the ability to apply scientific reasoning;
- Learn how to evaluate the quality and reliability of information and learn how to make decisions based on evidence;

- Understand how STEM concepts apply to everyday life;
- Develop an interest in studying STEM content areas;
- Understand what STEM professionals do.

In addition, community educators were also more apt to report having extensive experience with inquiry-based methods than their peers. Community educators were also more frequently involved in delivering activities that took place in field-based settings, as opposed to a more traditional classroom environment, an aspect we focus on later in the report when exploring how youth engagement varied across these two settings. Additional information about the demographic make-up of the activity leaders involved in the study can be found in Appendix C.

Within Individual Activity Sessions

The bulk of the data collection activities undertaken in relation to the STEM IE study involved documenting what transpired during the course of individual activity sessions and what youth were experiencing while participating in programming. In this section of the report, we focus on the constructs we were trying to measure and why these constructs are relevant to youth experiencing engagement while participating in the STEM programming being delivered and describing how these data were collected during the study.

Instructional Practices

The process of identifying instructional practices that were associated with positive youth in-the-moment experiences is at the heart of what the STEM IE study was seeking to accomplish. In order to accomplish this goal, the video of STEM programming collected during the six days site visits were conducted by members of the research team at each program was reviewed and coded in three areas: (1) the type of activity being provided; (2) episode quality; and (3) relevance statements made by activity leaders. In order to code the video in each of these three areas, we focused on what was transpiring in the program in the 15 minutes before a given ESM signal was issued. We termed this period of time an ESM episode. Of the 248 ESM episodes associated with the study, a total of 237 could be coded given the availability of video for the 15 minutes before an ESM signal was issued. Additional details about each area that was coded is outlined in the sections that follow.

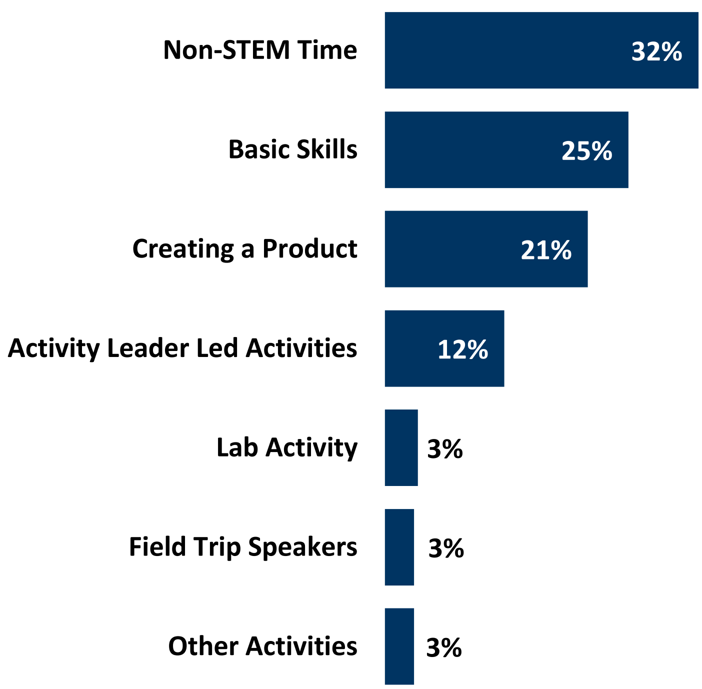
1. **Video Coding Area One - The type of activity being provided***.* Each ESM episode was coded for the type of activity that was taking place when a given ESM signal was issued. Each ESM episode was assigned one of the following activity type codes.

- ***Basic Skills.*** The activity taking place was focused on developing basic or routine skills and/or oriented at communicating factual knowledge about the topic in question. The most predominant activity here related to providing opportunities for youth to practice basic mathematics skills. This was particularly the case in the Boston programs where specific time was set aside in the morning of each program to focus on academic skill building in mathematics.
- ***Creating a Product.*** The activity taking place primarily involved youth designing, creating, or building (making) a product of some sort, ranging from building and testing a simple machine to designing and constructing an outdoor classroom space for one of the middle schools served by the program. It is important to note that a wide range of activities were classified under this heading, including products which were relatively low effort and required relatively little time to complete to capstone projects that spanned the duration of the program in question.
- ***Activity Leader-Led Activities.*** The activity taking place involved listening to or watching activity leaders present information and/or conduct a STEM-related demonstration. This included activities where activity leaders requested information from youth or led classroom discussions in a direct instruction type of format.
- ***Lab Activity.*** The activity taking place primarily involved planning, conducting, or communicating efforts taken to answer specific STEM-related questions (either youth or leader posed) and/or the collection or analysis of data to answer a question, including efforts by youth to discuss conclusions or implications pertaining to the STEM-related question(s) being explored.
- ***Field Trip Speakers.*** Most of the programs administered by PASA involved field trips to various locations in the community to further explore the STEM-related content being discussed within the confines of the program. At some of these locations, staff associated with the organizations being visited presented information to attending youth.
- ***Other Activities.*** Activities coded as other occurred relatively infrequently, including videos shown by the activity leader, youth presentations, and other types of problem-solving activities that weren't classifiable in any of the other categories identified.
- ***Non-Stem Time***. There were activities undertaken during each STEM learning segment that were not explicitly focused on STEM, including intentional activities meant to help youth get to know each, recreational activities, times when youth were transitioning or

being transported from one location or another, and a small number of segments when youth were simply off task. Collectively, we coded such activities as non-STEM time.

Figure 2. The majority of STEM-related activities taking place when ESM signals were issued involved a focus on basic skills, creating a product, or activity leader led activities.

Non-STEM time activities accounted for 32 percent of the activities occurring when ESM signals were issued.



N=235 ESM Episodes

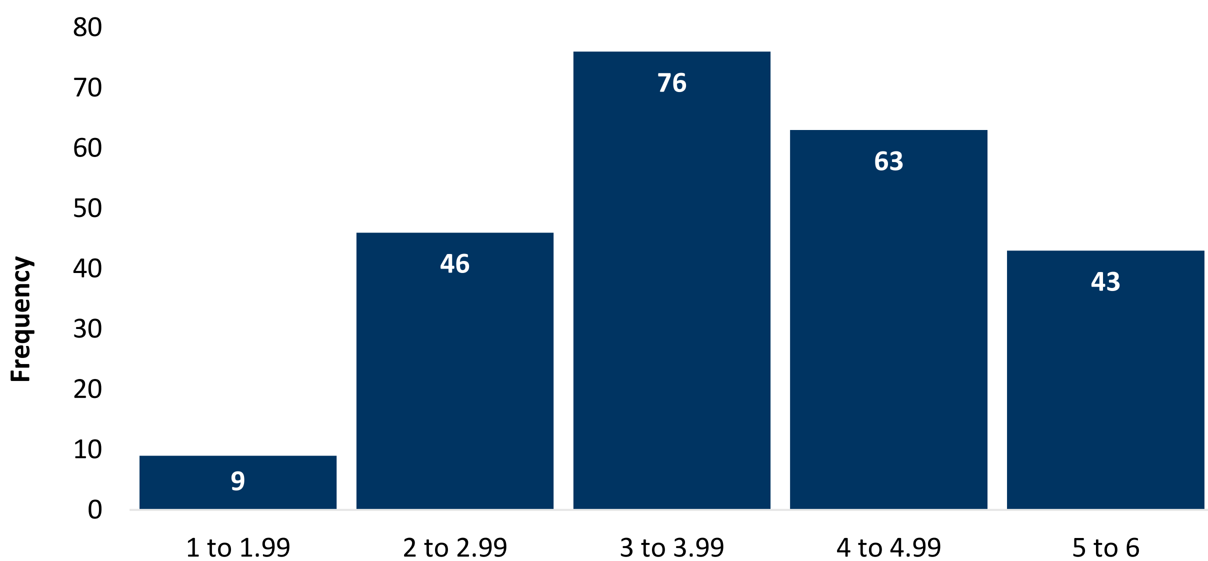
As will be shown later, activities focusing on basic skills and creating a product were both found to be positively related to a number of youth-reported in-the-moment experiences of interest.

2. **Video Coding Area Two - Episode Quality**. As already noted, program quality is a critical component of any ISL offering. In order to determine the quality of a given ESM episode, we adopted two different quality assessment strategies:

   - ***CLASS.*** We scored each 15-minute video segment prior to an ESM signal using the Upper Elementary Classroom Assessment Scoring System (CLASS). More commonly used as an assessment tool with school-day teachers, the CLASS was specifically chosen because it could be viably scored in relation to the 15-minutes of video before a given ESM signal was issued. The CLASS also contains dimensions that overlap with many of the practices found in observation tools commonly used in the afterschool and youth development field, like the YPQA, APT-O and DoS. While the CLASS contains three primary domains – (1) Emotional Support; (2) Classroom Organization; and (3) Instructional Support – **we found that practices described in the Instructional Support domain were especially related to the ESM outcomes we were examining as part of the STEM IE study.**

The Instructional Support domain of the CLASS is made up of five dimensions: (1) Instructional Learning Formats; (2) Content Understanding; (3) Analysis and Inquiry; (4) Quality of Feedback; and (5) Instructional Dialogue. Collectively, these dimensions of the CLASS assess the extent to which activity leaders provided opportunities and supports that pushed youth thinking and cultivated a deeper understanding of the STEM content being delivered. We also found that the Productivity dimension of the tool, which focuses on how organized and efficient the activity was, could also be viably folded into the Instructional Support domain and thereby was included in the CLASS quality score for each program. **The CLASS score was found to be significantly and positively related to a number of youth-reported experiences in programming as will be described later in this report in greater detail**. The distribution of CLASS scores across ESM episodes can be found in Figure 3.

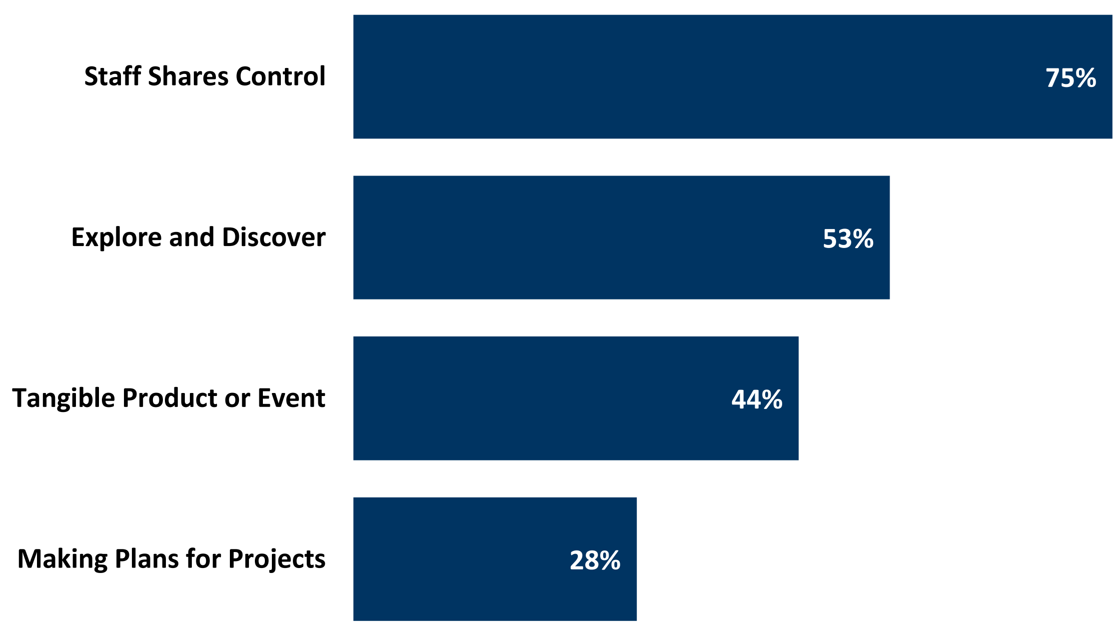
Figure 3. Rated on a scale of 1 to 7, the overall average CLASS score across all 237 ESM episodes rated was 3.77, which would be described as a mid-range level of quality on the CLASS tool.



N=237 ESM Episodes

- ***Quality Checklist.*** We developed a checklist informed by practices found on the STEM version of the Youth Program Quality Assessment (YPQA) and added others that we believed would be potentially related to the in-the-moment experiences we were studying based on past research and hypotheses around how youth experiences would be related to specific types of practices. Each practice on the checklist was identified as being present or not during the 15 minutes prior to an ESM signal being issued. These practices were organized into the following set of dimensions: (1) Active Participation; (2) Higher Order Thinking; (3) Belonging and Collaboration; (4) Opportunities for Agency; (5) Supports and Opportunities Related to the Pursuit of Self-Transcendent Goals and (6) STEM Skill Building. **Among these dimensions, both *Opportunities for Agency* and *Supports and Opportunities Related to the Pursuit of Self-Transcendent Goals* were found to be significantly and positively related to youth-reported in-the-moment experiences**, although the latter finding is described in a different paper (see Naftzger, 2018). The practices described in the *Opportunities for Agency* dimension are outlined in greater detail in Figure 4. The full quality checklist can be found in Appendix B.

Figure 4. Activity leaders sharing control of activities with youth and youth participating in activities that allow them to explore and discover new things on their own were the two most common agency-related practices observed in study programs.



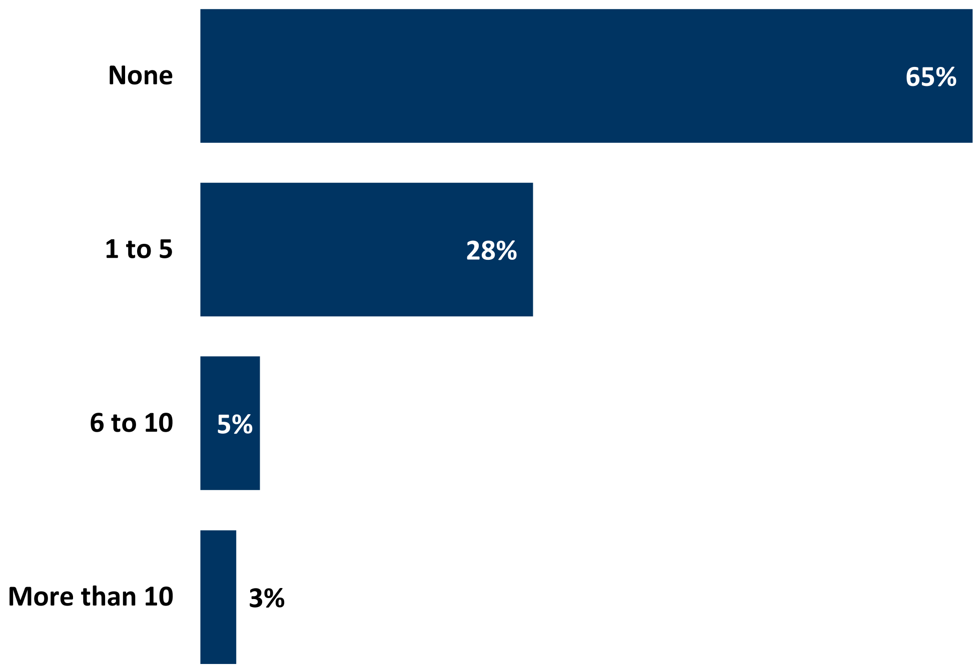
N=237 ESM Episodes

The majority of 15-minute video segments observed were characterized by the presence of these practices. Youth participating in activities that would eventually lead to the creation of a tangible product or culminating event or where they made plans for projects or activities were less commonly observed during these activity segments.

3. **Video Coding Area Three - Relevance Statements**. The final instructional practice we assessed as part of the STEM IE study were relevance statements made by activity leaders in the 15-minutes before a given ESM signal was issued. We counted every time an activity leader talked about the relevance of the STEM content associated with the activity youth were participating in when the signal was issued. If activity leaders talked or asked youth about how what they were learning was relevant to things like addressing local problems in their communities, careers, daily routines, and current events, that comment was counted as talking about the relevance of the STEM content in question for some broader purpose. This focus on relevance statements was predicated on the Expectancy-Value Theoretical Model of Achievement (EEVT; Eccles, 1987, 2009) which articulates that the subjective task value an individual assigns to carrying out a given task helps explain why individuals choose to engage in activities and persist in carrying them out. Relevance statements made by activity leaders were hypothesized by the research team as likely to enhance the value participating youth would attach to the STEM activities they were participating in and therefore support further engagement in those activities. The protocol used to code for relevance statements can be found in Appendix B. More specifically, we counted relevance statements that were coded as being indicative of *high utility value* as described in the protocol.

Figure 5. Almost two thirds of ESM episodes had no relevance statements made by activity leaders during the 15 minutes before a given ESM signal was issued, while 28 percent of episodes were characterized by 1 to 5 relevance statements made by the activity leader(s).

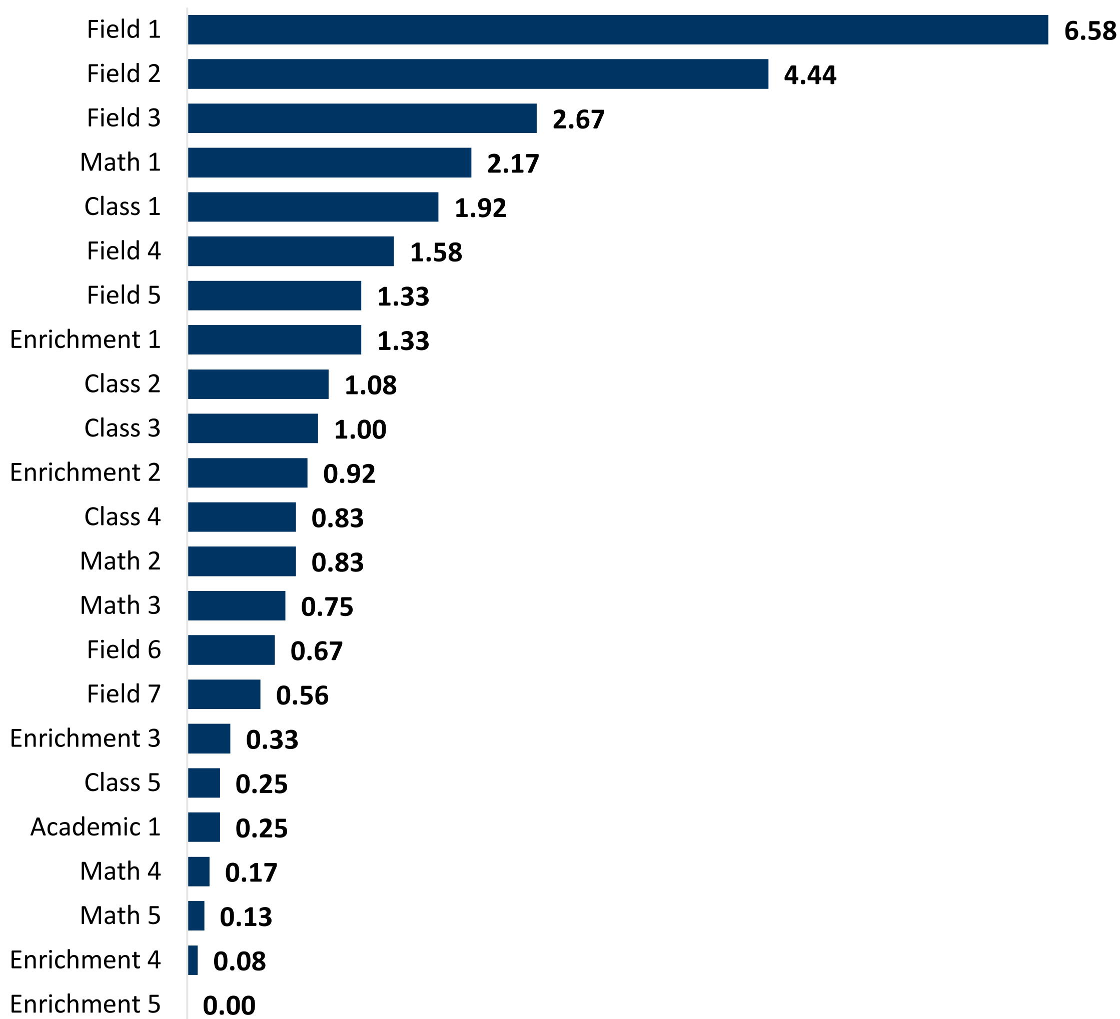
Overall, an average of 1.39 relevance statements were made per ESM episode.



N=237 ESM Episodes

While the overall average number of relevance statements made by activity leaders was relatively small, we did find fairly substantial variation from one activity to another. Within the nine programs enrolled in the study, there were 23 distinct activities that were offered to participating youth. These activities included academic-oriented offerings focused on skill development in mathematics, classroom-based activities focusing on STEM content, field-based activities, and STEM enrichment offerings. The 23 activities provided by the programs enrolled in the STEM IE study are listed in Figure 6, ordered by the average number of relevance statements made by the activity leader(s) associated with a given activity.

Figure 6. While the majority of activities offered within programs enrolled in the STEM IE study had fewer than one relevance statement made per ESM episode, there were two activities in particular where relevance statements were frequently made by activity leaders. Each of these activities were field-based activities that focused on helping youth understand the importance of the local ecosystem.



N=237 ESM Episodes

During these two activities, activity leaders made an average of 6.58 and 4.44 relevance statements per ESM episode on average.

Field-Based Settings

As previously noted, some of the programs enrolled in the STEM IE study were designed to offer participating youth the opportunity to participate in field-based learning activities. For the purposes of the study, field-based settings were defined as a learning environment where (a) the activity could only take place within that setting (e.g., searching for marine life in the local bay) and (b) involved identifiable STEM content related to the activity. Field-based activities had a tendency to be led by activity leaders classified as community educators and were more commonly found in PASA-administered programs given the structure of the PASA model which intentionally sought to link classroom activities with field-based experiences. A total of 19 percent of ESM episodes took place in field-based settings.

Youth Experiences in Programming

A focus on getting detailed information on what youth were experiencing in-the moment as programming was taking place was the other defining characteristic of the STEM IE study. Past studies completed by members of the STEM IE research team in high school science classrooms using a similar ESM design have shown that there are some key in-the-moment experiences youth have that are connected to being interested and engaged in a given learning activity (Shumow & Schmidt, 2014), specifically experiencing challenge, a sense that they are learning something, and feeling that what they are doing is relevant to their lives or some broader purpose. The ESM data we collected allowed us to explore the extent to which youth were having these key experiences while participating in programming. A total of 2,808 ESM responses were associated with the 237 ESM episodes that were video-coded which provided us with the capacity to explore the extent to which youth were having these experiences. Additional information on how each of these experiences were defined is outlined below.

- **Challenge**. Based on Emergent Motivation Theory (EMT) (Csikszentmihalyi, 1990; Csikszentmihalyi & Schneider, 2000), youth are most apt to experience a state of engagement when there is a relative balance between the difficulty of a task and their ability in an area where they feel generally competent, putting them in a position where there is a need to focus and concentrate in order to undertake the task in question. When this balance is achieved, youth will experience an appropriate level of challenge in the activity they are undertaking. In the STEM IE study, we measured in-the-moment challenge by asking the following question on each ESM survey: *How challenging was the main activity?*
- **Expression of Learning**. Interest is thought to be content or object specific (Renninger & Hidi, 2011), so it is important to assess whether program participants' thoughts and actions were focused on the STEM content being provided during a given activity and the extent to

which they felt they were learning something in relation to this content. Novelty (i.e., learning something new) is also an important feature of activities that generate interest in new content (Silvia, 2006; 2010). In the STEM IE study, we measured in-the-moment expression of learning by asking the following question on each ESM survey: *As you were signaled, were you learning anything or getting better at something?*

- **Relevance**. Relevance occurs when youth perceive an activity as having meaning, importance, or utility beyond the learning activity they are currently engaged in. Seeing science and related STEM content as relevant is a strong indicator of whether youth will value STEM, become engaged in it, and persist in it (Koballa & Glynn, 2007). In addition, promoting relevance has been shown to be one of the best strategies for triggering and sustaining youth interest and engagement in learning environments (Assor, Kaplan, & Roth, 2002). In the STEM IE study, relevance was defined by combining responses from the following three items asked on the ESM survey: *Was the main activity important to you?; Was the main activity important to your future goals?;* and *Could you see yourself using what you were learning in the main activity outside this program?*

Figure 7. In the charts below, score distributions across the three youth experience areas are outlined. Among the three key youth experience areas examined, youth reported being challenged the least frequently (overall mean of 2.28), while expressions of learning was the most common youth experiences reported (2.78). Youth reports that what they were doing was relevant was more varied, with an overall average score of 2.59.

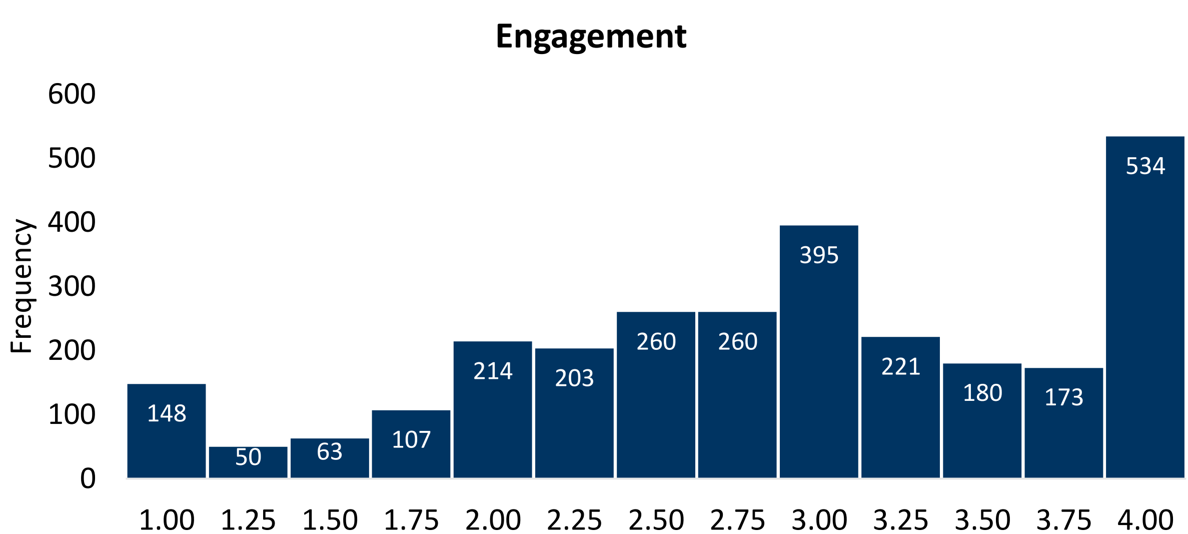
N=2,808 ESM responses associated with the 237 ESM episodes that were video-coded[2]

[2] In the Relevance figure, a value of 1 represents composite scores of 1.00 to 1.99; a value of 2 represents a composite score of 2.00 to 2.99, and a value of 3 represents a composite value of 3.00 to 3.99.

Engagement

A key hypothesis underpinning the STEM IE study was that the various instructional practices outlined in the previous section of this report would be related to youth experiencing challenge, relevance, and learning and these experiences in turn would be related to youth experiencing in-the-moment *engagement* in the activities in question. Similar studies oriented at measuring in-the-moment engagement base their conceptualization of engagement on the concept of *flow* as articulated by Csikszentmihalyi (1990), which is predicated on the simultaneous experience of interest, concentration, and enjoyment (Shernoff & Vandell, 2007). In this sense, engagement is generally seen as a composite variable predicated on a set of discrete experiences happening in-the-moment for participating youth. In the STEM IE study, engagement was measured employing four items from the ESM survey: (1) *As you were signaled, how well were you concentrating?* (2) *As you were signaled, how hard were you working?* (3) *As you were signaled, did you enjoy what you are doing?* and (4) *Was the main activity interesting?* This definition of engagement serves as a major outcome variable in the analyses underpinning the STEM IE study and will be featured prominently in our summary of key study findings described later in this report.

Figure 8. In the chart below, the score distribution for engagement is outlined. The mean engagement score was 2.87, with 50 percent of scores falling between 2.12 and 3.62.



N=2,808 ESM responses associated with the 237 ESM episodes that were video-coded

It is important to note that each of the ESM-based youth experience variables were found to be moderately to strongly correlated with each other as shown in Table 1. Challenge was the least strongly correlated with the other ESM variables examined, while engagement was most strongly correlated with learning and relevance. While our change model is based on the hypothesis that challenge, learning, and relevance support engagement, this is not something we could specifically examine as part of the STEM IE study given that these data were collected at the same point in time when youth completed an ESM survey.

Table 1. Youth experiences collected through administration of the ESM surveys were moderately to strongly correlated.

	Challenge	Learning	Relevance
Learning	.294**		
Relevance	.384**	.651**	
Engagement	.317**	.688**	.682**

Note. ***p* < .01

Cumulative Youth Experiences in the Program and Youth Outcomes

In the change model outlined in Figure 1, we expected that cumulative experiences youth had while in programming would be related to the degree to which youth became more connected to STEM, as indicated by a **growth in interest in STEM** and **future aspirations related to STEM** compared to levels captured on the youth pre-survey. Here, we were particularly interested in assessing how average engagement scores across the full domain of ESM episodes were potentially related to growth on these youth outcomes. Our goal was to document a cascading set of practices and youth experiences that connected what activity leaders did when delivering STEM activities to youth development of enhanced levels of interest and aspirations related to STEM.

Both interest in and future aspirations related to STEM were measured on hard copy pre- and post- youth surveys administered by members of the research team during the first and last week of programming. Questions related to interest were content specific, focusing on interest in science, mathematics, or building/engineering. The following domain of items were used to assess youth interest in a given content area: (1) *I am interested in science/math/building*; (2) *At school, science/math/building is fun*; and (3) *I have always been fascinated by science/math/building*. Youth responded to these items using a four-point rating scale: (1) Not at all true; (2) A little true; (3) Somewhat true; and (4) Really true. Pre- and post-survey results related to interest were collected from 142 youth.

Questions pertaining to future aspirations in STEM were more generic and not aligned to a specific content area. The following three closed response items were used to craft a separate future aspirations scale predicated on the extent to which youth agreed with the item in question: (1) *It would be interesting to work in a science or computer laboratory*; (2) *In my future job, I would like to use the science and math I learn in school*; and (3) *I would seriously think about becoming a scientist, mathematician, or engineer when I finish school*. Youth responded to these items using a four-point agreement scale: (1) Disagree a lot; (2) Disagree a little; (3) Agree a little; and (4) Agree a lot. Pre- and post-survey results related to interest were collected from 135 youth.

Finally, while our change model references youth persistence in STEM activities during future afterschool and summer programming and STEM-related course taking behaviors in high school, examination of these outcomes was outside the scope of the STEM IE study. Nevertheless, from a hypothetical perspective, we consider it reasonable to expect that positive youth experiences in STEM summer programming may support these future behaviors on the part of participating youth.

In-the-Moment Experiences - Results

In this section of the report, we first summarize the analytic approach undertaken to explore how instructional practices were found to be related to youth in-the-moment experiences, and then we detail the results of these analyses. The goal of this section of the report is to answer the following research questions and describe the manner in which this was done:

1. How are instructional practices in STEM summer programs related to perceptions of challenge, relevance, learning, and engagement for participating youth?
2. How is the relationship between STEM practices and perceptions of challenge, relevance, learning, and engagement moderated by youth characteristics at program entry?

Analytic Approach

Cross-classified hierarchical linear modeling was used to address study questions related to youth in-the-moment experiences in programming using the R computer program. Additional details about the models constructed to support these analyses can be found in Appendix D.

Instructional Practices and Youth Experiences

The first set of analyses undertaken by the research team explored how the **CLASS quality score**, specific scales from the **quality checklist**, and **relevance statements** made by activity leaders were related to youth experiencing challenge, relevance, learning, and engagement, with these latter, in-the-moment youth experiences serving as outcomes in the models in question.

A model building process was undertaken to explore what additional variables pertaining to youth characteristics, including those obtained from the youth pre-survey, and characteristics of the ESM episode warranted inclusion in the models because they were found to be significantly related to one or more of the youth experience outcomes of interest. Ultimately, the final models were comprised of the following set of predictors:

- **The CLASS Quality score** - Values ranged from 1 to 6, with higher scores indicating a higher level of observed quality.
- **The Opportunities for Agency score from the Quality Checklist** - Values ranged from 0 to 4, with higher scores representing the presence of more practices related to providing youth with the opportunity to experience a sense of agency.
- **The number of relevance statements made by activity leaders during the ESM episode** - Values ranged from 0 to 16, with higher values indicating more relevance statements made by the activity leader(s) in question.
- **Whether or not the ESM episode took place in a field-based setting** - ESM episodes occurring in a field-based setting were coded as 1, while other settings were coded as 0.
- **The youth's sense of competence in STEM from the pre-survey** – Values ranged from 1 to 4 with higher scores indicating a greater sense of competence.
- **The youth's motivation to attend programming based on responses to the pre-survey** - This was a dichotomous variable indicating if the youth was *sort of* or *really* looking forward to attending the program coded as 1, while those youth that were not looking forward to it and really didn't want to be there coded as 0.
- **The youth's gender** - Females were coded as 1, and males were coded as 0.

Results from each model are outlined in Table 2. Since we were primarily interested in how the domain of instructional practices were related to youth in-the-moment experiences, analysis findings have been organized initially by each of the three instructional practice areas examined, and then by the other predictors included in each model related to field-based settings and the domain of youth-level characteristics included in the models.

CLASS Quality Score

The CLASS quality score was the only instructional practice variable that was found to be significantly and positively related to each of the four in-the-moment youth experience outcomes examined. In this sense, a higher CLASS quality score was associated with youth feeling:

- More challenged by the STEM activities they were participating in;
- That what they were doing had a greater degree of relevance to them;
- That they were learning more; and
- More engaged in the activities taking place during a given ESM episode.

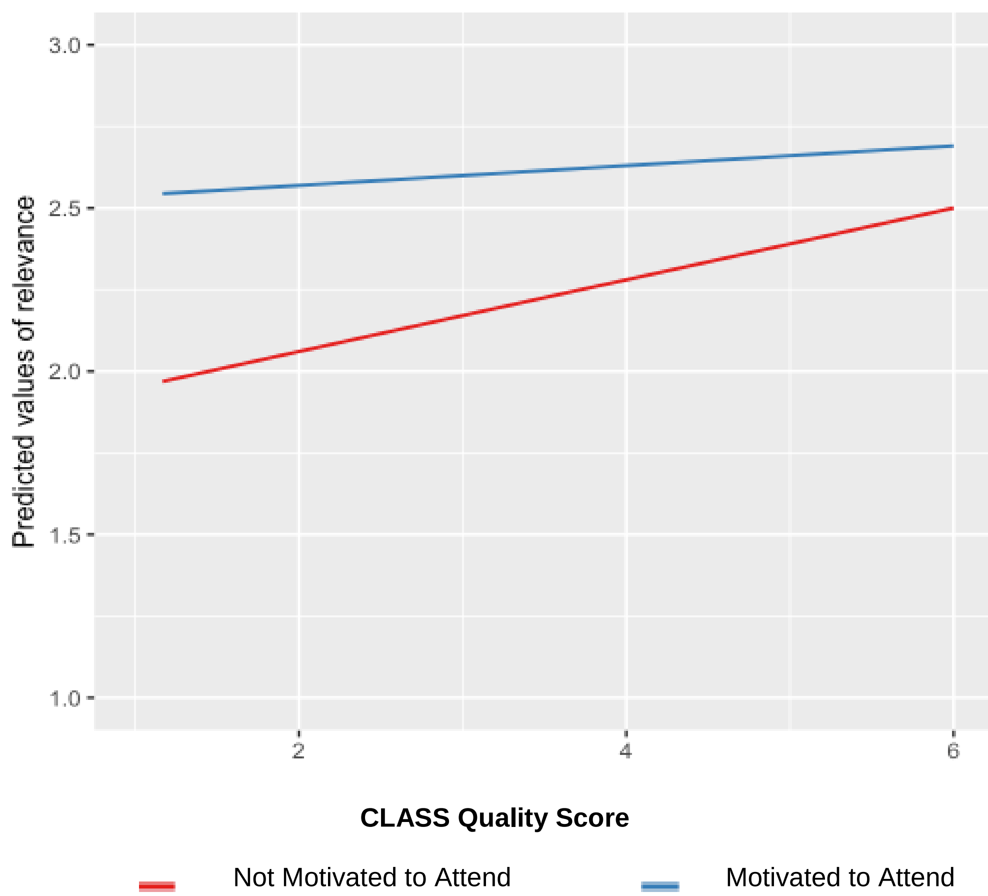
Table 2. Three-Level, Cross-Classified HLM Models Predicting the Relationship Between ESM Outcomes and Key Predictors

	Challenge			Learning			Relevance			Engagement		
Fixed Effects	***B***	**Sig**	**SE**	***B***	**Sig**	**SE**	***B***	**Sig**	**SE**	***B***	**Sig**	**SE**
Intercept	2.37	***	0.29	2.06	***	0.25	2.06	***	0.27	2.24	***	0.23
CLASS Score	0.07	**	0.03	0.07	***	0.02	0.04	*	0.02	0.03	†	0.02
Agency Score	0.05	*	0.02	0.00		0.02	0.00		0.01	0.02		0.01
Relevance Statements	-0.03	**	0.01	-0.01		0.01	0.01	*	0.01	0.00		0.01
Field-Based	0.20	**	0.07	0.12	*	0.06	0.10	*	0.05	0.03		0.05
STEM Competence	-0.15	*	0.07	0.07		0.06	0.04		0.07	0.08		0.06
Motivation to Attend	0.17		0.19	0.30	†	0.17	0.38	*	0.18	0.25		0.15
Female	-0.23	*	0.11	-0.06		0.10	-0.22	†	0.11	-0.07		0.09
CLASS Score x Motivation to Attend	-0.15	**	0.06				-0.08	†	0.04			
Relevance Statements x Motivation to Attend							-0.04	*	0.02			
Relevance Statements x Female				0.02	*	0.01						
Field-Based x CLASS Score	-0.15	*	0.06				-0.11	**	0.04			
Field-Based x Relevance Statements				-0.02	†	0.01						

Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

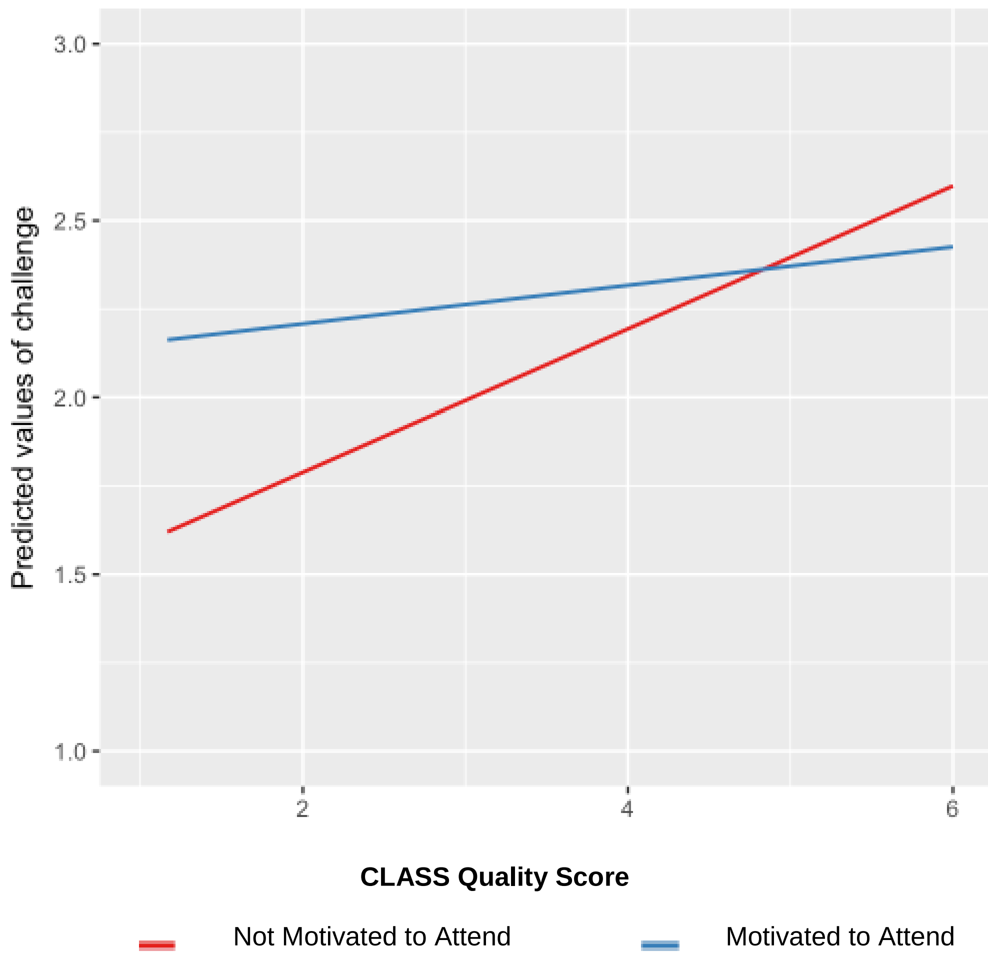
In addition, some interesting and significant interactions were also observed involving the CLASS quality score. For example, the positive relationship between the CLASS quality score and relevance was stronger for youth who were relatively unmotivated to attend the program in the first place. In other words, a higher CLASS quality score seemed to narrow the gap between youth with high- and low motivation to attend the program in terms of the perceived relevance of the STEM activity they were participating in when the ESM signal was issued. This relationship is shown in Figure 9. This is a potentially important finding. Informal STEM learning programs akin to those enrolled in the STEM IE study are likely to draw upon a wide variety of youth who come to programs of this type with a varying degree of motivation to attend and participate. Knowing that quality practices can move the needle in a meaningful fashion in terms of what youth experience is an important first step in understanding what can be done to connect youth with STEM content.

Figure 9. Higher CLASS quality scores narrowed the gap between youth motivated to attend programming and those that were not in terms of the perceived relevance of the activities they were participating in when the ESM signal was issued.



A similar interaction was found between the CLASS quality score and youth who were relatively unmotivated to attend at program entry in relation to youth experiencing a sense of challenge when participating in activities (see Figure 10). In this sense, a higher quality CLASS score also enhanced the likelihood that youth not motivated to attend programming would experience the type of challenge needed to promote further skill and knowledge development.

Figure 10. Higher CLASS quality scores were found to eliminate the gap between youth motivated to attend programming and those that were not in terms of the perceived challenge of the activities they were participating in when the ESM signal was issued.



Implications

During the span of the past decade, the field of afterschool in particular has invested heavily in using tools like the Youth Program Quality Assessment (YPQA), the Assessment of Program

Practices Tool (APT-O), and the Dimensions of Success (DoS) to define what quality looks like at the point of service and anchor quality improvement systems oriented at enhancing the capacity of activity leaders to provide high quality programming. While there is a fair degree of conceptual overlap between these tools and the instructional support domain of the CLASS, it may be worthwhile for the administrators of ISL programs to more closely review the types of practices outlined in the instructional support dimensions of the CLASS and explore what may be relevant to fold into their own quality improvement systems. While the CLASS was specifically designed to support school-day instruction, we found that practices described in the *Instructional Support* domain of the tool may potentially further enhance how content is delivered within the confines of ISL settings.

It is also conceivable that additional steps could be undertaken to explore how specific dimensions associated with the instruction support domain of the CLASS (e.g., analysis and inquiry; quality of feedback; and instructional dialogue, etc.) may be related to youth experiences in programming. This may further help programs hone in on what components of the CLASS may warrant particular attention when exploring if the tool offers some additional insight on what should receive attention from a practice standpoint when designing and delivering STEM-oriented programming.

Opportunities for Agency

Greater adoption of practices designed to provide youth with the opportunity to experience a sense of agency in programming was related to youth experiencing a greater degree of challenge while participating in STEM programming; however, these agency practices were not found to be related to youth experiencing a greater degree of relevance, learning, or engagement based on how the models were configured as outlined in Table 2. It is important to note, however, that in simpler models with fewer predictors, agency was found to positively related to engagement in a moderately significant fashion ($\beta = 0.02$, $p < .10$).

In addition, although not shown in Table 2, a series of supplemental analyses also showed that greater adoption of agency practices within the confines of an ESM episode was also positively related to youth feeling in control during the activity in question ($\beta = 0.02$, $p < .05$), a finding that would be expected given the nature of the practices in question. No significant interactions were found to exist between the agency variable and other predictors included in the models outlined in Table 2.

Implications

Providing opportunities for youth to experience a sense of agency is an important component of STEM programming designed for early adolescent youth, and the findings we were able to glean from the STEM IE dataset are partially reflective of this concept by linking these opportunities to youth experiencing challenge within the confines of program offerings.

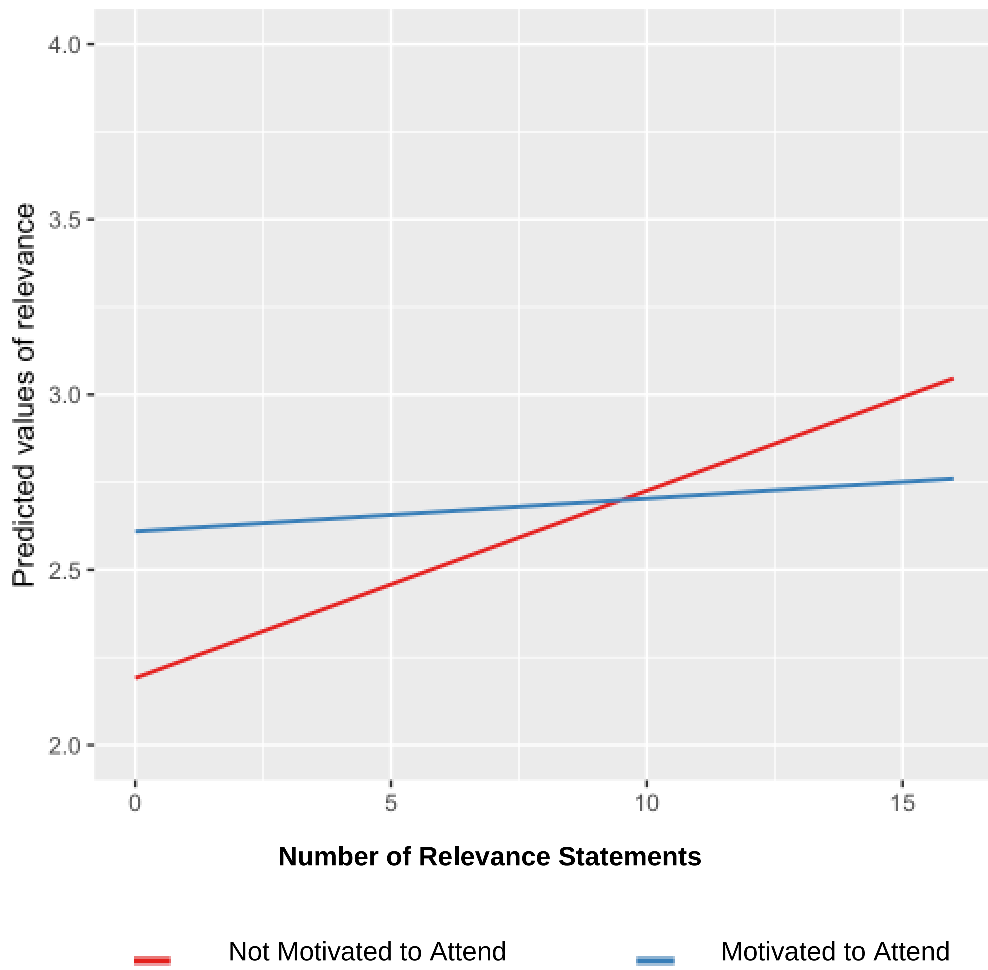
However, we wonder if our findings were influenced by the steps we took to convert items from a common assessment tool for afterschool to a checklist format that could be easily scored for the 15-minutes of programming occurring before a given ESM signal was issued. It may be advantageous in the future to score a full hour of programming taking place before a given ESM signal was issued using a complete quality assessment tool like the YPQA, APT-O, or DoS. It is possible that doing so would demonstrate an enhanced connection between agency-related practices and the ESM outcomes in question.

Relevance Statements

The more activity leaders made statements highlighting the relevance of the STEM content being examined within the confines of a given offering, the more likely youth reported that what they were doing was relevant to them. However, more frequent relevance statements made by activity leaders were not found to be related to either youth-reports of learning or engagement. Curiously, more frequent relevance statements made by activity leaders were also found to be significantly and negatively related to youth reporting experiencing challenge. This finding may suggest that difficult tasks may seem less challenging when youth perceive what they are doing as being relevant. Others have found related results when testing interventions designed to get youth to reflect on the relevance of learning tasks (Yeager et al., 2014).

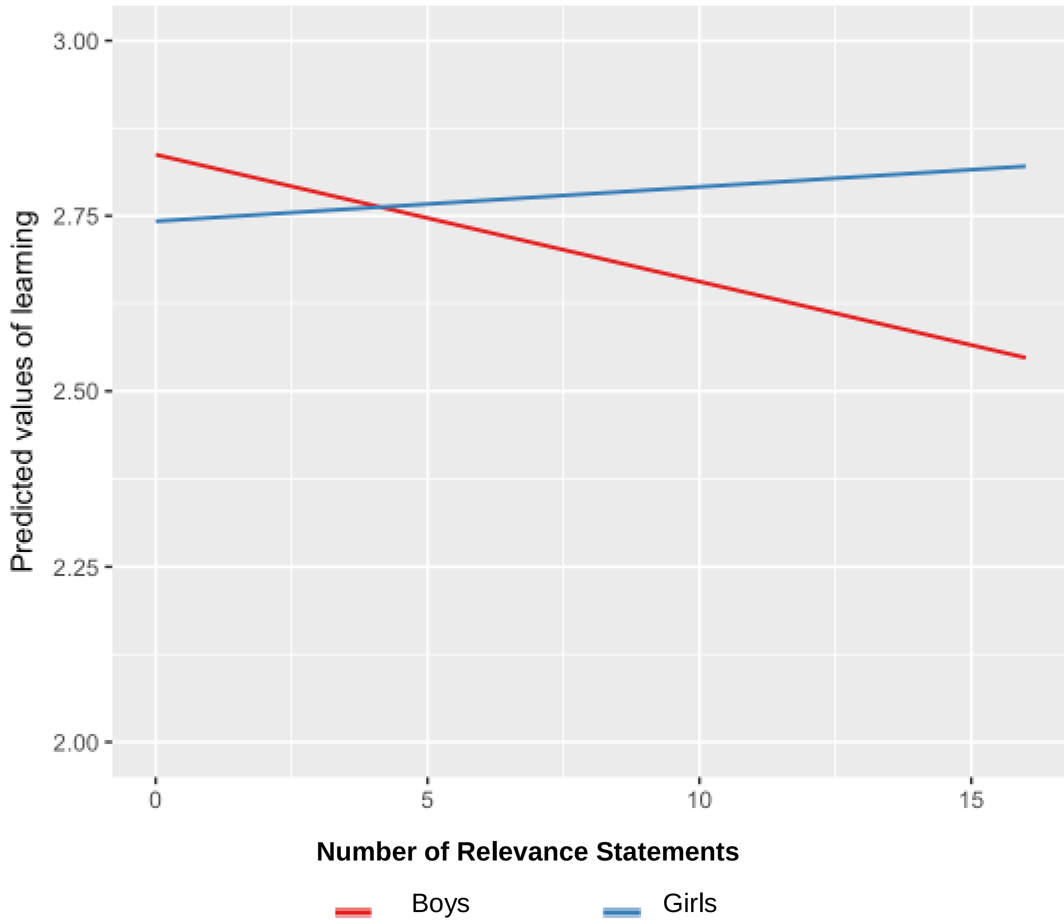
The frequency of relevance statements made by activity leaders was also found to interact with a number of other predictors included in the model when youth-reported relevance was the outcome of interest. Here again, we found that youth not motivated to attend STEM programming at the outset of the summer session perceived STEM activities as being more relevant when activity leaders made relevance statements more frequently.

Figure 11. More frequent relevance statements made by activity leaders eliminated the gap between youth motivated to attend programming and those that were not at the start of the program in terms of the perceived relevance of the activities they were participating in when the ESM signal was issued.



In addition, we found that boys and girls responded differently to activity leader relevance statements. Girls were more apt to report they were learning something new when activity leaders made more relevance statements, but this was not found to be the case with the male youth participating in programming.

Figure 12. While girls reported learning more when activity leaders made more frequent relevance statements, this was not the case for boys.



Implications

A number of studies have documented a decline in youth interest in school-related content areas, including science, as they enter adolescence (Barmby, Kind, & Jones, 2008; George, 2000; Gottfried, Fleming, & Gottfried, 2001). A key element of responding to this decline is to provide youth with opportunities to be exposed to STEM content in a way that demonstrates the relevance of that content to creating opportunities for participating youth in terms of college and career options, solving important community and global problems, enhancing our understanding of how the world works, and supporting the growth and development of society writ large. Findings from the STEM IE study demonstrate that activity leader efforts to promote the relevance of STEM content can help build these perspectives on the part of participating youth, particularly for those youth not initially inclined or motivated to participate in STEM programming. In addition, for girls, who have been shown to have a motivational disadvantage when it comes to STEM (Schmidt, Kackar, & Strati, 2010), highlighting the relevance of STEM content can also contribute to learning about the content in question.

Field-Based Settings

One of the unique opportunities associated with the STEM IE study was the ability to compare field- and classroom-based learning environments given that the majority of programs enrolled in the study were characterized as having robust field components as part of their program offerings. **When participating in activities located in a field-based setting, youth reported being more challenged, perceiving what they were doing as more relevant, and learning more**. However, youth did not report being more engaged in field-based settings.

In addition, being in a field-based setting was found to be associated with two curious interactions. We found two interactions related to the issue of relevance that seem to suggest that both the CLASS quality score and relevance statements made by activity leader may be less effective in field-based than classroom settings. For example, in contrast to classroom settings, when the CLASS quality score was higher in field-based settings, youth-reported experiences of relevance tended to decline (see Figure 13). In a similar fashion, when activity leaders made more relevance statements during field-based activities, youth reports of learning something new also declined, although the opposite pattern was found in classroom settings (see Figure 14).

While these results may seem initially surprising, we do have a hypothesis for why these interactions may have emerged. The majority of the field-based settings represented in the STEM IE study took place in a local ecosystem and involved youth largely exploring the environment in question to gather species or look for ecosystem elements that aligned with what was being studied in the classroom. In this sense, there was definitely an observable expression on the part of youth to want to engage in autonomous exploration and engagement with the ecosystem in question during these activities. However, both a higher CLASS quality score and more frequent relevance statements suggest activity leaders playing a more active role during the activity, potentially commanding the attention of youth at a time when they were more apt to want to be left to their own devices as they explored and interacted with the ecosystem in question.

In this sense, it may be important for learning and the emergence of feelings of relevance to allow youth to experience such authentic, field-based contexts in the moment and make meaning about it later by reflecting on and discussing the experience. Talking about it at the time the activity is underway or trying to convey additional content in that moment might be distracting to participating youth. Activity leaders also did talk about relevance much more often in community settings than elsewhere, so perhaps youth were simply reacting to the sheer volume of statements.

Figure 13. The higher the CLASS quality score in a field-based setting, participating youth were less apt to report that what they were doing was relevant.

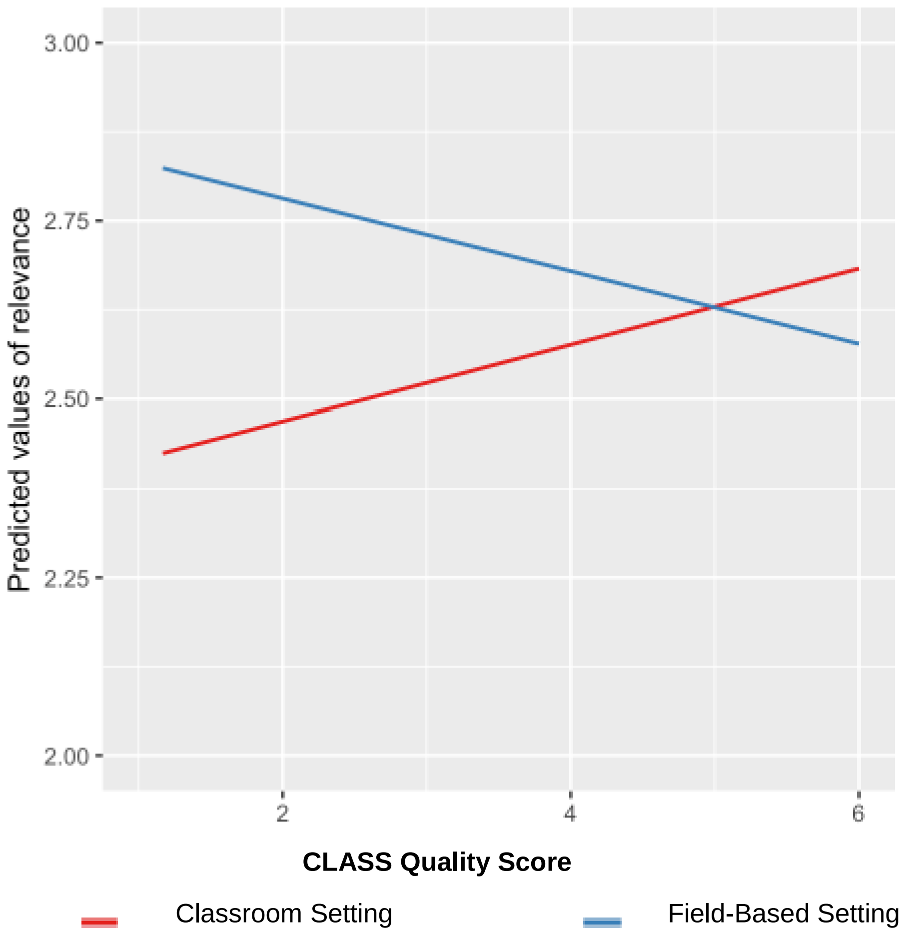
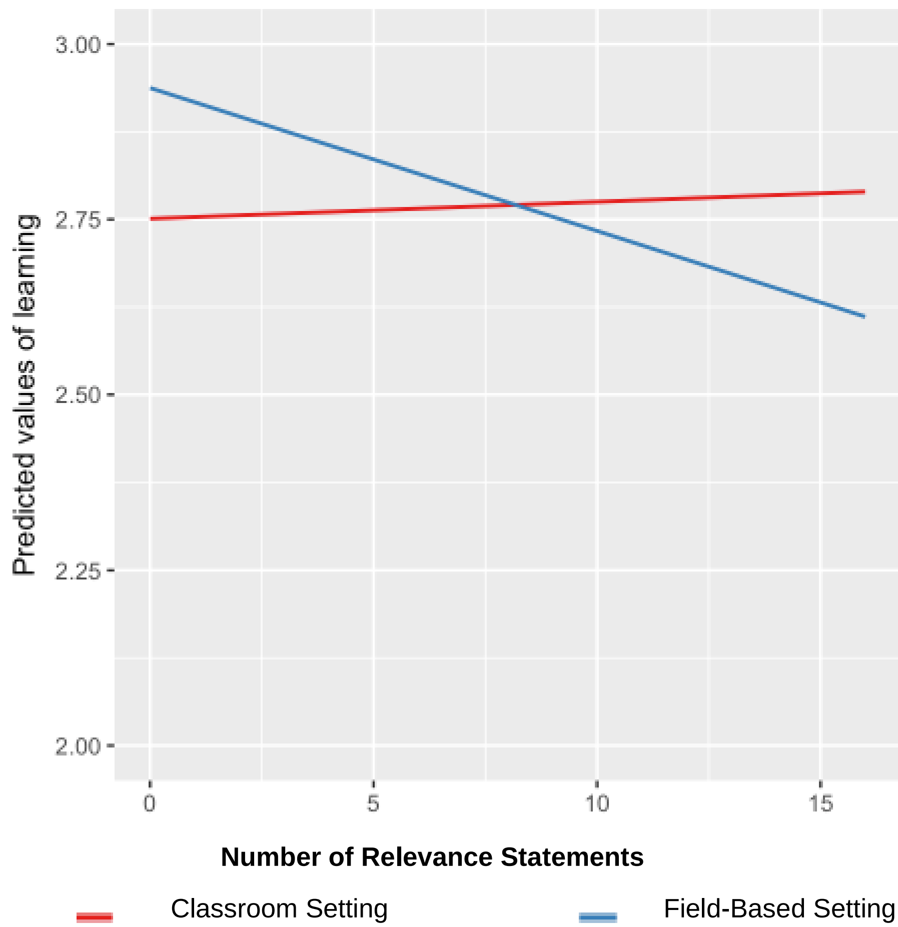


Figure 14. The more frequently activity leaders made relevance statements in a field-based setting, participating youth were less apt to report learning something new.



Implications

Participation in field-based activities appeared to support a number of positive experiences for youth participating in the STEM IE programs, including being challenged, seeing STEM content as relevant, and learning something new; however, to maximize what youth garner from these experiences, it may be important for activity leaders to recognize and support autonomous learning activities in field-based settings and use later classroom time to reflect on these experiences. Being too ambitious in terms of engaging in activity leader-led activities in field-based settings may serve to blunt what youth can gain from participating in such environments.

Youth Characteristics

In addition to the interactions already noted, each of the three youth characteristics included in the youth experience models were found to be related to one or more of the outcomes examined.

- Girls were less apt to report experiencing challenge and feeling that what they were doing was relevant than boys enrolled in the STEM IE programs.
- Similar findings were found in relation to youth that came into the programs in question with a higher STEM self-concept, who also reported being challenged less frequently in program activities.
- Youth that demonstrated a higher level of motivation to attend programming from the outset were more apt to report feeling that what they were doing was relevant and that they were learning something new by participating in program activities.

Implications

Generally, results from the STEM IE study suggest that a youth's gender, motivation to attend programming, and self-concept pertaining to STEM content areas can all play a role in how youth experience STEM programming and respond to various instructional practices employed by program activity leaders. In this sense, there isn't necessarily a one size fits all approach to designing and delivering ISL programming, and program staff should try to be mindful of these potential differences when planning how to design and deliver activities.

Activity Type and Youth Experiences

The next set of models run by the research team were very similar, largely involving the same set of predictors and outcomes, with the exception of the opportunities for agency variable which was dropped, and the addition of two activity type predictors: (1) if the activity taking place during the ESM episode largely focused on the cultivation of basic skills and (2) if the activity primarily focused on youth creating a product. Agency was dropped since one of the practices used in constructing the agency variable dealt with youth working on an activity that would eventually lead to a tangible product or performance, therefore overlapping conceptually with the creating a product activity type. Since this set of models is largely similar to those just described in detail, we focus exclusively on findings pertaining to how the type of activity being offered was related to youth in-the-moment experiences in programming. A table detailing results for each model can be found in Appendix E.

When an ESM episode was focused on an activity meant to cultivate the basic mathematics skills of participating youth, youth reported feeling both challenged and learning something new, but were not significantly more likely report feeling that the content they were working with was especially relevant or feeling engaged during such activities. Such results were largely consistent with what be expected in this regard.

In contrast, when youth were working on creating a product at the time an ESM signal was issued, they were more apt to report feeling challenged, perceiving the activity they were participating in as more relevant, and feeling engaged in the activity in question. However, youth did not report learning something new at a significantly higher level than other types of activities examined.

Implications

Summer programs for youth are commonly seen as opportune environments to promote academic skill building, either as a mechanism for stemming the summer slide or an opportunity to help youth struggling academically catch up on skills they have yet to have fully mastered. This was also true of the programs represented in the STEM IE study, and activities that focused on basic skills development, particularly in mathematics, were representative of this broader program goal. As may be expected, youth participating in these activities experienced both challenge and a sense that they were learning something. However, some caution here is advised in terms of ensuring youth have a broader array of experiences beyond activities that just focus on the development of basic academic skills. For example, supplemental analyses conducted by the research team suggested that a focus on basic skill development in mathematics was negatively associated with youth reporting being in a positive affective state when the ESM signal was issued (β = -0.22, $p < .01$). In this sense, focusing extensively on basic skills development does not seem to be a successful strategy for supporting interest development in STEM content areas for early adolescent youth.

In contrast, activities that involved creating a product were related to youth experiencing challenge, feelings of relevance, and importantly, a sense of engagement. For example, the overarching goal of one of the programs enrolled in the STEM IE study was to design and construct an outdoor classroom space for the school at which the program was housed. The emphasis here was on leaving a positive mark on the school community that would benefit the school for years to come. One activity leader described the goal of the program this way: "I guess our goal is to introduce students to the design process, while serving a community purpose and achieving a built structure by the end of the program, which is a lot for just four weeks." Another activity leader from the program later added, "I think by the end of it, especially in like three or four days [into the build] they started to take a lot more pride in what they're doing. It's like this is their wood, this is their project. At one point we were digging holes and like, "This is my hole. I'm digging this hole." That's what I like about this program compared to some of the others, is that like at the end they have a physical project that is going to be there for a long time, that they will have that sense of pride for it." Our sense is that these types of experiences will ultimately be more efficacious in achieving the longer-term interest and engagement in STEM sought by the programs in question.

Changes in Interest and Aspirations Related to STEM

As mentioned in the introduction to this report, the real value of STEM programs akin to those enrolled in the STEM IE study is seen as exposing youth to STEM content they otherwise would not have ready access to, and for those youth with a latent inclination to be drawn to STEM, help foster the emergence of sustained interest in and aspirations pertaining to the STEM fields.

As outlined in our change model (see Figure 1), it is anticipated that growth in STEM interest and aspirations will occur after a cascading set of experiences within the confines of the program, particularly ongoing and sustained engagement in program offerings. In this section of the report, we first explore the extent to which youth enrolled in the STEM IE programs demonstrated significant growth in interest and aspirations pertaining to STEM, and then asses if the level of youth-reported engagement in programming was related to the degree to which youth demonstrated growth on these outcomes during the span of the program.

Did youth demonstrate growth in STEM interest and aspirations?

Simple, paired-sample t-tests were performed to assess if youth with pre- and post-surveys scores on the interest and future aspirations scales demonstrated growth in these areas. As show in Table 3, while youth demonstrated significant growth in interest, this was not found to be the case for future aspirations. This result is not terribly surprising. Interest is seemingly a precursor to choosing a career in the STEM fields, and it would be expected that we would see growth here before seeing youth reach a point where they are inclined to consider STEM as a viable career pathway.

Table 3. Youth enrolled in the STEM IE programs demonstrated significant growth in STEM interest during the course of the summer session, while non-significant growth was demonstrated in relation to future aspirations related to STEM-related careers.

Scale	Pre-Survey Mean	Post-Survey Mean	Mean Difference
Interest (n=142)	2.75	3.10	0.35***
Future Aspirations (n=134)	2.76	2.83	0.07

Note. ****p* < .001

Was the level of engagement in programming related to growth in STEM interest and aspirations?

Finally, steps were taken by the research team to explore if the mean level of in-the-moment engagement experienced by youth as measured by completed ESM surveys was related to the growth demonstrated by youth pertaining to STEM interest and aspirations. In order to explore this relationship, a series two-level, multilevel models were run using the R computer program, with programs at level 2 and youth at level 1 (see Appendix D for additional information about these models). The outcomes assessed in each model was the post-survey score for interest and future aspirations pertaining to STEM. Three youth-level predictors were included in each model as the result of a model-building process undertaken to assess the viability of different youth-level predictors:

- **Pre-Survey Score** – Inclusion of the pre-survey interest or future aspirations score allowed to us to assess how much a given youth had grown on the scale in question between the pre- and post-administrations of the survey.
- **Mean Engagement Score** – The mean in-the-moment engagement score collected from administration of the ESM surveys was included in each model, although steps were taken to adjust this score to account for the fact that the number of ESM surveys completed varied from one youth to the next.
- **Youth's Gender** – Gender was also included as a predictor in each model. In this case, males were coded as 1 and females were coded as 0.

Results are shown in Table 4. As expected, **higher mean engagement scores were found to be significantly related to growth in youth interest in and aspirations pertaining to STEM**. In addition, boys attending the program were also more likely than girls to demonstrate growth on future aspirations related to STEM.

Table 4. Two-Level, HLM Models Predicting the Relationship Between Growth in STEM Interest and Aspirations and Key Predictors

	Interest–Post-Survey			Future Aspirations–Post Survey		
Fixed Effects	***B***		**SE**	***B***		**SE**
Intercept	0.10		0.37	0.72	†	0.39
Interest - Pre-Survey	0.53	***	0.07			
Future Aspirations – Pre-Survey				0.38	***	0.09
Engagement	0.46	***	0.11	0.30	***	0.03
Male	0.11		0.12	0.39	**	0.14

Note. † $p < .10$, ** $p < .01$, *** $p < .001$

These results are consistent with our expectation that enhanced levels of in-the-moment engagement in programming can help support growth in both STEM interest and future aspirations pertaining to STEM careers.

Study Limitations

Like any study, the design of the STEM IE study involves a series of limitations that readers should be mindful of when interpreting and seeking to apply study results:

1. The analyses undertaken do not support causal inferences to be made about the role of instructional approaches and experiences in cultivating youth interest and engagement in STEM. The analyses undertaken in conducting the study were purely descriptive. As a consequence, while statements can be made about the relationship between variables examined in the study, it is not possible to infer the directionality of a given relationship with certainty or infer causality. A more robust assessment of the role instructional practices play in supporting key in-the-moment program experiences and growth on outcomes associated with youth interest and engagement in STEM could be undertaken by crafting a more rigorous intervention study to explicitly test the viability of these practices using a more robust research design like random assignment or a strong quasi-experimental design that betters controls for issues of selection bias.
2. For analyses examining youth growth in interest in and future aspirations pertaining to STEM, the number of youth involved in programming was relatively small, as was the number of programs examined, which may have power implications in terms of detecting the relationships that were hypothesized to exist. This also made it infeasible to test the predictive value of potential program-level variables or explore how these variables may have interacted in a manner that may have been related to the outcomes being examined. For example, the staffing model varied across programs, with some programs reliant on a combination of school-day teachers and community educators, while some programs were more dependent on the former. It would have been ideal to explore how some of these additional program-level variables may have been related to the domain of outcomes examined. In addition, there may have been differences across programs in terms of the types of youth attracted to a given type of programming that may have been related to the outcomes explored. This seemingly is a challenge associated with undertaking studies that use the experience sampling method given the difficulty in undertaking these studies in a large number of settings given the shear effort that would need to be dedicated to collecting the ESM data in question.

Despite these limitations, the proposed study fills an important gap in understanding how youth engagement and interest develops in STEM-related content areas and has the possibility of providing practitioners with additional tools that can be employed to turn youth onto fields that are critically important to the sustained economic viability and competitiveness of the United States in the coming decades.

Conclusions and Toolkit

The primary purpose of the STEM IE study was to explore what types of practices, supports, and opportunities afforded to early adolescent youth attending nine STEM-oriented, summer programs were especially effective in helping youth experience in-the-moment engagement and therefore were likely to support growth in STEM interest and aspirations. From a practice standpoint, episode quality as measured by the CLASS observation tool, statements made by activity leaders to demonstrate the relevance of STEM content, and providing youth with opportunities to experience a sense of agency while undertaking program activities were all found to be related to a set of in-the-moment experiences reported by youth conducive to supporting engagement.

Some of these practices were also found to be related to getting youth not particularly motivated to attend the program in question at the start of the summer session plugged in to session offerings and having key experiences associated with engagement. Both the CLASS-derived quality score and the more frequent use of relevance statements by activity leaders were found to be especially effective in this regard. Informal STEM learning programs akin to those enrolled in the STEM IE study are likely to draw upon a wide variety of youth who come to programs of this type with a varying degree of motivation to attend and participate. Knowing that specific types of practices can move the needle in a meaningful fashion in terms of what youth experience is an important first step in understanding what can be done to connect youth with STEM content.

Field-based settings were also found to be effective in helping youth feel challenged, perceive what they were doing as relevant, and learn more about the STEM content being addressed. However, it also appears that these settings may be more effective when activity leaders afford youth a greater degree of autonomy in undertaking field-related tasks and using time set aside after the activity to reflect on session activities, discuss findings, and supplement what youth garnered from the activity with additional information.

As anticipated, the more youth experienced in-the-moment engagement in programming during the span of the summer session, the more likely they were to report growth in terms of interest and future aspirations related to STEM. This finding seems to both reinforce the importance of focusing on practices that will engender youth experiencing in-the-moment engagement while participating in programming and the viability of assessing changes in interest and future aspirations related to STEM when youth are engaged in programming. As the ISL field continues to explore ways to assess youth outcomes, this set of findings may be of particular import.

STEM IE Toolkit

Finally, a key component of the STEM IE study was to take what we learned about practices that seem to support youth having positive in-the-moment program experiences and constructing a free online toolkit that can be accessed by program practitioners to learn more about how to design and deliver STEM programming in a manner that incorporates these practices. The toolkit can be found at https://www.niu.edu/stemie. The toolkit contains video clips that demonstrate what a given practice looks like in live programs and professional development materials, including PowerPoint slides and facilitator guides. These resources can be used by training facilitators that would like to use the toolkit to further cultivate the capacity of STEM program activity leaders to adopt these practices when designing and delivering ISL programs for early adolescent youth. Our hope is that these resources will further enhance the capacity of STEM program practitioners to construct ISL programs that are conducive to supporting youth in-the-moment engagement and affording youth from low-income communities the opportunity to discover a previously unknown interest in and passion for STEM-related content areas.

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Appendix A. STEM IE Program Descriptions

STEM IE Program Descriptions

Program Name	Program Description
Adventures in Mathematics	**Primary content focus of program**: Mathematics **Aims**: The primary focus of the program was to develop the basic math skills and prevent summer learning loss among participating youth through direct instruction and participation in math-related games. **Location/facilities**: Classroom **Program size**: 20 **Ages/grades served**: Rising 8th to 10th graders **Program structure:** Youth participated in direct instruction in mathematics and math-related games in small groups. Program content was aligned with the state's standards in mathematics. The program took place for 5 weeks, Monday through Thursday from 8:30 am to 12:30 pm.
Building Mania	**Primary content focus of program**: Building **Aims**: The focus of the program was to provide youth with the opportunity to experiment in designing and using simple machines. During the course of program activities, youth were provided the opportunity to learn about and use hinges, rollers, weights, ramps, levels, and other technologies that support the movement of objects. A primary goal of the program was also to have youth engage in the engineering design process by determining a need, brainstorming possible designs, selecting a design, planning and drawing out the design, creating and testing and revising it, and producing a final machine. Additional skills developed by participating youth included recording, graphing, and reporting experimental data and using rulers, compasses, and graph paper to undertake program activities. **Location/facilities**: Classroom, design labs, and other local locations related to engineering **Program size**: 24 **Ages/grades served**: Rising 6th to 9th graders **Program structure**: Youth attended programming in a classroom at an area middle school and in a field-based setting on alternating days. Field-based settings included a design lab at a community-based organization and field trips to sites in the community related to the program's focus. In week 1 of the program, youth were introduced to

Program Name	Program Description
	simple machines. Week 2 focused on having youth learn about and work with inclined planes, wedges, and screws. Week 3 was dedicated to levers, and week 4 focused on wheel and axles. Projects completed during the course of the program were presented at a showcase on the last day of programming. The program took place for 4 weeks, Monday through Thursday from 9:30 am to 1:00 pm.
Comunidad de Aprendizaje	**Primary content focus of program**: Science, Mathematics, Building **Aims**: The focus of the program was to help youth improve basic skills in mathematics and develop interest in STEM content and entrepreneurship. **Location/facilities**: Classroom **Program size**: 33 **Ages/grades served**: Rising 5th to 8th graders **Program structure**: The program was split into morning sessions characterized by direct instruction in mathematics for individual grade levels and mixed grade level afternoon enrichment sessions in either robotics or dance. The direct instructions component of the program was organized around a theme of promoting entrepreneurship with the goal of helping participating youth better see the relevance of mathematics to future career goals and opportunities. Robotics involved building, programming, testing, and modifying robots using Lego Mindstorms EV3 kits to perform specific tasks. Dance was oriented at help youth explore their creativity and science through movement. The program ran for 6 weeks, Monday through Thursday from 9:30 am to 3:00 pm.
Island Explorers	**Primary content focus of program**: Science **Aims**: Develop expertise on one species found in the local ecosystem by reading and writing about related content for up to an hour per day; undertake data collection and analysis tasks to learn about the local ecosystem and how to communicate scientific data; develop vocabulary about the local ecosystem; use art to learn and communicate information; and draft, revise, edit, illustrate and publish a book illustrating important elements of the species being studied. **Location/facilities**: Classroom, local ecosystem **Program size**: 27 **Ages/grades served**: Rising 6th graders **Program structure**: Youth spent the morning in more academically-oriented sessions in a classroom setting, while afternoon sessions

Program Name	Program Description
	involved STEM-oriented enrichment sessions taking place outside with an emphasis on exploration of the local ecosystem. In week 1, students explored what an ecosystem is and what ecosystems exist on the island. In week 2, youth explored how organisms are interrelated and how organisms have adapted. In week 3, biodiversity and human impacts on ecosystems were explored. In week 4 and 5, final projects were drafted and published. The program ran for 5 weeks, Monday, Tuesday, Thursday and Friday from 10:00 am to 3:00 pm.
Jefferson House	**Primary content focus of program**: Mathematics, Science **Aims**: In addition to supporting the development of basic math skills, the program was primarily focused on helping youth develop problem solving, self-improvement, and critical thinking skills. **Location/facilities**: Classroom housed in a community-based organization **Program size**: 11 **Ages/grades served**: Rising 7th graders **Program structure**: Youth spent the morning in more academically-oriented sessions in a classroom setting focusing on basic skill development, while afternoon sessions involved STEM-oriented enrichment sessions involving media, art, and nutrition. Enrichment offerings varied by day, with math sessions occurring twice per week, alternating with academically oriented sessions in the am that were oriented at supporting skill development in English/language arts. The program took place for 5 weeks, Monday through Thursday from 10:45 am to 2:25 pm.
Marine Investigators	**Primary content focus of program**: Science **Aims**: The focus of the program was to provide youth with opportunities to learn about and experience Narragansett Bay; examine human impacts on the local ecosystem, including how the geography of the Bay helped influence human history and how the history of humans along the shoreline has impacted the Bay, and begin the process of cultivating a sense of stewardship among participating youth for caring for and protecting the Bay in the future. **Location/facilities**: Classroom, shoreline along the bay, ship on the bay, various field locations associated with bay health **Program size**: 19 **Ages/grades served**: Rising 7th to 9th graders

Program Name	Program Description
	Program structure: Youth attended programming in a classroom at an area middle school and in a field-based setting on alternating days. Field-based settings included the local bay shoreline, a voyage on a marine education ship conducting research in the Bay, and field trips to sites in the community related to the program's focus. Week 1 focused on introducing youth to the Bay, exploring how garbage impacts the bay, and the role of recycling in addressing this problem. Week 2 focused on the issue of water quality in the Bay and the role sewage treatment plays in preserving Bay health. The intent of week 3 was to explore the impact of watershed policy on preserving habitats. Week 4 allowed youth to work on a buoyancy lab and get familiar with additional species in the Bay. During the span of the program, youth had the opportunity to participate in both a water quality research study and a service learning project related to storm water diversion. The program took place for 4 weeks, Monday through Thursday from 9:30 am to 1:00 pm.
The Ecosphere	**Primary content focus of program**: Science **Aims**: The focus of the program was to explore the marine life of Narragansett Bay through hands-on experiences that familiarized youth with aquatic creatures like sharks, invertebrates, and tropical strays and the environment these creatures live in. A key goal of the program was to provide youth with the opportunity to consider how human actions affect marine habitats and what steps they can take to become better stewards of their environment. Efforts were undertaken to build youth content knowledge in the areas of ecosystem preservation, marine biology, and water quality, and related skills, such as questioning, showing initiative, data collection, measuring, maintaining an ecosystem, and analyzing water samples. **Location/facilities**: Classroom setting, shoreline, science education center **Program size**: 27 **Ages/grades served**: Rising 6th to 9th graders **Program structure**: Youth attended programming in a classroom at an area middle school and in a field-based setting on alternating days. Field-based settings included a science education center at a community-based organization and field trips to sites in the community related to the program's focus. Daily activities began with a discussion and involved daily journaling and data collection for a group specimen collection and scrap book. Activities during week 1 of the program

Program Name	Program Description
	focused on introducing local marine life, the Fibonacci sequence, and how to care for marine life living in tanks (e.g., maintaining salinity, pH, temperature, etc.). Week 2 was focused on water flow and interconnectedness between land and sea, while week 3 was dedicated to the importance of apex predators, specifically sharks. Week 4 focused on density and how it affects animals and included a shark dissection. A culminating group project incorporating something learned during each day of camp was presented at a final showcase. The program took place for 4 weeks, Monday through Thursday from 9:30 am to 1:00 pm. Other: Blog and Pinterest used as outlet for students to display their knowledge.
Uptown Architecture	**Primary content focus of program**: Building **Aims**: The primary focus of the program was to have youth participate in a process to design and build an outdoor learning space for use at the middle school where the program was housed. A key focus of the program was to provide youth with the opportunity to use design-thinking as a problem-solving tool and have the experience of affecting their community in a positive way through the design/build process. Youth were afforded the opportunity to learn how to work as part of collaborative team, develop their presentation skills, and learn basic carpentry skills and building techniques (e.g., using tape measures, miter saws, drills, etc.). **Location/facilities**: Classroom, building shop, various field locations **Program size**: 16 **Ages/grades served**: Rising 6th to 9th graders **Program structure**: Youth attended programming in a classroom at an area middle school and in a building shop located at a community-based organization on alternating days, while also taking field trips to locations associated with the program’s overall theme. Week 1 of the program was dedicated to identifying the needs of the school community and how their project could address these needs, while week 2 was focused on the design of the outdoor learning space. Week 3 was focused on obtaining and prepping materials for the build, while week 4 was focused on the actual construction of the final project. The program took place for 4 weeks, Monday through Thursday from 9:30 am to 1:00 pm.

Program Name	Program Description
Zoology Partners	**Primary content focus of program**: Science **Aims**: The primary focus of the program was to support the development of content knowledge related to the issue of endangered species, including how species become endangered, processes for monitoring ecosystem viability and population levels, solutions to prevent species from becoming endangered, and exploring approaches around how to revive populations that are currently endangered. Youth were exposed to new terminology in these areas, afforded the opportunity to partake in field work in local ecosystems to identify key indicator species, and explore the type of work scientist undertake in this area. It was also intended that youth would develop a sense of empowerment and stewardship in terms of helping endangered species. **Location/facilities**: Classroom, zoos, parks, and other natural areas **Program size**: 26 **Ages/grades served**: Rising 6th to 9th graders **Program structure**: Youth attended programming in a classroom at an area middle school and in a field-based setting on alternating days. Field-based settings included a local zoo and field trips to sites in the community related to the program’s focus. Week 1 of the program explored why species become endangered, while week 2 focused on conservation efforts. Week 3 focused specifically on conservation efforts related to water habitats, while week 4 focused on the process of studying animals and how different types of scientists undertake this work. Youth also completed journals daily, participated in debriefing and reflection sessions, and engaged in team-building and inquiry activities. The final day of the program involved showcasing a culminating project drawn from the work completed by youth during the course of the program. The program took place for 4 weeks, Monday through Thursday from 9:30 am to 1:00 pm.

Appendix B. Study Measures

STEM Interest and Engagement Study - Experience Sampling Form

1. **As you were signaled, where were you?**
   - Classroom
   - Outside
   - Other — locations customized for program

2. **As you were signaled, were you doing what you were supposed to be doing?**
   ○ Yes ○ No

3. **As you were signaled, what were you thinking about?**
   - Something related to the activity
   - Something unrelated to the activity

4. **As you were signaled, were you working alone on this activity?**
   ○ Yes ○ No
   a. [If no is selected] Please select all of the people you were working with on this activity.
      - A partner
      - A small group
      - The whole group
      - Leader(s)
      - Teacher(s)
      - Other

5. As you were signaled,	Not at all	A little	Somewhat	Very much
a. How challenging was the main activity?	○	○	○	○
b. Were you good at the main activity?	○	○	○	○
c. Was the main activity interesting?	○	○	○	○
d. Was the main activity important to you?	○	○	○	○
e. Was the main activity important to your future goals?	○	○	○	○
f. Could you see yourself using what you were learning in the main activity outside this program?	○	○	○	○

	Not at all	A little	Somewhat	Very much
g. As you were signaled, did you enjoy what you are doing?	○	○	○	○
h. As you were signaled, how well were you concentrating?	○	○	○	○
i. As you were signaled, were you learning anything or getting better at something?	○	○	○	○
j. As you were signaled, did you feel in control of the situation?	○	○	○	○
k. As you were signaled, how hard were you working?	○	○	○	○
l. How HAPPY were you feeling?	○	○	○	○
m. How EXCITED were you feeling?	○	○	○	○
n. How FRUSTRATED were you feeling?	○	○	○	○
o. How BORED were you feeling?	○	○	○	○
p. How STRESSED were you feeling?	○	○	○	○

6. Additional comments or thoughts? (open-ended)

STEM Interest and Engagement Study: Youth Survey

Youth Name:

This is a survey about the things you are interested in and about this program. The information will be used to learn how programs such as this one help youth become interested in science. **There are no right or wrong answers! This is not a test!**

Your answers will be kept private—no one in the program or your family will know what you answered. But to keep your answers private, you **must tear off this page with your name on it** before you turn this survey in. All answers will be sent to the study researchers, who will pull together all the information, without any names.

Please answer each question by filling in the circle next to the answer. Some questions ask you to fill in only ONE circle, and other questions ask you to fill in ALL the circles that apply to you. For example:

Example 1 (Fill in only one circle.)

	One	Two	Three	Four	Five
How many days do you come to this program each week?	○	○	●	○	○

Example 2 (Fill in all the circles that apply to you.)

What activities do you participate in during this program? Fill in ALL the circles that are next to activities you are in.	
●	Homework help
○	Computers
●	Art
●	Basketball

1. **What are your favorite classes in school? Please name up to three classes.**

____

2. **What are your favorite things to do outside school? Please name up to three things.**

____

3. Did you go to any classes, clubs, or programs last summer or after school *last year* where you learned about:

	Yes	No	I'm not sure
a. Science	○	○	○
b. Math	○	○	○
c. Computers	○	○	○
d. Building (like robots or Legos)	○	○	○

4. How much do you like to do these things?

	Not at all	A little	Somewhat	Very much
q. I like to watch TV shows about animals or nature.	○	○	○	○
r. I like to watch TV shows about discoveries.	○	○	○	○
s. I like visiting science museums or zoos.	○	○	○	○
t. I like reading science magazines.	○	○	○	○
u. I get excited to do a science activity.	○	○	○	○
v. I like reading science fiction books.	○	○	○	○
w. I like to solve problems.	○	○	○	○
x. I like to plan and make things that work.	○	○	○	○
y. I like to take things apart to learn more about them.	○	○	○	○
z. I like to see how things are made (for example, ice cream, a TV, an iPhone, energy).	○	○	○	○
aa. I would like to get a science kit as a gift (for example, a microscope or a robot).	○	○	○	○
bb. I like playing games that make me think.	○	○	○	○

5. How true is each of the following sentences?

	Not at all true	A little true	Somewhat true	Really true
a. I am interested in science.	○	○	○	○
b. I am good at science.	○	○	○	○
c. At school, I expect to do well in science.	○	○	○	○
d. At school, science is fun.	○	○	○	○
e. At school, I learn a lot about science.	○	○	○	○
f. I would be good at learning something new in science.	○	○	○	○
g. It is important to me to be good at science.	○	○	○	○
h. What we study in science class is useful to know.	○	○	○	○
i. I can see how what I learn from science applies to life.	○	○	○	○
j. I have always been fascinated by science.	○	○	○	○
k. I would like to understand more about scientific explanations for things.	○	○	○	○
l. Science will be important to me for <u>college.</u>	○	○	○	○
m. Science will be important to me for a <u>career.</u>	○	○	○	○

6. How true is each of the following sentences?

	Not at all true	A little true	Somewhat true	Really true
a. I am interested in math.	○	○	○	○
b. I am good at math.	○	○	○	○
c. At school, I expect to do well in math.	○	○	○	○
d. At school, math is fun.	○	○	○	○
e. At school, I learn a lot about math.	○	○	○	○
f. I would be good at learning something new in math.	○	○	○	○

	Not at all true	A little true	Somewhat true	Really true
g. It is important to me to be good at math.	○	○	○	○
h. I can apply what we learn in math class to real life.	○	○	○	○
i. What we study in math class is useful to know.	○	○	○	○
j. I have always been fascinated by math.	○	○	○	○
k. I would like to understand more about mathematical explanations for things.	○	○	○	○
l. Math will be important to me for <u>college</u>.	○	○	○	○
m. Math will be important to me for a <u>career</u>.	○	○	○	○

7. How true is each of the following sentences?

	Not at all true	A little true	Somewhat true	Really true
a. I am interested in building things.	○	○	○	○
b. I am good at building things.	○	○	○	○
c. At school, I expect to do well when we build things.	○	○	○	○
d. At school, building things is fun.	○	○	○	○
e. At school, I learn a lot about building things.	○	○	○	○
f. I would be good at learning something new about building things.	○	○	○	○
g. It is important to me to be good at building things.	○	○	○	○
h. I can apply what we learn about building things to real life.	○	○	○	○
i. What we study about building things is useful to know.	○	○	○	○
j. I have always been fascinated by building things.	○	○	○	○

	Not at all true	A little true	Somewhat true	Really true
k. I would like to understand more about building things.	○	○	○	○
l. Building things will be important to me for college.	○	○	○	○
m. Building things will be important to me for a career.	○	○	○	○

8. Whose idea was it to sign up for this summer program? Pick all that apply

a. It was my idea to sign up.	○
b. My parents or guardian wanted me to sign up.	○
c. My friend(s) wanted to me to sign up.	○
d. One of my school-day teachers wanted me to sign up.	○
e. One of my afterschool activity leaders wanted me to sign up.	○

9. How much have you been looking forward to this summer program? (Pick one.)

a. Not at all. I don't want to be here.	○
b. I have been ***sort of*** looking forward to it.	○
c. I have been ***really*** looking forward to it.	○

10. Are the following people in this summer program?

	Yes	No	Don't Know
a. Your friends	○	○	○
b. Teachers from school who you like	○	○	○
c. Activity leaders you like from after school programs you went to	○	○	○

11. What do you think you will do in this summer program?

	Yes	No	Don't Know
a. Learn new things about science	○	○	○
b. Build things	○	○	○

	Yes	No	Don't Know
c. Do experiments	○	○	○
d. Go to places I have never been before	○	○	○
e. Work on projects	○	○	○
f. Learn about what scientists do	○	○	○
g. Make new friends	○	○	○
h. Have lots of fun	○	○	○

12. How sure are you about these things in this summer program?

	Not at all sure	Somewhat sure	Fairly sure	Completely sure
a. I can do well even if activities are hard.	○	○	○	○
b. I can learn the material in this program.	○	○	○	○
c. I can to meet my goals in this program.	○	○	○	○
d. I can do well in this program.	○	○	○	○

13. As things stand now, how far in school do you think you will go? (Pick one.)

a. Go to high school but not graduate	○
b. Graduate from high school, but not go any further	○
c. Go to college	○
d. Graduate from college	○
e. Get advanced degree, like M.D., Ph.D., law	○
f. I do not know how far I will go.	○

14. If you plan to go to school after high school, what do you think you will study? (e.g., science, art, computers, psychology, literature, engineering)

____

15. What job do you think you will have when you are 30 years old?

____

16. Please circle how much you agree with each sentence.

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
a. It would be interesting to work in a science or computer laboratory.	○	○	○	○
b. In my future job, I would like to use the science and math I learn in school.	○	○	○	○
c. I would seriously think about becoming a scientist, mathematician, or engineer when I finish school.	○	○	○	○

Thank You!

STEM Interest and Engagement Study: Youth Post-Survey

Youth Name:

This is a survey about the things you are interested in and about this program. The information will be used to learn how programs such as this one help youth become interested in science. **There are no right or wrong answers**! **This is not a test!**

Your answers will be kept private—no one in the program or your family will know what you answered. But to keep your answers private, you **<u>must tear off this page with your name on it</u>** before you turn this survey in. All answers will be sent to the study researchers, who will pull together all the information, without any names.

Please answer each question by filling in the circle next to the answer. Some questions ask you to fill in only ONE circle, and other questions ask you to fill in ALL the circles that apply to you. For example:

Example 1 (Fill in only one circle.)

	One	Two	Three	Four	Five
How many days do you come to this program each week?	○	○	●	○	○

Example 2 (Fill in all the circles that apply to you.)

What activities do you participate in during this program? Fill in ALL the circles that are next to activities you are in.	
●	Homework help
○	Computers
●	Art
●	Basketball

1. When you are at this summer program…

	Never	Rarely	Sometimes	Often
a. Do you get to choose how you spend your time?	○	○	○	○
b. Can you suggest your own ideas for new activities?	○	○	○	○
c. Do you get to choose which activities you do?	○	○	○	○
d. Do you get to help plan activities for the program?	○	○	○	○
e. Do you get the chance to lead an activity?	○	○	○	○
f. Do you get to be in charge of doing something to help the program?	○	○	○	○
g. Do you get to help make decisions or rules for the program?	○	○	○	○

2. What are the teachers and staff members like at this summer program?

Is there an adult here …	Not at all true	A little true	Somewhat true	Really true
a. Who is interested in what you think about things?	○	○	○	○
b. You can talk to when you are upset?	○	○	○	○
c. Who helps you when you have a problem?	○	○	○	○
d. You enjoy being around?	○	○	○	○
e. Who has helped you find your special interests and talents (what things you are good at)?	○	○	○	○
f. Who asks you about your life and goals?	○	○	○	○
g. Who you will miss when the program is over?	○	○	○	○

3. At this summer program, how do kids get along?

	Not at all true	A little true	Somewhat true	Really true
a. Kids here are friendly with each other.	○	○	○	○
b. Kids here treat each other with respect.	○	○	○	○
c. Kids here listen to what the teachers tell them to do.	○	○	○	○
d. Kids here tease or bully other kids.	○	○	○	○
e. Kids here support and help one another.	○	○	○	○

4. How has this summer program helped you? After you have answered each question, go back and circle the <u>three items</u> where you think the program helped you the most.

Coming here has helped me ….	Not at all true	A little true	Somewhat true	Really true
a. Feel good about myself.	○	○	○	○
b. With my confidence.	○	○	○	○
c. Make new friends.	○	○	○	○
d. Find out what is important to me.	○	○	○	○
e. Find out what I'm good at doing.	○	○	○	○
f. Find out what I like to do.	○	○	○	○
g. Discover things I want to learn more about.	○	○	○	○
h. Learn things that will help me in school.	○	○	○	○
i. Learn things that will be important for my future.	○	○	○	○
j. Think about what kinds of classes I want to take in high school.	○	○	○	○
k. Think about what I might like to do when I get older.	○	○	○	○
l. Learn about things that are important to my community or the environment.	○	○	○	○
m. Feel good because I was helping my community or the environment.	○	○	○	○

5. What did you like best about this program?

____

6. If you were in charge, how would you change this program?

____

7. Would you recommend that your friends come to this program next year?

☐ **Yes** ☐ **No**

Please explain why or why not:

____

8. How true is each of the following sentences?

	Not at all true	**A little true**	**Somewhat true**	**Really true**
a. I am interested in science.	○	○	○	○
b. I am good at science.	○	○	○	○
c. At school, I expect to do well in science.	○	○	○	○
d. At school, science is fun.	○	○	○	○
e. At school, I learn a lot about science.	○	○	○	○
f. I would be good at learning something new in science.	○	○	○	○
g. It is important to me to be good at science.	○	○	○	○
h. What we study in science class is useful to know.	○	○	○	○
i. I can see how what I learn from science applies to life.	○	○	○	○
j. I have always been fascinated by science.	○	○	○	○
k. I would like to understand more about scientific explanations for things.	○	○	○	○
l. Science will be important to me for <u>college.</u>	○	○	○	○
m. Science will be important to me for a <u>career.</u>	○	○	○	○

9. How true is each of the following sentences?

	Not at all true	A little true	Somewhat true	Really true
a. I am interested in math.	○	○	○	○
b. I am good at math.	○	○	○	○
c. At school, I expect to do well in math.	○	○	○	○
d. At school, math is fun.	○	○	○	○
e. At school, I learn a lot about math.	○	○	○	○
f. I would be good at learning something new in math.	○	○	○	○
g. It is important to me to be good at math.	○	○	○	○
h. I can apply what we learn in math class to real life.	○	○	○	○
i. What we study in math class is useful to know.	○	○	○	○
j. I have always been fascinated by math.	○	○	○	○
k. I would like to understand more about mathematical explanations for things.	○	○	○	○
l. Math will be important to me for <u>college</u>.	○	○	○	○
m. Math will be important to me for a <u>career</u>.	○	○	○	○

10. How true is each of the following sentences?

	Not at all true	A little true	Somewhat true	Really true
a. I am interested in building things.	○	○	○	○
b. I am good at building things.	○	○	○	○
c. At school, I expect to do well when we build things.	○	○	○	○
d. At school, building things is fun.	○	○	○	○
e. At school, I learn a lot about building things.	○	○	○	○

	Not at all true	A little true	Somewhat true	Really true
f. I would be good at learning something new about building things.	○	○	○	○
g. It is important to me to be good at building things.	○	○	○	○
h. I can apply what we learn about building things to real life.	○	○	○	○
i. What we study about building things is useful to know.	○	○	○	○
j. I have always been fascinated by building things.	○	○	○	○
k. I would like to understand more about building things.	○	○	○	○
l. Building things will be important to me for college.	○	○	○	○
m. Building things will be important to me for a career.	○	○	○	○

11. As things stand now, how far in school do you think you will go? (Pick one.)

a. Go to high school but not graduate	○
b. Graduate from high school, but not go any further	○
c. Go to college	○
d. Graduate from college	○
e. Get advanced degree, like M.D., Ph.D., law	○
f. I do not know how far I will go	○

12. If you plan to go to school after high school, what do you think you will study? (e.g., science, art, computers, psychology, literature, engineering)

____

13. What job do you think you will have when you are 30 years old?

____

14. Please circle how much you agree with each sentence.

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
a. It would be interesting to work in a science or computer laboratory.	○	○	○	○
b. In my future job, I would like to use the science and math I learn in school.	○	○	○	○
c. I would seriously think about becoming a scientist, mathematician, or engineer when I finish school.	○	○	○	○

15. How much do you think your participation in this study disrupted your learning in this program? ***(fill in only one)***

Not at all	Only a little bit	Somewhat	Very much
○	○	○	○

16. How much do you think your participation in this study improved your learning in this program? ***(fill in only one)***

Not at all	Only a little bit	Somewhat	Very much
○	○	○	○

Thank You!

Interview Protocol for Activity Leaders, STEM IE Study

Thank you for taking the time to speak with me today. As you are aware, the purpose of this interview is to learn more about your implementation of Science, Technology, Engineering, and Math (STEM) activities. We are interested in how Summer STEM programs promote participants' interest and engagement.

We are going to begin with some general questions about you and your program and then we are going to watch a video together so we can get more specific about topics that relate to your STEM programming. We will conclude the interview with some general items.

We will take every measure possible to protect the privacy of interviewees as well as to ensure the confidentiality of the data collected. We would like to record this interview for note-taking purposes only. We won't name you by name in the report, although your program will be featured in it. Is that OK?

The interview should take no more than one hour. If you have any questions or want clarification on a question, please feel free to ask at any time.

Activity Leader Background
Let's start by talking about your role in the program.

1. Please tell me about your role and experience at this program. (**Only if not provided in the survey, probe for details in the following areas.**)
    a. Responsibilities
    b. Duration of tenure at the site and in the organization

We are interested in learning about the kinds of staff who work at the program and how they are trained to support the STEM program.

2. What is your professional background? (**Only if not provided in the survey, probe for details in the following areas.)**
    a. Previous teaching or youth work experience, including prior experience with afterschool and expanded learning programs
    b. Educational background (briefly: degrees, institutions)
    c. Teaching credential or credential related to youth development, or child care
    d. Training specific to one or more STEM areas

3. (**If not mentioned in the survey, probe for details in the following areas.)**
   Are you also a staff member in an afterschool program? If so, what do you do there?

4. If you are also a teacher or activity leader during the school year, how is your teaching the same or different between the school year and summer?

5. You are working in *X* program. How interested are you personally about topics in that area? How did you get interested? In a nutshell why do you think *X (e.g. design, exploring the bay, mathematics, etc.*) is important to learn about?

Program Overview: ***Now let's talk about your program in general.***

6. What are the main goals of the program? Would you say it focuses on Science, Technology, Engineering or Mathematics or some combination of those?

7. *Let's look over a typical weekly schedule*. Tell me about your program. How did/do you decide on which programs and activities to offer? How often, if at all do you change the schedule or activities?
   Probes: Is there a formal curriculum, which one?
   Lesson plans from past summers (your own/others)?
   Adaptations from school year? Other resources?

8. What kinds of settings do you have access to for STEM summer activities (e.g., classrooms, labs, computer labs)?
   How are you using these settings?
   Which settings do you use the most?
   In which settings do you find youth most interested and engaged in activities? Why do you think they are most interested and engaged there?

Program Practices

We are interested in learning about your (instructional) practices aimed at promoting STEM learning.

9. You/this program is known for being engaging and interesting. How do you engage and interest youth in the content you are teaching?

10. What's the value of having young people work with one another? How do you have them work together? Probe: How often and under what circumstance do you use:
    a. One-on-one instruction or independent activities
    b. Large/whole group instruction/activities
    c. Peer-to-peer learning

11. How do you build relationships with youth in the program? Why are those relationships important?

12. Tell me about opportunities that young people have to control their experience in the program. What opportunities do you provide that allow young people to lead, have a say in what they do, and ultimately make decisions for themselves? Probe: choices, leadership opportunities, inquiry/youth questions.

13. What do you see as the value of active learning? How do you incorporate active learning (e.g., hands-on, minds-on, project based, inquiry) into the sessions? Can you give an example that represents your approach?

14. What challenges did you encounter in trying to deliver the programming you planned to provide?

Recording Reflection. *We have been talking about your program in general, but now I want to turn to your STEM activities that we recorded. Let's take a few minutes to watch a recording of your program.*

15. What was the goal/purpose of this activity?

16. How did you decide on and plan this activity? Is this part of a series or set of activities?

17. We talked previously about active learning. Did you employ any of those strategies here? Probe: Why, why not, and how?

18. What are the key concepts you wanted youth to take away from the activity? Do you think most young people got this? Why/why not?
    a. Would you say the activity was generally an effective way to promote these concepts? Interest youth in these concepts? Why/why not?
    b. What kinds of cues from participants suggested to you that this was an effective/ineffective way to convey/interest them in these concepts?
    c. Do you think you will use this activity again in future programs? Why/why not? If so, would you do anything differently?

d. Was there anything going on related to this project that we didn't get to see that week? For example, were participants' doing work on other days or at home?

19. Is there anything else you want to tell me about this activity? PROBE: What were the challenges you encountered in leading this activity? SECOND LEVEL PROBE (when relevant): We noticed that some discipline issues arose here. Could you comment on what that was like for you?

STEM Futures (STEM Self-Concept) *We want to hear more about how your program aims to promote a positive STEM future for your participants.*

20. Youth usually enter programs like this with varying levels of interest in and commitment to the topic/subject. How do you manage these varying levels of interest?

21. How do you promote the value of the topic you are teaching for the program participants? PROBES: Do you try to link the content to their own lives? To issues that are important in their community? In what ways? Are youth exposed to careers related to the topic that you teach? Role models? Are participants exposed to goal setting or plans for postsecondary education or training? If so, how?

F. **Wrap Up**

22. Did our presence in your program influence the way you or participants acted? If so, how?

23. Were there other things going on in the program, community, or world during that week that you think changed the way you or your participants acted? If so, what?

24. In addition to the challenges previously identified, what barriers or challenges have you encountered in trying to create structures to implement the STEM program, and how have you overcome them?

25. Is there anything else you would like to tell us about the program's STEM activities?

QUALITY CHECKLIST (Derived from items appearing on the Youth Program Quality Assessment)

		Value
Site ID		
Date of Visit		
ESM Signal Number		
6th Grade Math		
7th Grade Math		
8th Grade Math		
Dance		
Robotics		

			Observed		Not Observed		No opportunity to observe		Notes/ Observations
Active Participation									
1	The activity involves concrete experiences involving materials, people, and projects (e.g., field trips; experiments; practicing dance routines; etc.).								
2	The activity involves **abstract** learning of concepts (e.g., talking about a topic; lectures; staff providing formulas, etc.)								
Higher Order Thinking									
3	Staff encourage youth to deepen or extend knowledge (e.g., staff asks youth questions that encourage youth to analyze, define a problem, make comparisons, predictions, applications, inferences, generate alternate solution, etc.)								

			Observed		Not Observed		No opportunity to observe		Notes/ Observations
4	Staff has youth make **connections** between session activities and other knowledge or experience (e.g., youth's prior knowledge; personal interest; hobbies; goals; related careers; real world applications or issues, etc.)								
5	Staff encourage youth in using their creativity, curiosity, or imagination (e.g., staff encourage youth to think outside the box; to use knowledge and skills in new ways; encourages wonder).								
Belonging and Collaboration									
6	Youth work toward **shared goals** (in a group or individually).								
7	Youth share their ideas and opinions about the content/structure of the activity.								
Opportunities for Agency									
8	Staff **shares control** of activities with youth, providing guidance and facilitation while retaining overall responsibility.								
9	Youth are participating in activities that will eventually lead to the creation of a tangible product or culminating event.								
10	Youth are participating in activities that allow them to **explore and discover** new things on their own.								
11	Youth are making plans for projects or activities.								

Supports and Opportunities Related to the Pursuit of Self-Transcendent Goals									
			Observed		Not Observed		No opportunity to observe		Notes/ Observations
12	Staff make statements which define or articulate the **causes** of a local, community, environmental, and/or societal problem.								
13	Staff make statements about the need for action to be taken to preserve, protect, or advance a local ecosystem, species, or community.								
14	Staff ask youth to **reflect** on what should be done to preserve, protect, or advance a local ecosystem, species, or community.								
15	Youth work on creating and/or delivering products, presentations, or projects that are meant to educate others about the causes of a community or societal problem and/or possible solutions.								
16	Youth are working on creating a **product** or completing a **project** which is directly helpful to others.								
17	Youth collect and/or analyze information that will help describe or inform solutions to local or community problems.								
STEM Skill Building									
18	Staff ask youth to make **predictions, conjectures, or hypotheses** (e.g., "if you …, then what will happen?")								

			Observed		Not Observed		No opportunity to observe		Notes/ Observations
19	Staff support youth in using a simulation, experiment, or model to answer questions, explore solutions, or test hypotheses (e.g., Youth run a robotics program to determine whether it does what they expect it to; Youth try an alternate way to solve an equation and test their results against another example, etc.)								
20	Staff support youth in **analyzing data** to draw conclusions (e.g., after an experiment, youth are asked to use results to make a generalization like "Your heartbeat increases when you exercise", etc.)								
21	Staff support youth in collecting data or measuring (e.g., Youth use rulers or yardsticks to measure length; Youth count the number of different species of birds observed in a specific location, etc.)								
22	Staff support youth in **using tools of the field** (e.g., youth use calculators for mathematics; ph-tests for biology; woodworking tools for building, etc.)								
23	Staff highlight the value of precision and accuracy in measuring, observing, recording, or calculating (e.g., measurement error can impact an experiment or conclusion; measure twice, cut once; scientist always need to double-check their calculations before drawing conclusions; you must observe carefully to see the difference between various species of sparrows, etc.)								
24	Staff model use of **STEM vocabulary terms** (e.g., SCIENCE - chlorophyll, density, atomic, nuclear, geologic, light year; ENGINEERING - torque, currents, force; MATH - rate of change, slope, percent, etc.)								

			Observed		Not Observed		No opportunity to observe		Notes/ Observations
25	Staff support youth in using classification and abstraction, linking concrete examples to principles, laws, categories, and formulas (e.g., Mice, porcupines, and squirrels are all rodents, rodents are all mammals; The pool ball moved because for every action, there is an equal and opposite reaction; etc.)								
26	Staff support youth in conveying STEM concepts through **symbols, models, or other nonverbal language** (e.g., youth use diagrams, equations, flowcharts, outlines, mock-ups, design software, dioramas, physical models, prototypes, graphs, charts, tables, equations, etc.)								

Which of the following subject areas was most prevalent during the activity?			
			Value
	Science		
	Mathematics		
	Building		
	No content area		

Coding Relevance Statements from STEM IE (adapted from IMUScLE)

Event coding will focus exclusively on value statements made by any of the Activity Leaders. Youth statements will not be coded. In cases where leaders make value statements as part of an interchange with youth, we will code the leaders' statements only.

Defining a value instance. A leader comment that contains a single instance of any type of value statement (i.e., we can identify and code V1), and the initiator (V2) and referent audience (V3) does not change. Any change in the type of value (V1), the initiator (V2), or the referent audience (V3) signals a new event. In the case of a utility value instance, the value instance should reference utility for only one purpose (a single code for V7). If two purposes are evident, recode as two separate instances. Likewise, in the case of cost instances, multiple costs (V8) should be recoded as separate instances of value.

V1. Type of Value (choose only 1)

1. **High utility value** of STEM (STEM or STEM content is useful for some purpose. Keep in mind that we are coding instances that emphasize the utility of <u>STEM or STEM content</u> for something else. We are NOT coding comments that emphasize the utility of particular tools, methods, or practices for understanding STEM, or for doing STEM better.) **If coded as 1., code V2–V8**
2. **Low utility value.** Explicit statement that science is NOT useful. **If coded as 2, code V2- UV6 only**
3. **High intrinsic value:** topic/activity/field is interesting, fun, cool.
    a. **High self-transcendent intrinsic value** – topic/activity/field will facilitate feelings of meaning/happiness by working for the betterment of others/making a contribution (e.g., you'll feel good for doing this because you're helping others; doesn't it feel good to help/make a contribution, etc.). The focus here is on the emotions the act of helping or contributing will engender. In a similar fashion, comments made by the activity leader may be oriented at sparking sympathy, outrage, or concern (e.g., you should be concerned because the consequences of inaction are severe to the ecosystem, species, this species may go extinct if things don't change, etc.)
4. **Low intrinsic value:** topic/activity/field is boring, uncool

5. **High attainment value** (engaging in this task or doing well in it is important to one's self-concept, you are good at this so you should care about it, expressions of striving for competence) a. **High self-transcendent attainment value** – The focus here is on one's self-concept as a person that is caring, giving, and willing to help/make a difference. Examples might include things like, "you have the skills and ability to make a difference; you're the type of person that cares about helping others/making a difference; doing this well is important for helping others etc." 6. **Low attainment value** (engaging in a task or doing well in it is not important to one's self-concept, you are not good at this anyway, it must not be important to you) 7. **Low cost.** Activity/Work requires little investment of time or effort ('easy'), or is low cost relative to other tasks/alternatives (e.g. because the cost of NOT doing it will be even higher), or has low social cost (won't hurt your reputation). 8. **High cost:** Activity/Work requires substantial investment of time or effort ('hard'), has high cost relative to other tasks/alternatives (e.g., by investing in science, you are short-changing something else of value), or has high emotional cost (causes anxiety, frustration, annoyance, anger) or social cost.
V2. Was the leader's reference to value unsolicited or in direct response to a comment, question or behavior? (choose only 1) 1. Leader's value reference was unsolicited (i.e., not in response to a comment, question or behavior by another person) 2. Leader's value reference was a response to a youth comment, question or behavior 3. Leader's value reference was a response to a comment, question, or behavior by someone other than a student (includes other leaders, STEM IE team members) 4. Unclear whether or not the value statement was unsolicited or a response to someone else
V3. The leader's value reference was addressed to: (choose only one) 1. Individual Youth 2. Small group 3. Whole Group 4. Other Activity Leader(s) 5. Other (includes STEM IE team members) 6. Unclear

V4. The value (or lack thereof) is explicitly for (choose only one) 1. Whole class/general population (this is the default coding category, the general 'you/we') 2. Activity Leader (self. If value is expressed for the non-speaking activity leader, choose 'other') 3. Individual Youth (can be more than 1, but must be indicated explicitly) 4. Other (includes known others, e.g., 'your dad finds this stuff really fun,' and general others, e.g., 'orthodontists need to know this.' Value statements referencing the non-speaking activity leader receive this code)
V5. Value statement (high or low) connects to: 1. Specific topic/activity within a broader STEM discipline (e.g. 'collecting water samples is really fun/boring,' 'mechanical engineers have to know a lot about how gear ratios work.') 2. A STEM field more generally (e.g., "engineers need to be good at math," "engineering is fun/boring")
ITEMS V6 – V8 SHOULD ONLY BE CODED FOR STATEMENTS ABOUT HIGH UTILITY VALUE (V1 =1)
V6. General Relationship between STEM and use: Specificity of utility (CHOOSE ONLY 1,) 1. Real life is related to STEM content OR utility/importance of content is stated without goal. (**STOP HERE. DO NOT APPLYL ANY OTHER CODES TO THIS INSTANCE**) 2. Content *impacts* real life for specific *passive* outcome (include comfort/discomfort/expectations)—EXCLUDE if content impacts decisions, plans, or actions. 3. Content is useful for some specific goal (achievement, attainment, understanding) OR career OR if content impacts real life in a way that affects decisions, plans, or actions (of anyone)
V7. Connection is made between STEM (content or field) and utility for: (CHOOSE ONLY 1. IF MORE THAN ONE OF THESE IS APPLICABLE, RECODE THE STATEMENT INTO 2 SEPARATE STATEMENTS) **Non-Directive – utility value not directed toward either personal utility or to serve a larger societal or local purpose** 1. understanding or explaining natural phenomena (e.g., tides, seasons); 2. bridge to understanding a concept, unit or experience in current summer program;

3. bridge to understanding in an academic year class (e.g. math, geography);
4. routine activities, events (eating, shopping, driving a car, getting dressed), relevant cultural activities (TV, pop culture);
5. explaining advances in science, health, and technology in general
6. contributing to human's general knowledge and understanding of phenomena/how things work

Self-Oriented – utility value directed at how STEM can have personal utility for youth attending the session:

7. a job or career;
8. future education in science (high school, getting into college, college majors);
9. personal health/safety/well-being (physical or mental);
10. developing a hobby or pastime (e.g. sports);
11. useful for understanding or advancing social relationships

Self-Transcendent - utility value directed at how STEM can have utility for something beyond the self

12. Explaining or solving a local problem that youth are directly exploring or addressing within the confines of the program (e.g., preserving the local ecosystem, helping a local species to survive by preserving its habitat, etc.)
13. Useful for accomplishing a collective program goal which is oriented at helping others or the local community in general (e.g., constructing an outdoor educational space for use by the school community)
14. Explaining, or solving a global problem that is relevant to a *specific* current event, news, or historical event (includes global warming/environmental issues).
15. Emphasizing usefulness for progressing and advancing as a society in terms of living in a world that is more equitable, secure, and sustainable.

Performance – utility for school work, or careers

16. Useful for getting good grades or test scores (e.g., this will be tested in school, you need this to stay at grade level at school)
17. Useful for general future success, fame, income, recognition

ITEM V8 TO BE CODED ONLY FOR STATEMENTS ABOUT COST VALUE
V8. Nature of the cost (CODED ONLY FOR STATEMENTS ABOUT COST VALUE, V1=7 OR 8) CHOOSE ONLY ONE. IF MORE THAN ONE OF THESE IS APPLICABLE, RECODE THE STATEMENT INTO 2 SEPARATE STATEMENTS) 1. Effort cost: cost is expressed in terms of time and/or effort (e.g., task is hard/easy, requires a lot of work, not a big commitment) 2. Opportunity cost: cost is expressed in terms of what would suffer or be missed by focusing on the activity at hand 3. Psychological Cost: cost is expressed in terms of emotional toll (e.g., causes anxiety, frustration, fear of failure, annoyance, anger OR engaging will cause one to be perceived as ‘nerdy.’)

Appendix C. Youth and Activity Leader Demographics

Youth Demographics

A total of 203 youth attended STEM-oriented programming at programs enrolled in the STEM IE study during the summer of 2015 and provided at least some ESM data during this period. Given that the majority of the models that were constructed as part of the study included covariates derived from the youth pre-survey in order to control for youth interest, self-concept, and motivation to attend programming at program entry and that not all youth enrolled in the study had pre-survey data available, a total of 177 of the 203 youth enrolled in the STEM IE study were actually included in study analyses. As shown in Table C1, the 177 youth in question were largely consistent with the overall STEM IE population in terms of demographic make-up.

Table C1. Demographic Characteristics of Youth Enrolled in the STEM IE Study

	All Youth with ESM Data (n=203)		Youth with ESM Data and Pre-Youth Survey Data (n=177)	
Characteristic	**#**	**%**	**#**	**%**
Gender				
Male	103	50.7%	89	50.3%
Female	100	49.3%	88	49.7%
Race/Ethnicity				
Hispanic	97	47.8%	83	46.9%
Black	72	35.5%	64	36.2%
Asian	14	6.9%	13	7.3%
White	13	6.4%	12	6.8%
Multiracial	5	2.5%	4	2.3%
Missing	2	1.0%	1	.6%
Grade Level				
5	1	.5%	0	0.0%
6	54	26.6%	50	28.2%
7	54	26.6%	47	26.6%
8	58	28.6%	49	27.7%
9	20	9.9%	18	10.2%
10	2	1.0%	2	1.1%
Missing	14	6.9%	11	6.2%

Activity Leader Characteristics

Programs were staffed by a combination of certified, school-day teachers and community educators and youth development workers employed by non-profit organizations located in the communities in question. Overall, the majority of the activity leaders delivering STEM programming to youth enrolled in the study were white, female, had at least a college education, and had worked in the program for less than two years. Just under half of activity leaders also held a teaching credential.

Table C2. Activity Leader Characteristics

	Activity Leaders (n=33)	
Characteristic	**#**	**%**
Gender		
Male	11	33.3%
Female	22	66.7%
Race/Ethnicity		
White	21	63.6%
Black	9	27.3%
Hispanic	1	3.0%
Missing	2	6.1%
Teaching Credential		
Yes	15	45.5%
No	17	51.5%
Missing	1	3.0%
Education		
Completed high school or GED	1	3.0%
Some college	4	12.1%
Completed four-year college degree	12	36.4%
Some graduate work	6	18.8%
Master’s degree or higher	9	27.3%
Missing	1	3.0%

Characteristic	Activity Leaders (n=33) #	%
Years Working in the Program		
1	12	36.4%
2	10	30.3%
3	7	21.2%
4	1	3.0%
5	1	3.0%
Missing	2	6.1%

Appendix D. Summary of Multilevel Models

Cross-classified hierarchical linear modeling was used to address study questions related to youth in-the-moment experiences in programming using the R computer program. This approach was used because the multiple responses provided by the same youth across multiple ESM episodes were likely to be related to one another, while ESM responses associated with a given episode were also likely to be related to one another, thereby violating assumptions about the independence of the model residuals. Cross-classified hierarchical linear modeling provides a solution to this problem. A series of three-level models were constructed and run, with programs at level 3; youth and ESM episodes at level 2; and youth-level, individual ESM responses at level 1.

HLM Models in Equation Form

Fully Conditional Model in Equation Form – ESM Outcomes (see Table 2)

Level-1 Model

$$Y_{ijkl} = \pi_{0jkl} + e_{ijkl} \qquad (1)$$

Level-2 Model

$$\pi_{0jkl} = \beta_{00l} + \beta_{1jl}(\text{CLASS Score}) + \beta_{2jl}(\text{Agency Score}) + \beta_{3jl}(\text{Relevance Statements}) + \beta_{4kl}(\text{Field-Based}) + \beta_{5kl}(\text{STEM Competence}) + \beta_{6kl}(\text{Motivation to Attend}) + \beta_{7kl}(\text{Female}) + r_{0jl} + s_{0kl} \qquad (2)$$

Level-3 Model

$$\beta_{00l} = \gamma_{000} + u_{00l} \qquad (3)$$

$$\beta_{10l} = \gamma_{100}$$

$$\beta_{20l} = \gamma_{200}$$

$$\beta_{30l} = \gamma_{300}$$

$$\beta_{40l} = \gamma_{400}$$

$$\beta_{50l} = \gamma_{500}$$

$$\beta_{60l} = \gamma_{600}$$

$$\beta_{70l} = \gamma_{700}$$

In equation 1, Y_{ijkl} represents each ESM outcome (i.e., challenge, learning, relevance, and engagement) examined resulting from a given ESM signal j of youth k in program l; π_{0jkl} represents the intercept or cell mean (i.e., the mean ESM score of individuals who belong to signal j and youth k in program l). e_{ijkl} is the random individual response effect (i.e., the deviation of the individual's response ijk score from the cell mean).

In equation 2, β_{00l} is the model intercept or grand-mean ESM score of all youth and all episodes; r_{0jl} is the residual random effect of signal j in program l (i.e., the contribution of signal j averaged over all youth) on π_{0jkl} and s_{0kl} is the residual random effect of youth k in program l (i.e., the contribution of youth k averaged over all signals). In addition, $\pi_{0jkl} = \beta_{00l} + r_{0jl}$ is the signal ESM score averaged over all youth, and $\pi_{0jkl} = \beta_{00l} + s_{0kl}$ is the youth ESM score averaged over all signals.

In equation 3, program means, β_{00l}, vary randomly around a grand mean, γ_{000}, with a random program effect, u_{00l}, that represents the deviation of the program l's mean from the grand mean.

Analyses that included variables for activity type followed a similar format (see Table E1), dropping the Agency Score variable and adding predictors for Basic Skills and Creating a Product. Interactions were examined at level 2.

Fully Conditional Model in Equation Form – Interest and Aspirations Outcome Models (see Table 4)

Level-1 Model

$$\gamma_{ij} = \beta_{0j} + \beta_{1j}(\text{Pre-Interest/Pre-Aspirations Score} + \beta_{2j}(\text{Engagement}) + \beta_{3j}(\text{Male}) + r_{ij} \quad (4)$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + u_{0j} \quad (5)$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

In equation 4, γ_{ij} represents the youth post-survey perceptions of STEM score (interest and future aspirations) of youth i in program j; β_{0j} represents the intercept mean (i.e., the mean perception score of youth in program j). r_{ij} is the random individual response effect (i.e., the deviation of the individual's *ij* score from the cell mean). The three predictor variables are also represented in the model (Pre-Interest/Pre-Aspirations Score, Engagement, and Male).

In equation 5 program means, β_{0j}, vary randomly around a grand mean, γ_{00}, with a random program effect, u_{0j}, that represents the deviation of the program *j*'s mean from the grand mean.

Appendix E. Cross-Classified Multilevel Models with Activity Type

Table E1. Three-Level, Cross-Classified HLM Models Predicting the Relationship Between ESM Outcomes and Key Predictors

	Challenge			Learning			Relevance			Engagement		
Fixed Effects	***B***	**Sig**	**SE**	***B***	**Sig**	**SE**	***B***	**Sig**	**SE**	***B***	**Sig**	**SE**
Intercept	2.50	***	0.29	2.04	***	0.25	2.10	***	0.27	2.25	***	0.23
CLASS Score	0.03		0.03	0.07	**	0.02	0.02		0.02	0.03		0.02
Basic Skills	0.11	†	0.06	0.13	**	0.05	0.03		0.04	0.03		0.04
Creating Product	0.38	***	0.07	-0.01		0.06	0.18	***	0.05	0.10	†	0.05
Relevance Statements	-0.02	*	0.01	-0.01		0.01	0.01	*	0.01	0.00		0.01
Field-Based	0.20	**	0.07	0.10	†	0.06	0.13	**	0.05	0.04		0.05
STEM Competence	-0.15	*	0.07	0.06		0.06	0.03		0.07	0.08		0.06
Motivation to Attend	0.18		0.19	0.32	†	0.17	0.37	*	0.18	0.26	†	0.15
Female	-0.22	†	0.11	-0.05		0.11	-0.20	†	0.11	-0.05		0.09
Relevance Statements x Creating Product	-0.08	†	0.05									

Note. † *p* < .10, * *p* < .05, ** *p* < .01, *** *p* < .001

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7398_02/19