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Experiences, activities, and personal characteristics as predictors of engagement in STEM-focused summer programs

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Abstract

Out-of-school-time programs for youth that are focused on STEM content are often seen as affording opportunities to increase youth engagement, interest, and knowledge in STEM domains, yet we know relatively little about how youth actually experience such programs. In this article, we explore how experiences and activities employed in the delivery of summer STEM programs are associated with youth engagement during programming, and whether youth characteristics moderate these relationships. Data were collected from 203 youth (ages 10–16) in nine summer programs using multiple methods including video, experience sampling, and surveys. Through the use of cross-classified, multi-level models, we found that youth reported higher engagement in program activities they perceived to be more challenging and relevant, and in activities, they perceived to have more affordances for learning or developing skills. Gender moderated these relationships such that the positive relationships observed among males were muted or nonexistent for girls. We further identify that program activities are differently associated with fostering challenge, relevance, and learning. Findings have implications for out-of-school STEM programming for youth.

KEYWORDS
adolescence, engagement, experience sampling method, gender, out-of-school-time programs

1 | INTRODUCTION

The past decade has seen a rise in out-of-school-time (OST) programs for youth that are focused on STEM content and practices. These after-school and summer programs are often seen as a supplement to classroom instruction and a mechanism to support positive youth development, with the dual aims of promoting engagement and interest in STEM careers and building academic skills (Dabney et al., 2012; Davis & Hardin, 2013; Elam, Donham, & Solomon, 2012; Kataoka & Vandell, 2013; Mohr-Schroeder et al., 2014). Research has shown that STEM-focused summer programs are effective at increasing youths' motivation and interest in STEM fields, and also help youth to improve work habits, task persistence, and peer interactions once they return to school (Greene, Lee, Constance, & Hynes, 2013; Kataoka & Vandell, 2013; Mohr-Schroeder et al., 2014). Because of these promising results, STEM-focused summer programs might represent an effective way to increase engagement in STEM fields, particularly among populations that are historically underrepresented and undersupported in such fields.

STEM-focused OST environments in general, and summer STEM programs in particular, are substantially different from school-day instruction (Renninger, 2017). While learning in school-based settings is likely to focus on transferring knowledge to students in accordance with curricular frameworks and standards, OST environments can provide youth with greater opportunity to engage with STEM-related content in ways that are presumed to generate and sustain interest in STEM fields. Specifically, such programs are focused on exposing youth to new settings and content as opposed to gauging the learning that is happening in these settings; creating space for youth to learn and discover things on their own that are not always explicitly anchored to a set of learning standards (Luehmann, 2009; Rennie, 2014). They also tend to focus on building positive relationships through interactive activities that are intended to be fun for participating youth. These settings may be ideal points of entry to STEM pathways because they typically afford youth greater choice and autonomy in terms of what they want to learn and how they go about conducting inquiry-related tasks (Falk & Storksdieck, 2005). It is important to understand youth experiences in OST programs in order to most effectively realize this potential. As an initial step toward better understanding how pathways to STEM fields might be facilitated in out-of-school STEM programs, this article examines the ways in which immediate features of the program environment and youth characteristics facilitate or hinder youths' in-the-moment engagement in program activities.

The purpose of this article, then, is to explore how various experiences and activities employed in the delivery of summer STEM programs are associated with youth engagement in these informal STEM learning settings. Based on existing theory and research, we hypothesize that when youth perceive a STEM-focused activity to be challenging or relevant, they will have greater levels of situational engagement within the confines of that individual activity session.

Likewise, engagement will be greater when participants feel they have an opportunity to learn something new or develop a skill. Additionally, we test whether the relationships specified in the above hypotheses differ by characteristics of the youth participants. Specifically, we examine the role of student gender and perceived competence. Finally, we conduct additional analyses with a more descriptive aim to identify specific program activities that are most likely to foster challenge, relevance, and learning, and explore the role of gender and perceived competence in these relationships as well.

1.1 | Frameworks for engagement

An increasing number of scholars have employed the framework of *engagement* to better understand learning experiences in and out of school (see Bell et al., 2019; and Christenson, Reschly, & Wylie, 2012 for reviews). Engagement frameworks have been used to understand and combat school dropout (Christenson et al., 2008; Finn & Owings, 2006) and engagement has been positively associated with achievement in a variety of academic domains, as well as other self-regulatory, social, and emotional learning outcomes both in and outside of school (Klem & Connell, 2004; National Research Council and the Institute of Medicine, 2004). Given recent efforts in the United States to strengthen its STEM workforce (National Academy of Engineering and National Research Council, 2014; National Academy of Sciences, National Academy of Engineering,, & Institute of Medicine, 2005), the engagement construct may be especially attractive, as it is posited to play an important role in promoting skill development and persistence in STEM majors and careers (Sinatra, Heddy, & Lombardi, 2015).

Much of the research and conceptual development related to engagement has centered around formal learning environments (see Christenson et al., 2012, for a review). Early applications of the engagement construct within the OST STEM learning community were focused narrowly on thinking about creative ways to attract the initial attention of potential program participants, museum visitors and media consumers, but over time thinking about engagement has expanded to include deeper and more sustained involvement in the learning experiences themselves (Bell et al., 2019).[1] An increasing number of researchers have fruitfully applied these more complex engagement frameworks to OST learning environments (Greene et al., 2013; Mohr-Schroeder et al., 2014; Shernoff & Vandell, 2007; Yilmaz, Ren, Custer, & Coleman, 2010).

While specific definitions of engagement vary, scholars across a variety of disciplines generally agree that engagement refers to active participation, investment, and value in learning. In both formal and informal contexts, engagement is viewed as a multidimensional construct that is context-dependent and includes behavioral, cognitive, and affective subtypes (Bell et al., 2019; Christenson et al., 2012). Behavioral engagement refers to one's involvement in learning activities in terms of their degree of participation and effort. This dimension of engagement is considered critical for academic achievement (Fredricks et al., 2011; Fredricks, Blumenfeld, & Paris, 2004); however, in a review of literature on science engagement, Sinatra et al. (2015) caution that the assessments used to establish links between behavioral engagement and achievement largely involve low-level processing tasks involving simple recall. They argue that science tasks are particularly complex, requiring understanding beyond recall. Thus behavioral engagement alone may be limited in its ability to predict success in STEM areas, and engagement on cognitive and affective levels might also be required. Cognitive engagement refers generally to the mental investment one makes in learning activities. Youth who are cognitively engaged are more thoughtful and focused on mastering challenging tasks (Finn & Zimmer, 2012; Fredricks et al., 2004). Finally, affective engagement refers to the positive and negative feelings students have toward their learning activities (Pekrun & Linnenbrink-Garcia, 2012). The affective dimension of engagement is believed to create a sense of belonging and influence the students' willingness to complete learning tasks (Connell & Wellborn, 1991; Fredricks et al., 2004; Sinatra et al., 2015). Eric Klopfer captured the multidimensionality of engagement in informal learning contexts in his description of engagement as "hard fun," invoking a term used by Papert (Bell et al., 2019, see also Ruiperez-Valiente, Gaydos, Rosenheck, Kim, & Klopfer, 2020).

To reflect the conceptualization of engagement as highly dependent on context, in the present study we sought to examine youths' behavioral, cognitive, and affective engagement in situ, as they are participating in a variety of summer STEM programming activities. Gathering systematic data on youths' educational outcomes—whether it be engagement, learning, or something else, poses particular challenges in OST settings because it is not always easy to identify appropriate outcome measures in these settings, learning is often not assessed directly, observation of individuals over an extended period can be difficult, and long surveys about one's experience are often not tolerated to the same extent they might be in formal educational environments (for a review of challenges related to evaluating outcomes in OST settings, see Allen & Peterman, 2019). To gather situational measures of youths' multidimensional engagement, we employ the Experience Sampling Method, a signal-contingent method used to gather brief repeated reports of participants' immediate experience as it is happening (see Hektner, Schmidt, & Csikszentmihalyi, 2007 for a comprehensive description of the method). This approach affords us the opportunity to examine how the specific momentary conditions of an activity related to one's engagement in that activity. Our exploration of these conditions focuses on the challenge the activity poses to the youth, the relevance of the activity to the youth, and the degree to which youth feel the activity affords them the opportunity to learn or develop their skills. We turn to a discussion of these conditions next.

1.2 | Challenge, relevance, and affordances for learning as conditions for engagement

One goal of this study is to explore how various subjective conditions in STEM-focused summer programs relate to youths' engagement in these programs. Theory and research suggest that certain conditions tend to foster engagement in academic settings, but few have examined whether these conditions are similarly linked to engagement in informal learning environments focused on STEM content where expectations and activities might be different.

1.2.1 | Challenge

Theory and research suggest that challenge is an important condition for engagement. Emergent Motivation Theory (EMT; Csikszentmihalyi, 1990; Csikszentmihalyi & Schneider, 2000) posits that individuals 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. Empirical research supports the link between perceived challenge and engagement (Fredricks, Blumenfeld, Friedel, & Paris, 2002; Lutz, Guthrie, & Davis, 2006; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003) in settings that are explicitly academic, but there is less evidence as to whether challenge similarly promotes engagement in out-of-school learning contexts, where youth may have greater expectations that they will have experiences that are "fun," which may or may not involve challenge. Acknowledging that challenge is generally conceived of as subjective, our examination of challenge focuses on youths' perception of the degree of challenge during specific program activities.

1.2.2 | Relevance

Relevance refers to the degree to which one perceives an activity as having meaning, importance, or utility beyond the immediate learning context. In traditional school environments, when students perceive their teachers as emphasizing relevance in their instruction, students report having more positive attitudes toward school and are more engaged (Assor, Kaplan, & Roth, 2002; Schmidt, Kafkas, Maier, Shumow, & Kackar-Cam, 2019). Koballa Jr. and Glynn (2007) provide evidence that seeing science and related STEM content as relevant is a strong indicator of whether youth will become engaged and persist in science. Making content relevant is often framed as an important feature of instructional design aimed at enhancing student motivation and engagement (Clegg & Kolodner, 2013; Keller, 1987) and some have argued that it is the most effective of all strategies for triggering and sustaining student engagement (Assor et al., 2002). Some scholars have argued that helping youth appreciate the relevance of science in their local context may be particularly impactful among youth from underrepresented and underserved communities (Boda & Brown, 2020). OST programs often have greater freedom than formal classrooms to provide youth with relevant, authentic, and meaningful STEM learning experiences (Rennie, 2014), and it is important to assess the extent to which perceived relevance fosters engagement in these settings.

1.2.3 | Affordances for learning and skill development

One of the primary ways that the OST programs of interest to this study differ from traditional classrooms is that the OST programs tend to be more focused on building positive relationships through activities that are interactive and fun while exposing youth to new settings and content in an environment that is largely free of formal assessment. These distinguishing characteristics of OST programs present both challenges and opportunities for learning. The potential challenge to integrating these features in programming is that one runs the risk of having significant portions of program time where students are entertained but not necessarily learning anything new or developing skills. On the other hand, the opportunity afforded by this focus is that programs are able to introduce youth to new concepts and settings through field experiences at locations such as wetlands or zoos. These settings may feel less like traditional learning environments, even though they provide considerable educational opportunities. The extent to which youth perceive the activities in the programs as opportunities to learn is not clear. It is also an open question whether the perception that a given activity affords the opportunity to learn something new or develop a skill would foster greater engagement in this less formal environment. Research suggests that novelty (i.e., learning something new, experiencing or seeing something for the first time, perceiving something unexpected) is also an important feature of activities that generate interest and engagement (Silvia, 2006, 2010).

1.3 | The role of youth characteristics: Perceived competence and gender

Youths' experiences in STEM-focused summer programs likely depend to some extent on youths' characteristics when they enter the program, such as their beliefs about their own competence in the domain. Youth who enter a program believing that they are highly competent in STEM areas may have the confidence to engage more fully in STEM activities. They may be more likely to embrace the challenges inherent in STEM-focused OST activities, and may also employ a wider range of learning strategies in program activities.

Due to socialization and persistent stereotypes about who participates in STEM, we may also see variation in engagement patterns by students' demographic characteristics. Women and girls continue to be underrepresented in many STEM fields, and gender-related stereotypes about ability and interest in STEM persist. Women and girls feel less competent in STEM subject areas—despite considerable evidence to the contrary—and are less likely to see themselves pursuing STEM in the future (see Hill, Corbett, & St. Rose, 2010, for a review). These gaps tend to emerge during early adolescence. Examining the experience of male and female youth while they are actually involved in STEM activities might inform our understanding of long-observed gender gaps in STEM interest and persistence.

We also acknowledge that individuals who identify as Black or Hispanic have historically been underrepresented and underserved in STEM fields in the United States, and these historic patterns and the racialized narratives often used to explain them may similarly influence the quality of experience in STEM engagement among students who identify with these groups (Visintainer, 2020). Women and girls from these underrepresented groups may be "doubly disadvantaged" in that they may identify with two different demographic groups who are underrepresented in STEM. Nearly all the participants in the current study identified as black and/or Hispanic; thus, preventing comparisons by race/ethnicity, but affording an exploration of gender among students who belong to racial and ethnic groups that are historically underrepresented in STEM. A primary challenge for the OST field is to better understand what general program conditions and specific instructional practices are likely to trigger engagement in STEM-related contexts while taking into consideration differences among youth such as perceptions of competence and gender.

Youth characteristics may have a moderating effect on the links between the conditions of challenge, relevance, and learning on the one hand, and engagement on the other. For example, some have suggested that there may be individual differences in how challenging situations are perceived and acted upon (Csikszentmihalyi, 1990; Strati, Schmidt, & Maier, 2017). Challenge may be energizing for some, resulting in increased engagement, but may be threatening for others and may not facilitate engagement. For example, it is well documented that women and girls report greater anxiety than males with respect to STEM subject areas (Britner, 2008; Mallow, 2010). This increased anxiety might dampen or altogether negate any motivational properties of challenge for girls and women when involved in STEM tasks. Strati et al. (2017) found that in high school science classrooms, male students showed increased engagement when they perceived the learning task to be challenging, while the effect among female students was significantly less pronounced. It is not clear whether similar individual differences in response to challenge are at play in less formal STEM learning environments where the stakes and pressure to perform may be lower.

There may also be individual differences in the degree to which perceived relevance facilitates engagement. Numerous studies have shown that interventions targeting relevance may have different effects on students depending on their perceived competence (Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Hulleman & Harackiewicz, 2009). Likewise, one's gender may influence the extent to which relevance promotes engagement. Women and girls are generally less likely to see themselves in STEM professions (Miller, Eagly, & Linn, 2015; Thomas, 2017; Wang & Degol, 2017), and thus may see STEM-related activities as less connected to who they are. Some have suggested that boys and girls hold different perceptions about how useful science can be to them (Catsambis, 1995; James, 2002; Lee & Berkham, 1996). Schmidt et al. (2019) found that in traditional science classrooms when teachers more strongly emphasize content relevance, girls rate the content as more useful, whereas boys do not. This suggests that male and female students may process information they consider about relevance differently. Such differences could be reflected in the degree to which perceived relevance stimulates engagement. Again, much of the prior research on individual differences and relevance has been conducted in traditional classroom settings. It is not clear the extent to which these findings may replicate in informal STEM learning environments.

1.4 | Unpacking the conditions for engagement

Once we understand whether and how youth perceptions of challenge, relevance, and learning relate to their momentary engagement in STEM-focused OST settings, we can then identify specific OST activities that are most likely to create these conditions among youth participants. For example, if perceiving activities as relevant is related to increased engagement, are there certain types of activities that youth tend to perceive as highly relevant? Additionally, to what extent are these activity perceptions consistent across youth (i.e., do male and female youth perceive a given activity as relevant to an equivalent extent?). Such questions are of interest to educators who design OST programs for youth. The unique design of this study, which combined video data of program activities with students' momentary reports of challenge, relevance, and learning, allows us to explore whether youths' perceptions of these conditions are systematically related to particular types of program activities.

1.5 | Research questions

The primary research questions guiding the study are as follows:

1. In what ways are youth experiences of challenge, relevance, and learning in STEM-focused summer programs related to their engagement in program activities, and what is the role of gender and perceived competence in these associations?
2. How are distinct activities in such programs related to youths' perceptions of challenge, relevance, and learning, and what is the role of gender and perceived competence in these associations?

2 | METHOD

2.1 | Context

The present study was conducted in the context of nine summer programs located in two cities in the northeastern United States. Programs were recruited through two large public–private partnerships whose purpose is to coordinate summer, after-school, and other informal educational programs in the urban centers in which they are located. Programs were selected for inclusion in the study if they (a) had an explicit focus on STEM; (b) occurred in summer; (c) were 4–6 weeks in duration; and (d) principally served youth from low-income households who were rising 5th to 9th graders. Enrollment in programming was generally voluntary (i.e., not compulsory), and 67% of the youth participants indicated on a survey that it was their idea to sign up for the program, whereas 33% indicated that they were attending primarily because their parents, friends, school-day teachers, or afterschool activity leaders wanted them to sign up (see Beymer, Rosenberg, Schmidt, & Naftzger, 2018). All youth who enrolled in participant programs were invited to participate in the study. Programming was provided through support from their associated public-school districts and external granting agencies. Seven programs had a singular content focus (four science-focused, one mathematics-focused, and two engineering-focused), while three programs focused on multiple content areas (one science and mathematics-focused, and one that focused on all three content areas). Brief descriptions of each of the programs can be found in Table 1. In each of the programs, about half of the programming time was spent in classroom locations with instruction focused on STEM concepts, and half was spent in different locations doing enrichment activities. Six of the programs held enrichment activities in field or community locations where students participated in a variety of program-relevant activities such as collecting water samples, building solar-powered go-carts, or observing animal life. Two programs held enrichment activities on college campuses in places other than classrooms, and one program held its enrichment activities in non-academic spaces in a community center. Each program lasted 4–6 weeks, offering STEM-oriented programming 4 days a week for 3.5–4 hr each day.

2.2 | Participants

Participants included 203 youth from the nine programs. Participants were primarily Hispanic (48%) or African-American (36%). The mean age of participants was 13 years (range 10–16). Youth were about evenly split by gender. Refer to Table 2 for additional details.

2.3 | Procedures and measures

Data were collected from all nine programs during the summer of 2015. At the start of each program, youth responded to a survey, which was used to create a composite measure of preprogram STEM competence beliefs. Data on adolescents' momentary experience of challenge, relevance, learning, and engagement were collected on multiple occasions over a 3-week period via the Experience Sampling Method (described below). The data collection schedule was designed so that every week, data would be collected from each program during both enrichment activities and classroom activities. On each day that Experience Sampling data were collected, program activities were videotaped. Across all programs, the mean attendance rate was 83.1% ($SD = 0.16$), with a range of 20–100%.

2.3.1 | Experience sampling method

Students' immediate experiences in the program were measured via the Experience Sampling Method (ESM; Csikszentmihalyi & Larson, 1987; Hektner et al., 2007). ESM is a signal-contingent

TABLE 1 Descriptions of participant summer programs

Program[a]	Content focus	Grade levels served	Size	Program aims
Adventures in Mathematics	Mathematics	Rising 8th to 10th	20	To develop basic math skills and prevent summer learning loss through direct instruction and participation in math-related games.
Building Mania	Engineering	Rising 6th to 9th	24	To engage in the engineering design process by determining a need, brainstorming possible designs for a simple machine, and creating, testing and revising a final machine.
Comunidad de Aprendizaje	Science, Mathematics, Engineering	Rising 5th to 8th	33	To help youth improve basic skills in mathematics and develop interest in STEM content and entrepreneurship through activities related to robotics and dance.
Island Explorers	Science	Rising 6th	27	Develop expertise on one species found in the local ecosystem through reading, writing, data collection and analysis, and communication to the public.
Jefferson House	Mathematics, Science	Rising 7th	11	To develop basic math skills, problem solving, self-improvement, and critical thinking skills through classroom-based activities and sessions involving media, art, and nutrition.
Marine Investigators	Science	Rising 7th to 9th	19	To learn about and experience a local ocean bay, examine the bi-directional impacts between humans and the local ecosystem, and cultivate a sense of stewardship among participating youth.
The Ecosphere	Science	Rising 6th to 9th	27	To explore the marine life of a local ocean bay through hands-on experiences that familiarized youth with water quality, aquatic creatures like sharks, invertebrates, and the environments these creatures live in. Focus on human-environment interactions and environmental stewardship.
Uptown Architecture	Engineering	Rising 6th to 9th	16	To develop design-thinking, and collaborative problem-solving to build an outdoor learning space for use at the middle school where the program was housed.
Zoology Partners	Science	Rising 6th to 9th	26	To develop content knowledge and stewardship related to the issue of endangered species through fieldwork, exposure to terminology, and interaction with scientists.

[a]all program names are pseudonyms.

method of data collection in which participants answer a series of rating scale questions about their immediate experience in response to a number of randomly generated signals. This method is desirable for collection of data regarding youth's OST experiences because it responds to calls for methods that are more proximal to youth's OST experiences (Allen & Peterman, 2019). In the current study, signals were emitted by mobile phones provided by the research team, and

TABLE 2 Participant demographic characteristics

Students ($N = 203$)	% Students
Sex	
Male	50
Female	50
Race/ethnicity	
Hispanic	48
White	6
Black	36
Multi-racial	3
Asian/Pacific islander	7
Age	
10	4
11	28
12	31
13	21
14	12
15	3
16	1
Parent education ($n = 171$)	
High school or below	79
Graduated from college (BA or BS)	21

students used these phones to rate their perceived challenge, perceived relevance, and the degree to which they felt they were learning something new at the time of the signal, as well as multiple items indicating their level of engagement across multiple dimensions (for a discussion on the affordances of ESM to measure engagement, see Xie, Heddy, & Vongkulluksn, 2019). All ESM items were on a 4-point scale that ranged from "not at all" to "very much." ESM was administered in each program on 6 different days; 2 days each week during Weeks 2–4 of the program, with approximately equal time sampled from field-based and classroom activities. Participants were randomly signaled four times each day, with the condition that two consecutive signals must occur at least 15 min apart. A total of 2,970 completed ESM surveys were collected, which amounts to an average of about 15 responses per participant (63% completion rate, which is fairly typical for ESM studies with similar populations, see Hektner et al., 2007). Approximately half of the missing signal data is attributable to youth absence (see attendance rates reported above).

Before describing the measures used in analysis, we note that short scales and single-item scales are standard for research involving the ESM because of the frequency with which data on immediate experience are collected (Hektner et al., 2007, see also Goetz, Frenzel, Stoeger, & Hall, 2010; Nett, Goetz, & Hall, 2011). A recent examination of reliabilities and validity between short scales (1–3 items) and traditional longer scales suggests the promise of using shorter scales (Gogol et al., 2014).

2.3.2 | Momentary engagement

A four-item composite measure of momentary engagement was constructed by taking the mean of youth ratings of hard work (i.e., how hard were you working?), concentration (i.e., how well were you concentrating?), enjoyment (i.e., did you enjoy what you were doing?), and interest (i.e., was the activity interesting?). These items were included in the composite engagement measure to represent dimensions of engagement that are arguably behavioral and/or cognitive (e.g., hard work, concentration),[2] and as well as affective (enjoyment, interest). While our measure included indicators representing multiple dimensions of engagement, for this initial exploratory study we did not attempt to examine the different dimensions separately. Similar measures of engagement have been used in prior research (Shernoff et al., 2003; Shernoff & Schmidt, 2008; Strati et al., 2017), and this composite measure had an acceptable level of internal validity in the current sample, as indicated by Cronbach's alpha ($\alpha = .85$).

2.3.3 | Perceived challenge

Challenge was measured using a single item on the ESM (i.e., how challenging was the activity?).

2.3.4 | Perceived relevance

Relevance was computed as the mean of three ESM items including importance to you (i.e., was the activity important to you?), importance to future (i.e., was the activity important to your future goals?), and utility (i.e., could you see yourself using what you were learning outside of this program?). This measure also indicated an acceptable level of internal validity ($\alpha = .84$).

2.3.5 | Learning

Youths' perception of learning was measured using a single item (i.e., were you learning anything or getting better at something?).

2.3.6 | Program activities

On the days ESM was administered, program sessions were videotaped, and the video was marked to indicate when ESM signals were emitted so that coded video data regarding program activities could be linked to participants' ESM responses. The NVivo software package was used to code each video to characterize the nature of the program activity from the beginning to the end of the recorded session. Following criteria used by Duke (2000), in situations where multiple discrete activities occurred simultaneously (e.g., 3 youths are meeting in a small group to discuss a building project while most others are completing a worksheet in which they are reviewing basic terminology related to simple machines) the video were coded according to what the majority of youth were involved in. Activity categories were informed by prior research on instructional activities in STEM domains (Barak & Shakhman, 2008; Thier & Daviss, 2002;

Von Secker & Lissitz, 1999); and reflect categories that we employed productively in our prior research involving other adolescents STEM learning settings (Schmidt, Rosenberg, & Beymer, 2018). The activity categories and a brief operational definition of each are provided below.

Basic skills activities

Activities whose primary purpose is introducing youth to or practicing a STEM-related skill (e.g., measuring), becoming familiar with STEM terminology (e.g., review games), tools (e.g., saws), or procedures (e.g., worksheets on order of operations). These are “stand-alone” activities that are not embedded in the broader context of creating a product or conducting a lab (both are described below).

Creating products

Activities related to planning, designing, building, demonstrating, or displaying a product (e.g., simple machines), as well as instances where program participants are preparing to share their ideas, designs, and conclusions about a STEM topic with the larger group in a formal way that reflects advance preparation (e.g., posters, presentations).

Listening to STEM expert speakers (not program staff)

Any instance where youth are listening to a presentation, demonstration or lecture by a STEM expert from the community (e.g., zoo researcher, ranger from the local Department of Natural Resources). Demonstrations by program staff are coded as Program Staff Led activities (see below).

Lab activities

Includes planning an investigation, observing, collecting observations and constructing measures, analyzing data, and/or interpreting results and making predictions. Includes immediate preparation for and subsequent discussion of these activities.

Program staff led activity

Refers to large group instruction or discussion when an activity leader explains concepts, ideas, and presents STEM content. May include lecture, presentation, adult requests for information from students in a direct instruction format, or more open-ended discussion in which multiple youth perspectives/explanations are solicited in an exchange of thinking that is not simply checking knowledge of facts.

Non-STEM related activity

Program activities in which STEM content or practices were not emphasized. Most programs included a variety of “leisure” activities such as watching popular movies, team-building activities like obstacle courses or capture the flag, in which STEM content or practice was not explicitly emphasized. Such activities were typically indicated in program planning schedules as “non-STEM time,” and program planning documents were consulted to determine STEM-related intent of any activities whose purpose was not clear.

2.3.7 | Initial perceptions of competence

At the outset of each program, a survey for youths’ perceived competence in the STEM area or areas that were an explicit focus of the program was administered. The survey consisted of a

4-point rating scale ranging from 1 (not at all true) to 4 (really true). For each relevant area, youth responded to two questions each about their abilities with regard to mathematics, science, and/or building (i.e., "I am good at math/science/building things," and "at school I expect to do well in math/science/building things"), and the competence measure represented the mean of competence items across all relevant domains. Thus, for some students, the mean was based on two items, while for others it was based on as many as six items representing all three domains.[3]

2.4 | Analytic approach

In order to account for the complex dependencies associated with the data collection approach, the data were analyzed using three-level cross-classified, random effects models. In these models, youths' momentary responses about engagement, challenge, relevance, and learning were nested within particular signaling episodes and youth. The responses were nested within signaling episodes in that multiple responses were generated as a result of each signal, and also within persons as each youth responded to multiple surveys. Both signal and youth were also nested in program. Response-level variables consisted of momentary engagement (outcome), as well as challenge, relevance, and learning (predictors). Gender and initial perceived competence at program outset were modeled as person-level predictors of engagement, and program activity (i.e., lab, basic skills, etc.) was modeled at the level of the ESM signal episode. Due to the small number of programs (9) and the limited variance in outcomes at the program level (<3%), no program level predictors were explored in this analysis. The analyses related to the building of our final model, in which individual variables of interest were added sequentially, are presented in Table S1.

3 | RESULTS

Means, standard deviations, and Pearson correlations of all scaled study variables are displayed in Table 3. Intraclass correlations (ICCs) from fully unconditional multilevel models predicting the engagement, challenge, relevance, and learning outcomes, suggest that 35–52% of the variance in these outcomes is attributed to differences across persons, while 2–7% is attributable to differences across situations. Less than 3% of the variance in these outcomes is due to differences between programs (Table 4).

3.1 | How youth experiences of challenge, relevance, and learning are related to engagement, and the role of gender and perceived competence

Table 5 presents results of the final cross-classified random effects model examining associations between youth characteristics (gender, initial competence beliefs), momentary conditions (challenge, relevance, learning), and momentary engagement (see Table S1 for results model building that resulted in this final model). This analysis includes an examination of whether gender moderates the relations between each of the momentary conditions and youths' engagement. In analyses not shown here, we also explored initial competence as a moderator and

TABLE 3 Descriptive statistics and Pearson correlations

	1	2	3	4	5
1. Engagement					
2. Challenge	.32***				
3. Relevance	.68***	.39***			
4. Learning	.69***	.30***	.65***		
5. Initial competence	.08***	−.12***	.03	.09***	
Mean	2.87	2.27	2.58	2.77	3.13
SD	0.87	1.12	0.96	1.06	0.81
Minimum	1.00	1.00	1.00	1.00	1.00
Maximum	4.00	4.00	4.00	4.00	4.00

Note: ***$p < .001$.

TABLE 4 Intraclass correlations (ICCs) for all variables

	ICCs		
Item	**Situation**	**Student**	**Program**
Engagement	0.04	0.44	0.01
Challenge	0.07	0.37	0.03
Relevance	0.02	0.52	0.01
Learning	0.02	0.35	<0.001

TABLE 5 Results of cross-classified, random effects model examining relations between perceptions of challenge, relevance, learning, and engagement

	Outcome: Engagement	
Fixed effects	***B* (*SE*)**	***d***
Intercept, β_{00}	2.89** (0.07)	
Initial competence beliefs, β_{01}	0.08 (0.06)	0.26
Female, β_{02}	−0.08 (0.09)	0.13
Challenge slope, β_{10}	0.07** (0.02)	0.16
Female, β_{11}	−0.05* (0.02)	0.08
Relevance slope, β_{20}	0.39** (0.02)	0.65
Female, β_{21}	−0.08* (0.03)	0.10
Learning slope, β_{30}	0.27** (0.02)	0.56
Female, β_{31}	0.01 (0.02)	0.02
Random effects		σ^2
Beep, r_0		0.02**
Person, r_1		0.35**
Program, r_2		0.01
Level 1 error, e		0.22

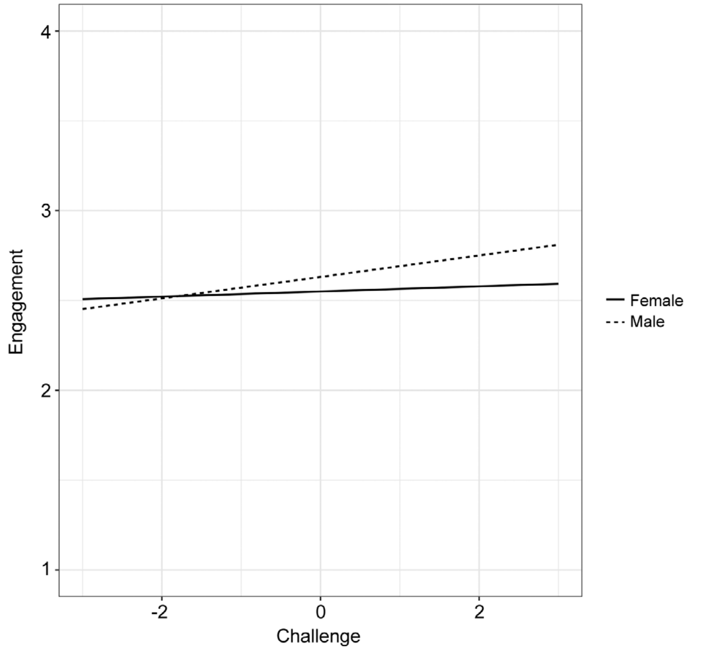
Note: *$p < .05$; **$p < .001$.

learned there were no effects. Because gender is included as a moderator, the coefficients for the challenge, relevance, and learning slopes (β_{10}, β_{20}, and β_{30}, respectively) represent the effects of these conditions for male youth, while the "female" coefficients (β_{11}, β_{21}, and β_{31}) represent the extent to which the slope for female youth differs from the slope for males. Across programs, when male youth experienced program activities as more challenging ($\beta_{10} = .07$, $p < .001$, $d = 0.16$), more relevant ($\beta_{10} = .39$, $p < .001$, $d = .65$), and as providing more affordances for learning ($\beta_{30} = .27$, $p < .001$, $d = .56$), their engagement was significantly higher.

The significant negative coefficients for females on the challenge and relevance slopes ($\beta_{11} = -.05$, $p < .05$; 1 and $\beta_{21} = -.08$, $p < .05$, respectively) indicate that the associations of challenge and relevance with engagement were different for females relative to males. In both cases, female youth appear to be less "responsive" to challenge and relevance in that they do not engage to the extent that male youth do when they perceive a learning situation as more challenging or more relevant. The interaction effects regarding challenge and relevance are represented graphically in Figures 1 and 2, respectively. As seen in the figures, the positive effect of challenge on engagement that was observed for male youth was essentially nonexistent for female youth, whereas the positive effect of relevance on engagement was simply more muted for female youth than it was for male youth. The nonsignificant coefficient for females on the slope for learning ($\beta_{31} = .01$, *ns*) means that the female youth in the sample experienced essentially the same positive association between learning and engagement that was observed among males.

It is important to note that because youths' perceptions of challenge, relevance, and learning were all included in the same model predicting engagement, the effects of each can be interpreted as independent of the other effects. In other words, when youth perceived their program activities as more relevant, their engagement was higher, regardless of how challenged they felt or how much they felt they were learning. Likewise, the perception that one was learning was

FIGURE 1 Association between perceived challenge and engagement, by gender



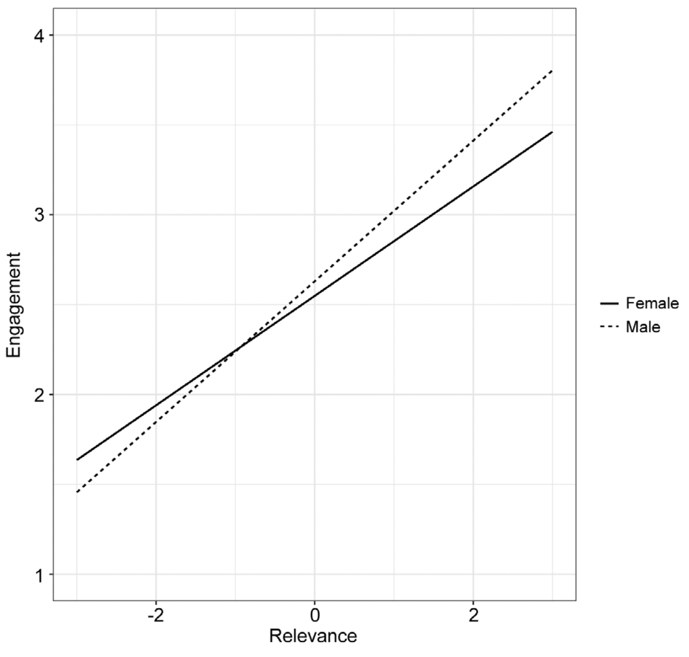


FIGURE 2 Association between perceived relevance and engagement, by gender

associated with increased engagement regardless of whether one perceived the content as relevant or felt especially challenged.

3.2 | How specific program activities are related to youths' perceptions of challenge, relevance, and learning, and the role of gender and perceived competence

The finding that youth are more engaged when they perceive an activity to be challenging, relevant, and affording opportunities for learning and skill development will lead youth educators to a very practical question: "Are there certain activities that youth tend to see as challenging, relevant and affording opportunities to learn?" In the analysis that follows, we sought to identify concrete activities that systematically elicited perceptions of higher challenge, relevance, and learning among our participant youth. It is important to note that we had no illusions about identifying any single activity that acts as a "magic bullet" for engaging all students because these conditions are highly subjective. In the interest of moving toward more concrete action steps for practitioners, however, we endeavored to explore whether there were associations between particular types of activities and students' perceptions of those activities.

To this end, we identified six types of activities that were employed to various degrees across the programs we studied. Using video data that were linked to youths' ESM responses, we identified the activity youth were participating in at each signal to explore how each activity was generally perceived by students while they were involved in it. In these analyses, we ran three separate multilevel models with challenge, relevance, and learning as the outcome variables. Predictor variables included dichotomous indicators of which activity youth were involved in at the time they provided ratings of challenge, relevance, and learning. In all three models, we explored whether gender or initial competence beliefs moderated any of the effects of activity type on the outcomes of interest, and there were no significant associations. In the interest of parsimony, our final models do not include these interactive effects. The variance components at the person level are statistically significant, suggesting that there is substantial person-level variation in the extent to which activity type is associated with challenge, relevance, and learning: However, gender and perceived competence do not account for any of this person-level variance.

While youths' initial perceptions of their STEM competence were not systematically related to their perceptions of challenge, relevance, or learning while doing program activities, their gender was (Table 6). Youth who identified as female tended to perceive program activities as less challenging ($\beta_{02} = -.24$, $p < .05$) and less relevant ($\beta_{02} = -.25$, $p < .05$) than their male peers. Male and female youth did not differ from one another in the degree to which they felt they were learning during the programs ($\beta_{02} = -.08$, *ns*).

Relative to the non-STEM related activities across these programs (the reference category for activity), youth perceived basic skills activities like completing mathematics worksheets or reviewing basic concepts as affording greater opportunity for both challenge ($\beta_{10} = .13$, $p < .05$) and learning ($\beta_{10} = .21$, $p < .001$). Youth also rated basic skills activities as being significantly more relevant than the non-STEM related activities in the program, meaning that students felt those activities were important to them and their futures, and would be useful outside of the program ($\beta_{10} = .11$, $p < .01$). Activities in which youth were creating a product (e.g., building a robot, constructing a model, preparing an interactive presentation) also stand out as optimal in

TABLE 6 Results of cross-classified, random effects models for the relations between program activities and perceptions of challenge, relevance, and learning

	Model 1		**Model 2**		**Model 3**	
	Outcome: Challenge		**Outcome: Relevance**		**Outcome: Learning**	
Fixed effects	***B* (*SE*)**	***d***	***B* (*SE*)**	***d***	***B* (*SE*)**	***d***
Intercept, β_{00}	2.30*** (0.10)		2.64*** (0.09)		2.73*** (0.08)	
Initial competence beliefs, β_{01}	−0.12 (0.07)	0.28	0.05 (0.07)	0.14	0.08 (0.06)	0.20
Female, β_{02}	−0.24* (0.11)	0.33	−0.25* (0.11)	0.34	−0.08 (0.10)	0.12
Basic skills[a], β_{10}	0.13* (0.06)	0.30	0.11** (0.04)	0.36	0.21*** (0.05)	0.61
Creating products[a], β_{20}	0.44*** (0.07)	0.88	0.19*** (0.04)	0.56	0.11* (0.05)	0.28
Field trip speaker[a], β_{30}	−0.05 (0.13)	0.08	0.24** (0.08)	0.57	0.07 (0.09)	0.15
Lab activities[a], β_{40}	0.21 (0.13)	0.27	0.08 (0.08)	0.16	0.19 (0.10)	0.35
Program staff Led[a], β_{40}	−0.05 (0.08)	0.09	0.10 (0.05)	0.28	0.07 (0.06)	0.17
Random effects	σ^2		σ^2		σ^2	
Beep, r_0	0.05***		0.01**		0.01	
Person, r_1	0.47***		0.48***		0.40***	
Program, r_2	0.03		0.01		<0.001	
Level 1 error, e	0.65		0.41		0.71	

Note: *$p < .05$; **$p < .01$; ***$p < .001$.

[a]Reference activity (the activity that these activities are compared to) is non-STEM program activities.

that youth not only perceive these activities as highly challenging ($\beta_{20} = .44$ $p < .001$) and relevant ($\beta_{20} = .19$, $p < .001$), but they also feel that they are learning or developing skills while involved with them ($\beta_{20} = .11$, $p < .05$). Listening to community experts—an important element to these programs—was perceived by youth as a highly relevant activity ($\beta_{30} = .24$, $p < .001$), though youth did not report especially high levels of challenge ($\beta_{30} = -.05$, *ns*) or learning ($\beta_{30} = .07$, *ns*) while doing so. Youth did not perceive labs or program staff led activities (like lectures and demonstrations) as particularly challenging or having particular relevance, and they reported similar levels of learning as they did in non-STEM activities.

4 | DISCUSSION

This study explored potential conditions for youth engagement in STEM-focused summer programs targeting underserved youth. The results deepen our understanding of how specific subjective experiences cultivate engagement in STEM, how the effects of these subjective experiences vary by characteristics of the participating youth, and which program activities predict these subjective states of youth experience. Perceived challenge, relevance, and opportunities for learning each emerged as conditions that generally heighten youth engagement in summer STEM programs. It is notable—particularly in light of the finding that different program activities seem to differently elicit youths' perceptions of challenge, relevance, and learning—that the effects of these conditions upon engagement are independent. Together these findings demonstrate that there are multiple pathways to engaging youth in summer STEM programs. Importantly, our finding that challenge, relevance, and opportunities for learning are all associated with increased engagement (even when all three are considered in models simultaneously) is consistent with research conducted in traditional classroom environments (Fredricks et al., 2002; Koballa Jr. & Glynn, 2007; Lutz et al., 2006; Shernoff et al., 2003). Even in summer programs when youth tend to be less focused on academic pursuits, the experience of challenge, relevance, and learning tend to engage youth, as indicated by a composite measure that included youth ratings of interest, enjoyment, concentration, and an investment of hard work.

However, an examination of the magnitude of the coefficients and the calculated effect sizes for perceived challenge, relevance, and learning suggests that certain of these conditions produce greater gains in engagement than others. Perceiving the activity one is doing as relevant was a more robust predictor of engagement than any other variable in the model, with a moderate effect size. The effect for perceived learning is only slightly smaller, but still would be characterized as moderate. In contrast, the effect of perceived challenge should be understood as small, both in terms of absolute effect size and relative to the other situational variables examined. These results suggest that those interested in increasing youth engagement in summer STEM programs may see greater results by focusing efforts on highlighting activity relevance and making sure activities provide affordances for learning something new, rather than focusing on challenge per se.

Analyses of specific program activities provide some clues about what youth leaders can do to help students experience challenge, relevance, and learning in the context of summer STEM programs. Activities focused on creating products, and those emphasizing basic STEM skills stand out from other activities as affording all three of these conditions and highlight the potential power of both active learning strategies and basic STEM content for summer programs.

4.1 | Gender, perceived competence, and engagement in OST programs

4.1.1 | Gender

Male and female youth appear to be differentially responsive to the conditions of challenge and relevance in terms of its effects on engagement. Whereas male youth evidence modest but significant increases in engagement when they perceive program activities to be challenging and relevant, the pattern for female youth is significantly different. Among the female youth in our sample, mean levels of engagement remained relatively constant, regardless of the extent to which they perceived what they were doing to be challenging. Similar results were obtained in a classroom study using nearly identical methods (Strati et al., 2017). The findings from the present study differ from the study conducted in traditional classrooms in that on average, girls perceived the informal summer program activities to be less challenging than boys, whereas no gender differences in mean levels of perceived challenge were observed in science classrooms.

While this intriguing combination of gender differences related to challenge merits discussion and further examination, we wish to remind the reader that the association between challenge and engagement was small, both in absolute terms and relative to the associations observed for relevance, so we are discussing gender differences in a relatively small effect. The combination of gender differences in mean-level challenge and gender-different associations between challenge and engagement might be explained in at least two different ways, and unfortunately, our data do not afford us the opportunity to test these alternative explanations. The first possibility is that—in STEM areas at least—girls may feel more threatened by challenge than boys, and as a result choose not to engage as deeply in STEM-related activities when they become more challenging (see Strati et al., 2017 for a discussion of this possibility in the context of science classrooms). The second possible explanation is that there is some level of challenge that serves as a critical threshold beyond which engagement is triggered, and girls simply may not be reaching it in these programs (i.e., they are not being challenged enough to trigger heightened engagement). This explanation is consistent with Emergent Motivation Theory (Csikszentmihalyi, 1990), which posits that a certain degree of perceived challenge is a necessary precondition for deep engagement. These two explanations for the observed gender differences suggest two very different possibilities in terms of understanding gendered pathways in STEM areas and the resulting implications for practice. This is an area for future research.

While both of the above explanations may explain gender differences in the relation between challenge and engagement, neither provides any insight into why girls may be less challenged than boys. These mean-level differences may reflect gender differences in academic achievement in STEM disciplines during the adolescent years. For example, research indicates that girls tend to earn higher course grades in mathematics than boys (American Association of University Women, 2008; Voyer & Voyer, 2014). While these trends are not necessarily indicative of any gender-related differences in ability, it might suggest that girls are generally more equipped or more motivated to take on school-related tasks in ways that result in higher grades. Girls may similarly feel more equipped to take on STEM-related activities in summer programs, and thus may find those activities to be less challenging. Alternatively, if girls see STEM activities as less relevant than boys do (see discussion below), thinking about whether those (potentially less valuable) activities are challenging or not may not be a salient concern.

As was the case for challenge, not only do girls generally see summer STEM program activities as less personally relevant, but even when they do perceive an activity as highly relevant their engagement is not triggered to the same extent as it is for boys. Our findings regarding relevance differ from those regarding challenge in two important ways, however. First, the magnitude of the association between relevance and engagement is much greater than the association between challenge and engagement. In other words, increases in relevance result in much larger changes in engagement than do increases in challenge. Second, associations between relevance and engagement are decidedly positive for female youth, just less so than for male youth, whereas associations between challenge and engagement were essentially flat for female youth. It will be important for future research to explore the reasons behind these gender differences in perceptions of relevance. Researchers who focus on both formal and informal STEM learning have identified a number of gender-equitable instructional strategies, and one key strategy is making instruction personally relevant and meaningful (Karl, McLain, & Santiago, 2017). Multiple researchers have documented that STEM careers are still largely seen as "male" professions (Miller, Nolla, Eagly, & Uttal, 2018; Stout, Ito, Finkelstein, & Pollock, 2013) and that women and girls are less likely to see themselves as having a future in STEM disciplines (Cheryan, Master, & Meltzoff, 2015; Wang & Degol, 2017). A recent national poll of youth indicates that women and girls see fewer connections between themselves and science (National Academy of Sciences Labx, 2020). Such gendered beliefs about STEM may have contributed to a general perception among the female youth in our study that the summer STEM activities were less relevant to their lives, and because the activities were seen as less relevant, they may have been slightly less likely to trigger student engagement in the moment. Of course, this explanation is speculative at this point but seems consistent with trends observed among young adults. For example, the national poll mentioned above reports that millennials who fail to see connections between their lives and science tend to engage less frequently in a variety of STEM-related community experiences as adults, and are less likely to hold the belief that local issues that are important to them like pollution and public health could be improved through a scientific approach. Thus, helping youth in general and girls, in particular, appreciate the relevance of their STEM activities, could have long-lasting effects on their engagement as adults.

An important point to consider in understanding the aforementioned gender differences is that male and female youth did not appear to differ from one another in how they perceived specific program activities in terms of their affordances of relative challenge or relevance. While girls generally saw all of their program activities as less challenging and relevant than boys did, the various activities we explored had the same affordances for challenge and relevance relative to one another within gender. In other words, the same activities that boys saw as having higher relevance (or challenge) were also seen by girls as having higher relative relevance (or challenge). The difference is in the overall mean levels and in the degree to which the perception of challenge and relevance (regardless of its source) triggers engagement. The conditions of challenge and relevance were observed at higher levels for boys and seem to more consistently trigger engagement for boys than girls.

We observed no gender differences with respect to youths' perception of learning something new during their time in the programs. Not only did male and female youth in the study perceive similar levels of learning during program activities, they also evidenced similar associations between learning and engagement. This suggests that female youth in the programs felt they were learning as much as male youth, and this learning was engaging to a similar extent for both groups.

4.1.2 | Perceived competence

Initial competence beliefs did not moderate the associations between youths' subjective experience and their engagement. Initial competence beliefs have been shown to moderate youths' reactions to school-based relevance interventions in STEM and other disciplines (Hulleman et al., 2010; Hulleman & Harackiewicz, 2009). The finding in this study might suggest that youth approach informal summer program experiences differently than they do formal schooling. Perhaps they are more open to participating in the informal settings in which they are not pressured to achieve, and thus their competence in the domain is less salient.

4.2 | Program activities as creating conditions for engagement

Our results indicated that youth responded positively to both creating products and basic skills activities: These are the only two activities that youth reported to be relevant, challenging, and educational. That students held these perceptions of these two activities is surprising, because in many ways they represent opposite ends of the activity spectrum we observed. The basic skills activities looked very much like traditional school activities, and included worksheets, other individual work, and practice drills that might not be the most appealing activities to youth as a summer activity. The activities coded as "creating products," on the other hand, included designing and building machines, creating models to represent concepts and other more presumably active and creative pursuits. Researchers who study maker and tinkering activities in OST settings also have observed that creating activities engages youth and promotes learning (Bevan, Gutwill, Petrich, & Wilkinson, 2015). What these two types of activities may share in common, however, is that they each required that students either practice or apply their STEM knowledge and skills. The OST programs offered the opportunity for youth to apply the basic skills that they were learning in a more informal and creative setting thus promoting a STEM learning ecosystem (Bell & Bevan, 2014) and deepening their STEM learning (National Research Council, 2012). It is important for OST educators to understand that both types of STEM-focused activities were engaging for youth. A longitudinal study of the career trajectories of participants in a STEM focused OST program identified having diverse opportunities to practice science as a key program design principle that contributed to persistence in STEM (Habig, Gupta, Levine, & Adams, 2018). As such, offering multiple ways for youth to interact with science content may not only be engaging in the moment but if sustained over time may have longer-term impacts on career development as well.

Many of the opportunities afforded to youth when creating a product also provided youth with the opportunity to potentially experience a sense of agency by allowing choice and autonomy in program offerings and providing opportunities to solve problems and develop solutions to issues they encountered. The activities allowed youth to be in charge to some degree in terms of how their project was designed and what work they would need to do to accomplish it. Providing youth with an opportunity to experience a sense of agency is particularly important starting in early adolescence, enabling youth to utilize emerging cognitive skills, such as higher order reasoning and greater executive control of their own thought processes to more effectively solve problems and take the steps needed to achieve goals they are pursuing (Larson & Angus, 2011; Larson & Dawes, 2015; Nagaoka, 2016). This provides youth with feedback about what they can accomplish and their ability to solve problems and overcome challenges, enhancing an underlying sense of self-efficacy and confidence that may support their engagement. Larson, Izenstark, Rodriquez, and Perry (2016) highlight how staff working to design and deliver high-quality OST activities take steps to try maximize the opportunities participating youth have to experience a sense of agency.

On the surface, lab activities and creating products may seem to share some characteristics in that both are "hands-on" activities that require active participation to complete. However, the youth in our study perceived lab activities very differently from creating products. Youth reported that labs did not engender any of the conditions for engagement in that they were not especially challenging, relevant, or educational relative to other activities they did in their programs. In these particular programs, however, labs were rarely designed by the youth, whereas youth were responsible for planning and designing the products they created. The lab activities that we observed across these programs tended to suffer from some of the same limitations researchers have observed in science classrooms: They were structured as opportunities for youth to follow a series of predetermined steps in order to reach a known "right answer," rather than as a process of more authentic inquiry and discovery (Furtak & Penuel, 2019; Kang, Windschitl, Stroupe, & Thompson, 2016; Roth et al., 2011). Unlike program activities that were centered around creating products, the lab activities we observed did not appear to afford youth agency. Additionally, creating products was central to the purpose and identity of several of the programs in this study in a way that labs were not (i.e., the programs were billed as a "building" program, whereas lab activities were conducted in the service of learning about something else). Thus, it might be that the program staff were particularly committed to facilitating the youth experience in product creation. The observed differences in student experience in lab relative to creating products might reflect the programmatic emphasis in the nine programs we studied, and so results might look different in programs where lab activities are more integral or authentic.

Youth reported that listening to presentations of community experts was relevant to them, though they did not see this activity as challenging or as providing opportunities for learning. It might be that youth do not see listening as an activity that is challenging, or perhaps the presentations were simply clear and easy to follow. Youths' assessment that they were not learning something new from the expert presentations is consistent with the idea that they were not challenged. Recall, however, that youth's perception of relevance was more predictive of their engagement than was their perception of challenge or learning, so community experts may have an important role to play in facilitating youths' engagement in summer STEM programs. Other longitudinal research suggests the effects of interaction with experts on longer-term engagement outcomes as well. For example, Habig et al. (2018) find that exposure to STEM professionals within the context of OST programs is a program design feature that is associated with persistence in a STEM career, and they further explain that the value of this type of exposure is the development of shared science identities and building of social networks (rather than the transmission of specific STEM content knowledge per se). Thus, at a very fine grain size, the results of our exploratory analysis of program activities might be reflecting the broader phenomenon that different design aspects of OST programming support youth engagement in STEM through different "channels," with some activities (like interacting with community experts) primarily addressing issues of relevance (and in the longer-term, identity and networks), whereas other activities (like creating products) provide challenge and affordances for learning as well (National Research Council, 2009).

4.3 | Limitations and future directions

This study had several limitations which should be considered when drawing conclusions from our results. First, the sample size for this study is relatively small, both in terms of the number of youth who reported on their experience ($n = 203$) and the number of summer STEM programs ($n = 9$) that were observed. The participant programs represented a rather limited range of program foci and program activities, and primarily served youth from lower socioeconomic backgrounds who identify as Black or Hispanic; therefore, our results may not be generalizable beyond our study population.

The second word of warning concerns the way engagement was conceptualized and measured in this study. The procedures we used to measure engagement had a high degree of ecological validity in that they elicited youths' reports of engagement as they were experiencing program activities. Additionally, the engagement measure was comprised of items that arguably represented cognitive, affective, and behavioral dimensions, which is consistent with current theorizing about engagement (Christenson et al., 2012; Fredricks et al., 2002). However, in our analyses, we did not consider the various dimensions independently to explore whether one dimension was driving our results more than others. Relatedly, we did not attempt to construct "profiles" representing different combinations of these dimensions—an approach that has been taken up in recent research (Schmidt et al., 2018). Our conceptualization of engagement in this article is thus relatively broad and does not attempt to distinguish the impacts of its various dimensions. Future research may endeavor to unpack a more nuanced understanding of how perceptions of challenge, relevance, and learning are related to each individual dimension, and/or to the various combinations of these dimensions.

Third, we want to remind the reader that our indicator of perceived learning is a subjective youth report, which may or may not correspond to actual, measurable learning gains. Arguably, both actual and perceived learning are important to understand, and we thought it particularly important to examine whether students in a summer program would engage more or less during those times when they felt like they were learning. Additionally, it is unclear from the youth reports what exactly they thought they were learning or the extent to which it was directly connected with the STEM content that was the focus of the program (i.e., were they learning about thermodynamics, were they learning how to collaborate effectively with their peers or were they learning that their lab partner likes to play the saxophone in his free time?). So, while we found that students engage more deeply when they perceive themselves as having the opportunity to learn something new, we do not have a clear sense of what they might think they are learning in these situations. Our findings that youth reported learning more when they were creating products, doing labs, and doing basic skills activities, relative to when they were doing non-STEM related activities, suggests that youth thought of learning in reference STEM skills and content, but we cannot be absolutely certain about this. Future research might both seek to understand in greater detail what students perceive themselves to be learning, and also include more objective assessments of learning in these areas.

Fourth, our analyses of the extent to which youth perceived certain program activities as challenging, relevant, or providing affordances for learning operationalized these activities at "face value" without accounting for the quality with which these activities were delivered. To be sure, there are better and worse ways to deliver a lecture or facilitate a lab, and how activities are delivered likely impacts how challenging, relevant, or learning-rich that activity will be. As we mentioned in our discussion above, the way labs were facilitated in the programs we observed may explain our finding that youth did not generally perceive labs as challenging, relevant, or educational. Future research might focus on how variation in the delivery of certain program activities affects students' perceptions of their affordances for challenge, relevance, and learning.

Fifth, the small sample size and limitations in the scope of data collected did not permit us to statistically control for factors outside of the program that could potentially influence youths' subjective perceptions of challenge, relevance, and learning. For example, youth whose families provide greater support for pursuing STEM interests or who espouse and communicate greater value for science may perceive their program activities to be more relevant and/or providing more affordances for learning (Koch, Lundh, & Harris, 2019).

Finally, our exploration of individual differences in youths' engagement and their perceptions of challenge, relevance, and learning was limited to an examination of gender and perceived competence. It is likely that other youth characteristics may help explain individual differences in youths' engagement and experience: Future research should expand the range of characteristics examined.

5 | CONCLUSION

In spite of its limitations, this study contributes to our understanding of youth experience in out of school STEM programs by examining both subjective and objective features of the program environment. Using rigorous research methods that mirror studies of classroom engagement, this research examines youth engagement in summer STEM programs and identifies conditions for youth engagement as well as gender-related variations in how these conditions might impact engagement. Results highlight the importance of creating appropriate conditions for engagement in out of school STEM programs, as well as the need to continue to focus on strategies for engaging all students in these programs.

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ENDNOTES

[1]We wish to clarify that our description of *engagement* in OST settings refers to what science communication experts refer to as *educational engagement*. Educational engagement refers to an individuals' interaction with particular materials, and is distinct from democratic engagement (which has to do with who in society should be involved in decisions about resource allocation and what is valued in science), and institutional engagement (which has to do with how often members of a community utilize science learning resources, such as membership numbers for a museum). For a review, see McCallie et al. (2009).

[2]We note that youths' reports of their own hard work and concentrated effort might possibly refer to both behavioral and cognitive dimensions of their engagement (for discussion of the challenges inherent in measuring multiple dimensions of engagement from self-reports, the reader is referred to Fredricks & McColskey, 2012)

[3]We note that we examined alternative approaches to constructing a measure of initial perceived competence including taking the scores from the single domain in which perceived competence was highest. These measurement modifications did not appreciably alter the results.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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