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Changemakers: Influences on Engagement in STEM Curricula Among Underrepresented Youth

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Abstract: Despite the desirability of working in science, technology, engineering, and math (STEM), Black and Latinx people are underrepresented in these fields. Sustaining engagement in STEM is central to addressing the representation gap. This qualitative study examined whether and how a STEM-based after-school program (Changemakers) impacted students' sense of engagement in STEM. Changemakers incorporates the basic tenets of STEM engagement and a purpose curriculum to increase students' sense of engagement. Purpose is an aspiration towards future-oriented goals, active engagement with one's goals, and intention to contribute to the world. The sample was composed of students, ages 15-17 years old (N=10, 5=M; 5=F), from a public, low-income high school. Findings suggested that three elements helped engage participants with STEM material: challenging and novel curriculum, experiential learning, and supportive relationships. These findings underscore additional STEM programs can enhance their student's learning and connection to the field by ensuring that their program encapsulates these identified components.

Keywords: *Adolescents, purpose development, qualitative study, STEM.*

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Introduction

Careers in science, technology, engineering, and mathematics (STEM) are often highly desirable due to their lucrative benefits, stability, and opportunities for advancement (Arcidiacono et al., 2016). People who work in the STEM fields have the potential to earn a higher salary than their similarly educated non-STEM peers (Beede et al., 2011; National Science Foundation, 2021). Moreover, in the past fifteen years, there have been more jobs in STEM than any other field (U.S. Bureau of Labor Statistics, 2017). Thus, given the instability of the current job market, many students view STEM careers as a way of increasing their opportunities for financial benefits and job security.

Despite the desirability of STEM fields, Black and Latinx people compared to their White counterparts are significantly underrepresented in these fields (Arcidiacono et al., 2016). This difference in representation is not due to a lack of interest amongst those from underrepresented backgrounds (Gilliam et al., 2017). At the start of college, Black and Latinx students exhibit the same level of interest as White students in the STEM fields, yet are significantly underrepresented in the STEM workforce. Numerous factors contribute to this disparity, including: disproportionate precollegiate exposure to STEM, resulting in a decreased sense of competence in college; negative perceptions about the field as a whole, such as it being individualistic and competitive; and lack of exposure to STEM professionals with similar racial and ethnic backgrounds (Gilliam et al., 2017).

The age of introduction to STEM may predict career intention and persistence, and so significant efforts have been made to introduce minority and marginalized populations to STEM fields at younger ages through after-school programs and summer internships (Carpi et al., 2017; Chemers et al., 2011; Estrada et al., 2018). Research suggests that

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an introduction to extracurricular STEM curriculum by eighth grade can result in a later sense of competence in STEM content (Chittum et al., 2017) that then carries over to confidence in STEM competence during college. When college students, especially minorities, enrolled in STEM majors, maintain higher SAT scores than the campus average, they are more likely to persist in their STEM majors (Arcidiacono et al., 2016). In addition, it appears that the match between student and university is an important predictor in graduating with a STEM degree. That is, more selective colleges are less likely to graduate students with less knowledge in the STEM fields, compared to less selective colleges, which are more likely to graduate students who do not have prior experience with the STEM fields (Arcidiacono et al., 2016). Thus, it stands to reason that minority students at selective colleges wishing to enter into the STEM field are at a disadvantage if they lack prior knowledge and experience in the field.

For all these reasons, it is important to introduce and engage students in STEM fields early. Few studies have illuminated ways to engage marginalized and minority students in STEM programs prior to college (Barton & Tan, 2018). This present study evaluated an after-school intervention designed to do just that.

Current STEM Engagement Among Marginalized Students

The racial and gender disparities in STEM fields are widely acknowledged, and leading STEM institutions (e.g. National Institute of Health and the National Science Foundation) have prioritized closing these demographic gaps (Hurtado et al., 2010; Ridgeway & Yerrik, 2016). Unfortunately, these efforts have failed to significantly diversify STEM fields. Researchers theorize that part of this failure is due to efforts to assimilate female and POC students into the preexisting STEM community that is dominated by White male professionals, values, and systems (Ridgeway & Yerrik, 2016). These underrepresented students are turned off by the exclusionary aspects of STEM and ultimately disengage with the field. Scholars have argued that interventions aimed at minority and marginalized populations must doubledown on increasing inclusivity and highlighting these populations' unique strengths and skills as advantageous and necessary in order to bring innovation to STEM fields.

Benefits of Engagement

Engagement is an essential part of learning and growing. Indeed, when individuals are continually engaged in an educational task or activity, they tend to experience increased interest in their learning goals, sense of motivation, interest in school, job market optimism, and decreased desire to pursue extrinsic goals (Chapman et al., 2017). In addition, youth who are more emotionally engaged present as less depressed and are less likely to be involved in behavior delinquency and abuse substances (Li & Lerner, 2011). Evidence also suggests that students with higher behavioral and cognitive engagement have higher grades and are more likely to aspire to higher education (Wang & Eccles, 2012). Finally, increasing student engagement is a critical aspect of many intervention efforts aimed at reducing school dropout rates (Archambault et al., 2009; Christenson & Reschly, 2010; Wang & Fredricks, 2014). Considering these impacts, programs would be wise to prioritize participants' sense of engagement in the field.

Lack of Impact on Engagement

Creating a program that is both engaging and enriching is a difficult task even for seasoned educators. Research has found that engagement petered out when students felt that the instructors provided the same instructions numerous times (Chittum et al., 2017). In other words, pacing of novel curricula is important, as students often lose interest and express boredom when subjected to repetition. Maintaining engagement in curricula requires knowledgeable and skilled educators who can detect when they are losing their students' interests. Unfortunately, research has found that many science teachers report feeling a lack of confidence in their ability to teach science, and/or a dissatisfaction with the school or science program (Margot & Kettler, 2019). Indeed, more than 40% of beginning science and math teachers left their jobs within the first five years (Ingersoll, 2003). In addition, many of the STEM teachers or instructors complained about lack of adequate equipment and technology to teach their students (Hossain & Robinson, 2012; Margot & Kettler, 2019). It is likely that this apprehension on the instructors' part can be felt by the students and may lead to disengagement. In addition, STEM teachers' identity can inadvertently affect students' engagement. Moreover, minority students, specifically girls, students of color, and those from lower SES, struggled with maintaining the belief that they are the type of people who can succeed in the STEM field (Hughes et al., 2013). Thus, lack of representation may further hinder engagement as part of a vicious cycle.

Program structures can also influence students' engagement with curriculum. Programs that are immersive but brief, tend to result in student interest during the program, but a decline and or loss of interest once the program ends. In addition, students tend to later reflect that the program was not thorough enough to help them build a sense of commitment to the field (Barab & Hay, 2001). Indeed, programs that fail to consider context and flexible thinking tend to alienate marginalized populations. For example, programs that fail to explore the intersectionality of race, class and gender, in relation to the STEM field appear less inclusive and accessible to marginalized populations (Hughes et al., 2013). This lack of integration may isolate minority students and thus cause them more distress than desire to engage.

Engagement in STEM

Research suggests that students' engagement increases when they can connect the content and material to their everyday lives. This sense of relevance makes the content feel more accessible and exciting. Specifically, students find science curricula to be engaging when it feels useful and relevant to their own lived experiences (Basu & Barton, 2007). For example, when programs allow children to play an active role in finding the relevance of science in their own lives, they in turn feel more connected to the program, the science community, and their science identity (Fusco, 2001). Also, hands-on learning opportunities (e.g. the opportunity to use advanced equipment) can enhance students' experiences and are central to their long-term interest. Additionally, the funds of knowledge theory states that there is an increase in engagement of marginalized students when science curricula interfaces with students' unique identities, belief systems, experiences, and future aspirations, via project-based opportunities to solve problems that are relevant to their lives and communities (Moje et al., 2001).

Current Study

Given the vast empirical evidence demonstrating the importance of student engagement for STEM-related outcomes among minority youth (e.g., Basu & Barton, 2007), the current study closely examines influences on engagement in a particular STEM program for marginalized youth. This specific after-school program, called Changemakers, incorporates the basic tenets of STEM engagement infused with a purpose curriculum in an effort to increase students' overall sense of engagement. The Changemakers program is designed for high school students in the Northeast region of the United States from low-income and urban backgrounds. The goal of the program is to expose and integrate students to a science and technology education that would otherwise not be available to them. The program focuses on teaching students the interdisciplinary science of hydroponics, managing an urban hydroponic farm, and selling what they grow to the local community while utilizing a social justice framework. In contrast to traditional classroom learning, program participants learn to construct technology that helps address the issues surrounding food insecurity and food justice while simultaneously reflecting on how this engages their own individual life aspirations. The students are accepted into this program based on their academic drive, leadership qualities, and commitment to their local community. In addition to a science curriculum, students are exposed to a purpose and career development curriculum.

A similar purpose curriculum has been incorporated into other school-based programs (Klein et al., 2019), but to our knowledge, STEM-related programs have yet to integrate purpose curricula. Youth purpose has been defined as having a personally meaningful aspiration or long-term goal one is actively engaged in, that is intended to contribute to the world beyond yourself (Bronk et al., 2018; Damon et al., 2003). Liang et al. (2016) have identified four major influences on purpose development: passion (an interest or enjoyment in the tasks associated with an long-term goal/aspiration); prosocial benefits (an intention to contribute to others through the goal/aspiration); people (a relationship that supports this goal/aspiration); and propensity (character strengths and skills associated with the goal/aspiration). When youth are more purposeful, they tend to be more engaged in thinking about their future (Damon, 2009; Liang et al., 2018; Nurmi, 1991). This "future-oriented" thinking tends to be a powerful motivator for youth. In fact, reflecting on one's purpose in life increases engagement in out-of-school activities among older adolescents (Burrow et al., 2018). Minority students, in particular, feel especially engaged in their schoolwork when they are able to picture themselves as successful adults (Hill, Liang, Bravo et al., 2018; Hill, Liang, Liu et al., 2018; Oyserman et al., 2002).

In the current study, in-depth interviews were conducted with Changemakers participants. Through an inductive interview approach, students shared how they viewed their engagement in their own words. Research questions included: Did students experience a sense of engagement with the program? If so, what aspects of the program were influential in helping students feel engaged?

Methodology

Participants

This study focused on a sample of high school students (N=10, 5=M; 5=F) from a public high school in the United States' Northeastern region who participated in the Changemakers program. The Changemakers program was specifically designed for students from low-income and urban backgrounds. Participants represented a diverse group of workingto-middle class people and self-identified as African-Americans/Black (n=2), Latinx or Hispanic (n=4), Haitian/Caribbean (n=1), Multi-ethnic including Black, Caribbean, Asian and Pacific Islander (n=2), and unknown (n=1). All of the students identified as eligible for free and reduced lunch at their schools, which is offered to lower income students. The students ranged in age from 15-17 years old.

Reflexivity

The three authors that analyzed the data are graduate students at a university in the Northeast region of the United States. They identify their race as white and gender as female. The lead PI, who supervised the analyses identifies as an Asian

American woman. The lead PI helped the three of the authors to consider any biases that may arise, such as assumptions they have about working with minority students. These discussions and raising of awareness sensitized them to potential biases during the coding process.

Procedure

The Institutional Review Board (IRB) at Boston College approved the study. Additionally, the research participants and their parents/guardians provided informed assent and consent, respectively, prior to participating in the study. Research participants could opt into a drawing to win a mini-iPad but no other compensation was given in exchange for study participation. All consenting program participants were asked to complete a written survey at the start and end of the program, which took about 15 minutes to complete. Some participants were randomly selected to participate in an approximately 30-minute interview, conducted in private classrooms, at both the beginning and completion of the program. The study's purpose was to investigate how engaging high school students with social and food justice through a STEM-focused program might affect their views on STEM, and impact their purpose and career development. The survey and interview questions were designed to evaluate these aims. This study focused on the pre and post interview data. The pre data was collected before the program began and the post data was during the last week of the program. These two time points are integral to the study as the researchers can evaluate the students commitment to STEM prior to the program, and after participation. For the sake of anonymity and confidentiality, participants were each assigned a code number and a pseudonym. The interviews were professionally transcribed.

The semi-structured (Seidman, 1991), in-depth (Johnson, 2002) interviews were conducted by trained research assistants. The interview questions were derived from research on youth purpose (Bronk et al., 2018), career (Crocetti et al., 2008), and science interest/identity (Weinburgh & Steele, 2000). Examples of interview questions include: "When you hear the word "science," what do you think? Is it good? Is it positive or is it more negative?" and "If someone asked you to describe the Changemaker's Program in a few words, not too many, what would you say?"

Analysis

We used a naturalistic inquiry approach which enabled us to collect data as close to the participants words as possible and minimize researcher interference (Jiggins Colorafi & Evans, 2016). Since the goal is to better understand the phenomenon of marginalized students in STEM, directed content analysis with theoretically driven codes was implemented. Directed content analysis produces both straightforward and rich descriptions of data (Sandelowski, 2000), as well as provides insight on otherwise vaguely understood phenomena (Sullivan-Bolyai et al., 2005). We chose this methodology as opposed to phenomenology, because the latter approach tends to investigate the meaning behind experiences, whereas our intent was to identify participants' own expressions of their shared experiences. In addition, conventional content analysis is preferable when working with minorities, as it allows participants to describe and highlight their own cultural experiences (Sullivan-Bolyai et al., 2005).

In preparation for coding, trained authors immersed themselves in the data by reading the interview transcripts multiple times (Elo & Kyngäs, 2008). They utilized a previously constructed purpose-based codebook as guidance (Liang et al., 2017) to code five transcripts in dyads. Teams of two coded independently, then reconvened in order to come to a consensus (Saldana, 2011), and finally, the whole team met regularly to discuss interview content, to create a more comprehensive code book, and to add new codes as they emerged (e.g. the inclusion of science identity codes). This process was repeated until all interviews were coded. After the completion of coding, the authors reread the transcripts with the codes and met to identify key themes. In particular, they recognized that participants provided rich descriptions of their engagement in the program. The authors then returned to review the data in order to identify themes that captured influences on participants' program engagement.

Results

When analyzing the data for influences on participants' engagement in the curriculum, three themes emerged: "novel curriculum," "experiential learning opportunities," and "relationships." In table 1, we describe each theme and provide examples.

Student respondents began the program with differing levels of motivation to pursue science-related aspirations. But, in post-interviews, they all reported deeper appreciation for and engagement in science-related pursuits. For example, pre-interview, Martin said, "I've never really been much of a science guy in school, because it's kind of hard." At the post-interview he remarked:

"The Changemakers program has changed my mind a little bit because it shows me new things… I don't know if I'm going to do anything in the science field, but it is interesting to have the knowledge and the experience."

In contrast, pre-interview Aaliyah already expressed science-related motivation: "I think anything having to do with any sort of science is interesting to me, considering there's so many parts of it." Post-interview, Aaliyah reported:

"[Changemakers] does make me even more interested. You know, like growing plants indoors and stuff like that, and not in a natural setting with the weather, and soil. The fact that we can do it this way and it produces healthier food, that's very interesting to me."

Other respondents shared this sentiment at post-interview: "[Changemakers] made me fall in love with science even more than I already was"; "I had a lot of fun and I actually enjoyed it"; "when it comes to [Changemakers], I sort of just adjusted into the sense of, 'Yes, it's work, but at the same time, it's play.'" Participants' attributed their deepening STEM engagement to three major influences: challenging and novel curriculum, experiential learning opportunities, and supportive relationships (with mentors, peers, and younger students in the program).

Novel Curriculum

Respondents noted that the Changemakers curriculum exposed them to aspects of science they had never before engaged in. Martin remarked in his pre-interview: "[Changemakers] shows another side of the science that I haven't seen before. So it gives me a change in my mind." Similarly, Michael said: "I [looked forward to] being able to do a lot of things that I wouldn't have done if I didn't go to this program." He later stated in his post-interview: "You [think] you know a thing about science and you hear something like 'Hydroponics' and…it just blows your mind."

For some participants, an initial sense of novelty is what enticed them to join the program in the first place. Brett said, "Hydroponics is a new thing for me. It sounded interesting to learn." In post-interview, Brett described how the newness of his learnings kept him engaged in the program: "We had to create the plumbing system and the timers….We've been learning about the science behind hydroponics and what the advantages are. This [was a] new topic and new information for me to learn, so it was interesting."

Pre-interview, Isabella described the desire for "a new understanding for science and a new view of how people actually do things and how it works." At post-interview, Isabella reported:

"[Changemakers] builds on your knowledge...you get to do more stuff in Changemakers than you get to do in science classes because you get to sell things and to sell the plants that you actually grow. You get to use hydroponic systems."

When considering the impact of this novel science curriculum, respondents described feeling empowered to engage with science and having a greater awareness of how science permeates every facet of life. Aaliyah stated, "[Changemakers teaches] you that, 'you could do this anywhere… You don't have to rely solely on nature, and you don't have to buy everything, you can do it yourself, with household materials." Then, at post-interview, she said, "The fact that we can do it this way and it produces healthier food, that's very interesting." Camila shared, "Well, I think [Changemakers] will affect me to like [science] even more. To keep engaging in it and to keep wanting to learn more…
Dig deeper into what I'm really doing." Post-interview, Lucas acknowledged the relevance of science, stating that "Almost everything has to do with science." Brett shared this sentiment: "Science is connected to everything. It's like how the world works." Respondents explained that Changemakers unique curriculum and approach to science learning first attracted them to the program and then, after participating in it, enhanced their engagement with science, bolstered their motivation, and empowered them to continue engaging with science. For example, Martin stated in his pre-interview: "I will be able to have different skillset that I haven't had yet. That I haven't learned. So just learning new things, and it's going to make me more knowledgeable as a person." Then, during post-interview, Martin voiced:

"I am not necessarily [going to be] a farmer but participating in [Changemakers] and learning new skills and knowing that experiencing new things, I'm going to have new abilities. It's really changed my mind that I can maybe do another program...a couple new programs, and then those also expand my mind, give me new skills, and then that could probably put me on a career path that I might be interested in."

Martin was motivated to join Changemakers in order to gain new skills through unique experiences. Post-interview, Martin described feeling motivated to pursue opportunities for expanding a science-oriented skill set and to find a profession that feels purposeful and aligned with interests and skills discovered during Changemakers.

Experiential Learning Opportunities

Respondents noted that the Changemakers curriculum was not only novel, but also provided numerous experiential learning opportunities. Camila noted pre-interview: "I like being hands-on with things. I like being able to do something. And then, to be able to teach it to other kids and be able to keep sharing that. I find it very engaging." Again, post-interview, Camila remarked:

"I really like hands-on. So when we were first introduced to hydroponic systems [in Changemakers] and they didn't baby us or like they actually let us learn from trying things out and making mistakes. That's what made me want to keep coming back."

Similarly, pre-interview, Michael explained that before Changemakers, his preferred style of learning science was experiential and experimental: "I grew orange trees, apple trees. They didn't work out, they died. But, it was fun to see how they [grew]." Then, in the post-interview, Michael said:

"We made an Ebb and Flow System. Basically to hold the plants from the hydroponic stuff we're doing and… it's a better way of making food without using soil; it's usually water only with nutrients. So I really like that part...It challenges your mind and gets you thinking about how to do things and how science works."

Finally, Isabella stated during pre-interview that her "curiosity" drew her to Changemakers. She explained, "[I'm really interested] to learn how we can grow vegetables inside, without soil or things that regular plants need," and then later, during the post-interview, Isabella said:

"We got our hands-on knowledge by practicing our communication skills, collaboration skills, critical thinking and problem solving. We got to do hands-on work, and with all of that, we learned more, we worked together more, and we actually got, we could actually do stuff that improved our environment."

Isabella described the practical and generalizable skills she gained from the experiential aspects of the program. She and other students explained that it was meaningful to them that the product they created had the potential to make a difference in the world.

Mentors and Peer Relationships

Analysis of pre and post interviews revealed that students greatly valued the relationships that were cultivated through the Changemakers program. Indeed, through these relationships, students were able to engage more deeply with the science material and their aspirations for the future.

Students stated that they appreciated when the teachers took the time to explain how science could connect to their lives. A primary way they did this seemed to be through making the science content less abstract and easier to process for these students. For example, Aaliyah stated pre-interview: "whenever he was able to make those life connections, and connect it to myself, it made me actually want to do it even more, and possibly teach other people, if I get more into it." Through this personal mentoring style, the student felt inspired to think about her own future. Aaliyah emphasized the impression that teachers made on her over the course of the program by instilling a sense of belief in one's own self efficacy and contribution to the science field:

"They sort of give you key points and make you say that you can, ...The first step is to believe it's not what could you do, but it's you can do something, and then you figure out what you could do. So, I like that perspective on it a lot."

Another student, Joseph, has been in the program for a few years, and highlights that this relational teaching style is embedded in the Changemakers program. He described how the mentors' encouragement enabled him to become more proactive when thinking about his future: "They [the teachers, the mentors] really pushed me to think more about what I wanted to do since last year and since I've been here. So, I believe that they will help me even more than they already have." It is clear that the relationships cultivated through the program allowed the students to grow and gain a sense of mastery over their ideas and abilities in multiple ways.

Through the creation of a strong relationship between mentors and students, a positive learning environment amongst peers was cultivated. Isabella articulated that she gained a strong sense of support and encouragement to ask questions that led to confidence and personal growth through the program. In the pre-interviews, she described how the teacher created a sense of immediate acceptance: "any time one of us doesn't understand something we ask questions if we need to. We're not afraid to ask her [the teacher] for help with something or tell her that we need help with this or that." This environment of support and safety created by the teacher translated into the students also helping each other. Post-interview, Isabella described being given opportunities to help her friends learn: "if one of my friends like got it like a little wrong, I would like try to help and like find a different way to make it work. And we can like work together."

Lastly, this program brought together a diversity of students and allowed them an opportunity to build meaningful relationships with peers they may never have encountered otherwise. This sense of community appeared to be a major source of motivation to sustain engagement in the program. Nearly all the participants suggested that they continued to return to program sessions because of their enjoyment and valuing of peer interactions in the program. Joseph stated, "What I really like about it is the different collaborations of different people because you get different perspectives when you talk to other people when you're doing a certain lesson." He summed up his experience by stating, "I met a lot of people and we just talked about our careers and what we wanted to do in the future. And what do we need to do in order to achieve that goals." In addition, these peer connections seemed to provide role-modeling, as did the mentor connections. Pre-interview,

Table 1. Examples of the 3 Influences/Mechanisms

Central Mechanism	Exemplary Quotation

Novel Curriculum	"I would say it gives you an opportunity to learn more, to experience new things. It helps you create. It helps you expand in the science community. And it gives you new perspectives and new achievements...I'd tell them that we grow food. We learn really cool things about science. We figure out how plants grow, what lights they needs and stuff like that. We go on really cool field trips that teach us even more about science"
Experiential Learning Opportunities	"I really liked the program. A few of my favorite things the hands on work. We didn't do, "Here's a textbook, here learn from this". I like doing hands on, we built the systems ourselves. We built the systems ourselves, they walked us through the process…"
Relationships	"I mean the name itself, Changemakers, I would just say you're just really making a change. And it's really a community type thing because we have different kids from every single district school, so it's bringing them together and making a change" and "I liked the mentoring part with the kids. I liked doing the systems. I liked the friends I made. This is my first year and I made a lot of friends."

Discussion

As education in the STEM fields becomes increasingly associated with growing career opportunities, it is concerning that access to STEM education continues to be divided down socioeconomic and racial lines. Black and Latinx, as well as women, and especially women of color, are significantly underrepresented in STEM fields (Arcidiacono et al., 2016). While there have been efforts to address this underrepresentation by introducing marginalized and minority populations to STEM, this introduction has not been sufficient to create a change in the demographics of the field. The present findings from the Changemakers program suggested that three elements helped engage participants with STEM material: a challenging and novel curriculum, experiential learning, and supportive relationships. The participants articulated that during the program, they were able to "engage in science in a way they never had before," and they were "able to expand their understanding of science beyond what [they] learned in the classroom." They noted the importance of hands-on learning experiences, including experiments. Our findings complement existing research on the benefits of experiential learning and other pedagogical approaches (e.g., service-learning) as ways of fostering youth purpose (Koshy & Mariano, 2011).

Additionally, the participants articulated that the teachers in the program encouraged them to try things on their own and learn from their mistakes, rather than giving them strict instructions about how to manipulate each experiment. Students found this hands-on and exploration-based teaching style conducive to making the science content enjoyable and exciting to learn. Lastly, the participants deeply valued the relationships that were cultivated during the program. Many noted that the teachers created a safe space for them to learn and ask questions. They also noted the fact that the program included a blend of students from various schools and ages, enabling participants the opportunity to learn from people with diverse perspectives and eventually form a supportive community of learners. Similarly, extant research on purpose cultivation has highlighted the critical importance of caring for adults and peers as youth explore and pursue a sense of purpose in life (Liang et al., 2016).

An overarching influence on engagement in the STEM material seemed to be the curriculum's infusion with purpose and career development lessons. Throughout the program, the students were encouraged to reflect on how the science they were learning in this program could relate to their overall future and life goals. This included activities explicitly focused on identifying their own strengths, skills, values, and passions as well as structured reflections on how their unique attributes might serve them well in STEM careers. Moreover, participants were exposed to a diversity of STEM career paths and often engaged in discussions about how what they are doing in the classroom could be used to directly benefit their own communities. Notably, the STEM curriculum itself was designed to equip participants to use their new STEM learnings and techniques to contribute to their communities. For example, through the program, participants sold food they had grown at farm stands. As a result, many participants described feeling personally empowered when engaging in these prosocial actions (e.g. "We could actually do stuff that improved our environment"; "You don't have to rely solely on nature, and you don't have to buy everything, you can do it yourself, with household materials."). The program's emphasis on cultivating students' sense of purpose seemed to contribute to their engagement in the STEM curriculum. They felt that STEM was relevant to achieving a purpose that was personally meaningful and of consequence in the world around them. This finding aligns with other research that has highlighted the role of out-ofschool activities as contexts of purpose cultivation (Burrow et al., 2020).

Conclusions

The present study illuminates the critical role that novel curriculum, experiential learning opportunities, and relationships play in engagement of marginalized and minority students in the STEM fields. As stated, the uncertainty in the economy, and lack of security in the job market, may increase students' anxieties, especially students of marginalized backgrounds. Furthermore, the appeal of a STEM career is illuminated, as it offsets these barriers. All students should have equal opportunity to enter STEM fields if they choose to, regardless of race, class or gender.

Recommendations

There are a few limitations worth noting as well as future directions that would advance our understanding of how to engage underrepresented students in STEM programs. First, future studies should explore whether findings from this study are replicated in other diverse populations. Qualitative and quantitative research including more than self-report data would be helpful in triangulating the results.

A strength of our study is that it analyzes data collected at two time points: a pre and post test. While this offers the opportunity to analyze change in engagement over time, studying the mechanisms of engagement over a longer period of time, with more data collection points, would provide insight into whether the positive effects of similar programs change over time. In particular, it would be valuable to follow participants as they enter college and/or the workforce to see whether engagement in STEM continues into these stages of their vocational trajectory. Of obvious interest is whether STEM engagement in school-based or afterschool programs leads to increased matriculation into STEM careers.

Limitations

Given that the current data had limited generalizability as it comes from one high school in the Northeast, future studies should be conducted in other parts of the country with different cultural norms, beliefs, and practices. Research should be done to see whether our influences or mechanisms of engagement hold true across diverse populations and vocational development stages.

While our findings highlight the importance of the three mechanisms of engagement, more research is needed to explore how programs might cultivate each of these influences on engagement. Our data was also focused on a small sample of students from marginalized backgrounds, but the majority are Black or Latinx students of low SES. Further research should be done to consider engagement among even more diverse racial, gender, and socioeconomic identities.

Finally, it is worth noting the potential influences of the COVID-19 pandemic. The current data was collected before the pandemic, and future studies are needed to assess whether the pandemic has had an effect on students' interest and engagement in STEM fields. For example, shifts in the economy and students' anxieties about job security might increase their interest and engagement in the STEM fields.

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References

Archambault, I., Janosz, M., Morizot, J., & Pagani, L. (2009). Adolescent behavioral, affective, and cognitive engagement in school: Relationship to dropout. *Journal of School Health*, *79*(9), 408-415. https://doi.org/10.1111/j.17461561.2009.00428.x

Arcidiacono, P., Esteban, M., Aucejo, E. M., & Hotz, V. J. (2016). University differences in the graduation of minorities in STEM fields: Evidence from California. *American Economic Review*, *106*(3), 525-62. https://doi.org/10.1257/aer.20130626

Barab, S. A., & Hay, K. E. (2001). Doing science at the elbows of experts: Issues related to the science apprenticeship camp. *Journal of research in science teaching*, *38*(1), 70-102. https://doi.org/dsjq2w

Barton, A. C., & Tan, E. (2018). A longitudinal study of equity-oriented STEM-rich making among youth from historically marginalized communities. *American Educational Research Journal, 55*(4), 761-800. https://doi.org/10.3102/0002831218758668

Basu, S. J., & Barton, A. C. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *44*(3), 466-489. https://doi.org/10.1002/tea.20143

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). *Women in STEM: A gender gap to innovation: Economics and Statistics Administration Issue Brief No 04-11.* SSRN. http://doi.org/10.2139/ssrn.1964782

Bronk, K. C., Riches, B. R., & Mangan, S. A. (2018). Claremont Purpose Scale: A measure that assesses the three dimensions of purpose among adolescents. *Research in Human Development*, *15*(2), 101-117. https://doi.org/10.1080/15427609.2018.1441577

Burrow, A. L., Agans, J. P., & Rainone, N. (2018). Exploring purpose as a resource for promoting youth program engagement. *Journal of Youth Development, 13,* 164-177. https://doi.org/10.5195/jyd.2018.601

Burrow, A. L., Ratner, K., Porcelli, S., & Sumner, R. (2020). Does purpose grow here? Exploring 4-H as a context for cultivating youth purpose. *Journal of Adolescent Research, 37*(4), 471-500. https://doi.org/10.1177/0743558420942477

Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, *54*(2), 169-194. https://doi.org/10.1002/tea.21341

Chapman, C. M., Deane, K. L., Harre, N., Courtney, M. G. R., & Moore, J. (2017). Engagement and mentor support as drivers of social development in the Project K youth development program. *Journal of Youth and Adolescence, 46*, 644-655. https://doi.org/10.1007/s10964-017-0640-5

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues*, *67*(3), 469-491. https://doi.org/10.1111/j.1540-4560.2011.01710.x

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, A. B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education, 4*(11), Article 11. https://doi.org/10.1186/s40594-017-0065-4

Christenson, S. L., & Reschly, A. L. (Eds.). (2010). *Handbook of school-family partnerships*. Routledge. https://doi.org/10.4324/9780203876046

Crocetti, E., Rubini, M., & Meeus, W. (2008). Capturing the dynamics of identity formation in various ethnic groups: Development and validation of a three-dimensional model. *Journal of Adolescence*, *31*(2), 207-222. https://doi.org/b6qm6z

Damon, W. (2009). *The path to purpose: How young people find their calling in life*. Simon and Schuster.

Damon, W., Menon, J., & Cotton Bronk, K. (2003). The development of purpose during adolescence. *Applied Developmental Science*, 7(3), 119-128. https://doi.org/10.4324/9780203764688-2

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of advanced nursing*, *62*(1), 107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE—Life Sciences Education*, *17*(1). https://doi.org/10.1187/cbe.17-04-0066

Fusco, D. (2001). Creating relevant science through urban planning and gardening. *Journal of Research in Science Teaching, 38*(8), 860-877. https://doi.org/10.1002/tea.1036

Gilliam, M., Jagoda, P., Fabiyi, C., Lyman, P., Wilson, C., Hill, B., & Bouris, A. (2017). Alternate reality games as an informal learning tool for generating STEM engagement among underrepresented youth: A qualitative evaluation of the source. *Journal of Science Education and Technology*, *26*(3), 295-308. https://doi.org/10.1007/s10956-016-96794

Hill, N. E., Liang, B., Bravo, D. Y., Price, M., Polk, W., Perella, J., & Savitz-Romer, M. (2018). Adolescents' perceptions of the economy: Its association with academic engagement and the role in school-based and parental relationships and academic engagement. *Journal of Youth and Adolescence, 47*(5), 895-915. https://doi.org/10.1007/s10964-0170802-5

Hill, N. E., Liang, B., Liu, P. P., Price, M., Perella, J., & Savitz-Romer, M. (2018). Envisioning a meaningful future and academic engagement: The role of parenting practices and school-based relationships. *Psychology in the Schools, 55,* 595-608. https://doi.org/10.1002/pits.22146

Hossain, M. M., & Robinson, M. G. (2012). How to Overcome Barriers and Misconceptions of STEM Education in the United States. In P. Resta (Ed.), Proceedings of SITE 2012--Society for Information Technology & Teacher Education International Conference (pp. 3367-3372). Association for the Advancement of Computing in Education (AACE). https://bit.ly/3y7aNPG

Hughes, R. M., Nzekwe, B., & Molyneaux, K. J. (2013). The single sex debate for girls in science: A comparison between two informal science programs on middle school students' STEM identity formation. *Research in Science Education, 43*(5), 1979-2007. https://doi.org/10.1007/s11165-012-9345-7

Hurtado, S., Newman, C. B., Tran, M. C., & Chang, M. J. (2010). Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project. *New Directions for Institutional Research, 2010*(148), 5-15. https://doi.org/10.1002/ir.357

Ingersoll, R. M. (2003). *Is there really a teacher shortage?* Penn Libraries. https://bit.ly/3C8TXkF

Jiggins Colorafi, K., & Evans, B. (2016). Qualitative descriptive methods in health science research. *HERD: Health Environments Research & Design, 9*(4), 16-25. https://doi.org/10.1177/1937586715614171

Johnson, J. (2002). In-depth interviewing. In J.F. Gubrium & J.A. Holstein (Eds.), *Handbook of interview research* (pp. 103-119). Sage.

Klein, T., Liang, B., Sepulveda, J., & White, A. (2019). MPower: An empirically-based youth purpose intervention. *Journal of Character Education*, *15*(2), 103-113. https://bit.ly/3y8cgVU

Koshy, S. I., & Mariano, J. M. (2011). Promoting youth purpose: A review of the literature. *New Directions for Youth Development, 132,* 13-29. https://doi.org/10.1002/yd.425

Li, Y., & Lerner, R. M. (2011). Trajectories of school engagement during adolescence: Implications for grades, depression, delinquency, and substance use. *Developmental psychology*, *47*(1), 233-247. https://doi.org/10.1037/a0021307

Liang, B., Lund, T. J., Mousseau, A., White, A. E., Spencer, R., & Walsh, J. (2018). Adolescent girls finding purpose: The role of parents and prosociality. *Youth & Society, 50*(6), 801-817. https://doi.org/10.1177/0044118X17697850

Liang, B., White, A., Mousseau, A., Hasse, A., Knight, L., Berado, D., & Lund, T. (2016). The four P's of purpose among College Bound students: People, propensity, passion, and pro-social benefits. *Journal of Positive Psychology, 12*(3), 281-294. http://doi.org/10.1080/17439760.2016.1225118

Liang, B., White, A., Rhodes, H., Strodel, R., Gutowski, E., DeSilva Mousseau, A. M., & Lund, T. J. (2017). Pathways to purpose among impoverished youth from the Guatemala City Dump community. *Community Psychology in Global Perspective, 3*(2), 1-21. http://doi.org/10.1285/i24212113v3i2p1

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education, 6*(2), Article 2. https://doi.org/10.1186/s40594-018-0151-2

Moje, E., Collazo, T., Carillo, R., & Marx, R. W. (2001). "Maestro, what is 'quality'?": Examining competing discourses in project-based science. *Journal of Research in Science Teaching*, *38*(4), 469-495. https://doi.org/10.1002/tea.1014

National Science Foundation. (2021). *The STEM labor force of today: scientists, engineers and skilled technical workers. science and engineering indicators 2022.* https://ncses.nsf.gov/pubs/nsb20212

Nurmi, J. E. (1991). How do adolescents see their future? A review of the development of future orientation and planning. *Developmental Review*, *11*(1), 1-59. https://doi.org/10.1016/0273-2297(91)90002-6

Oyserman, D., Terry, K., & Bybee, D. (2002). A possible selves intervention to enhance school involvement. *Journal of adolescence*, *25*(3), 313-326. https://doi.org/10.1006/jado.2002.0474

Ridgeway, M. L., & Yerrik, R. K. (2016). Whose banner are we waving? Exploring STEM partnerships for marginalized urban youth. *Cultural Studies of Science Education, 13*(1), 59-84. https://doi.org/10.1007/s11422-016-9773-1 Saldana, J. (2011). *Fundamentals of qualitative research*. Oxford University Press.

Sandelowski, M. (2000). Whatever happened to qualitative description? *Research in Nursing and Health, 23,* 334-340. https://doi.org/fvxrh4

Seidman, I. E. (1991). *Interviewing as qualitative research: A guide for researchers in education and the social sciences.* Teachers College Press.

Sullivan-Bolyai, S., Bova, C., & Harper, D. (2005). Developing and refining interventions in persons with health disparities: The use of qualitative description. *Nursing outlook*, *53*(3), 127-133. https://doi.org/cvg9m3

U.S. Bureau of Labor Statistics. (2017). *Employment and wages, annual averages 2017.* https://bit.ly/3DdNg2W

Wang, M., & Eccles, J. S. (2012). Social support matters: Longitudinal effects of social support on three dimensions of school engagement from middle to high school. *Child Development, 83*(3), 877-895. https://doi.org/10.1111/j.1467-8624.2012.01745.x

Wang, M., & Fredricks, J. A. (2014). The reciprocal links between school engagement, youth problem behaviors, and school dropout during adolescence. *Child Development, 85*(2), 722-737. https://doi.org/10.1111/cdev.12138

Weinburgh, M. H., & Steele, D. (2000). The modified attitudes toward science inventory: Developing an instrument to be used with fifth grade urban students. *Journal of Women and Minorities in Science and Engineering*, *6*(1). https://doi.org/jfdm