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ORIGINAL ARTICLE

Supporting the STEM Aspirations of Youth Who Have Been Pushed Out

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ABSTRACT

A lack of diversity permeates the science, technology, engineering, and mathematics (STEM) field. Under-representation within STEM fields can stifle innovation and progressive approaches to the future of STEM. Traditional STEM pathways focus on identifying participants who show academic promise in schools. One segment of young people, youth who have been "pushed out" of high schools, have often been excluded from STEM pathways. Alternative education programs have the potential to support youth who have been pushed out, to re-engage in STEM. The purpose of this study was to understand what factors contributed to the STEM aspirations of students at Xinaxtli Charter School (XCS), an alternative education program for youth who have been "pushed out" in South California. This quantitative study utilized Structural Equation Modeling to analyze a conceptual model for STEM aspirations at XCS. Specifically, this study looked at how each of the following areas – student perception of their science teacher, critical science education, student sense of agency to create knowledge in science class, student engagement in science class, and the relevance of science to the student – impacted student STEM aspirations. The best predictors of student STEM aspirations came from the following factors: (a) Relevance of science to students, (b) student sense of agency to create knowledge, (c) and critical science education. Findings from this study provide a framework for educators of STEM classrooms to re-engage youth who have previously "pushed out" of their traditional secondary schools.

KEY WORDS: Science education; alternative education; STEM aspirations; push out

INTRODUCTION

In the United States (US), participation in science, technology, engineering, and mathematics (STEM) fields is overrepresented by white males (Landivar, 2013). According to the report *Women, Minorities, and Persons with Disabilities in Science and Engineering* by the National Science Foundation and National Center for Science and Engineering Statistics (2019), women and people of color (i.e., Black or African-Americans, Hispanics or Latinos, and American Indians or Alaskan Natives) have been largely underrepresented in most STEM fields; that is, that their representation in STEM education and STEM employment is smaller than their representation in the US population. When looking at STEM degrees earned by "under-represented minority" women and men as percentage of all STEM degrees awarded by each degree, by degree type, we see that following:

1. STEM bachelor's degrees earned in 2016: 9% by men and 12.6% by women
2. STEM master's degrees earned in 2016: 5.5% by men and 7.8% by women
3. STEM doctorate degrees earned in 2016: 3.8% by men and 5% by women.

These numbers continue to be low in relation to their White and Asian peers in the same fields of study (National Science Foundation and National Center for Engineering and Statistics, 2019).

Diversity in science means ensuring that all have an opportunity to succeed in science academically and to pursue a career in science if they so choose. Further, it refers to actively including those from backgrounds that are traditionally underrepresented and excluded. One group of young people who have traditionally been excluded from pursuing a STEM pathway is youth who have been "pushed out" of their high schools. They have been excluded for several reasons that will be explored in the following sections. The purpose of this study was to fill a gap in the literature that focuses on how to better support young people who have been "pushed out" of their high schools to re-engage and to pursue a STEM pathway, if they choose to.

The purpose of this study was to better understand what factors may impact Xinaxtli Charter School (XCS) student STEM aspirations. Specifically, this study looked at how each of the following areas – the student perception of teachers, critical science education, the student sense of agency to create knowledge, the student engagement in science class, and the relevance of science to the student – impact student STEM aspirations. The research question that guided this investigation is: (1) What factors may contribute to future STEM aspirations of XCS students?

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LITERATURE REVIEW

Issues within Traditional Science Education

Lack of representation within STEM fields is an issue because a more diverse STEM culture may have the ability to more creatively and effectively identify and propose solutions to problems, drawing on a range of life experiences, and the lenses different people bring to the field. Given the lack of representation by people of color – such as Black and Latinx youth – in STEM fields, it is important to practice a culture of science that is inclusive and critical of oppressive ideologies. Criticality is important because current science research, and by extension science education, is geared toward militarism, consumerism, and for profit (Harding, 1993; Conner, 2020). The secondary science classroom is a space that is impactful on students, their science experience, and their future STEM aspirations. However, when science education is promoted in a limited capacity, such as a means to only advance economically, it may cater to a homogenous culture of science where specific students are sought after.

Studies have shown that in the earlier years of education, there is no significant opportunity gap in science; but as students transition to secondary science, this gap increases. Research has indicated that students from non-dominant backgrounds, such as Black and Latinx, lose interest in learning science as early as middle school and that this loss of interest has an impact on student attitude toward future participation in science (Barmby et al., 2008). This finding informs us that, as youth progress through the academic years, something changes for them with regard to science. Student interest in science, support they receive in science, and overall opportunities to succeed seem to shift. This conclusion is supported by the fact that students of color also earned fewer credits than their White peers in science classes. According to the High School Longitudinal Study of 2009 (HSLS:09) (2013) Update and High School Transcript Study: A First Look at Fall 2009 Ninth-Graders in 2013, ninth grade Black and Latinx student earned fewer credits in science classes than their White peers, on average (Dalton et al., 2018).

Aksakalli (2018) has spoken to how the marketization of education has led to the transformation of schools into businesses, thus also changing science education. When science education is seen as an instrument to advance economically, rather than as a contribution to the development of a young person, it loses its social quality and becomes merchandise (Aksakalli, 2018). A major issue with current science education is that it emphasizes a focus on what Aikenhead (2006) has called the "pipeline" approach, which refers to the preparation of science professionals, such as engineers, doctors, and scientists. This model perpetuates a fallacy that understanding or engaging with science is only for those who want to go into those fields. Current trends in science education, such as standards and testing, are striving to meet global economic objectives, promoting a generic science education with no local ties and no relevance to the students in the class. Science education should be made local and relevant to all students. A science education from "nowhere" – that is not localized or made relevant to students – can act as a "systemic colonizer" (Aikenhead et al., 2006). Aikenhead and his colleagues argued that school science driven by standards and high stakes examinations is grounded in a specific worldview and way of knowing that continues to be reproduced in traditional schools, thus normalizing this culture, a monoculture. According to Pratt (1994), this occurs through a process of "cultural transmission," a perspective that maintains that the primary purpose of curriculum (in this case, traditional science curriculum) is to "transmit the best products of the intellectual culture" (p. 9). When schools value this culture, students who do not assimilate to it (i.e., perform well on exams and meet all standards), or educators who do not abide by it, are seen as "distractions" or "deviances" (Aikenhead et al., 2006). Unfortunately, for many young people who are viewed as lacking the qualities of successful students, they may be "pushed out" of schools, which is an additional gatekeeper to a STEM career.

Youth Who are Pushed out

A young person is understood to have been "pushed out" of a high school when their education is discontinued before completing a high school diploma. The term "push out" is used to emphasize the school-based and social factors that lead to students leaving school (Youth United for Change, 2011). This population is largely composed of students of color (Child Trends Databank, 2018; McFarland et al., 2018). Students who have "pushed out" of their traditional secondary educational programs are in a position to reintegrate and complete their secondary education; however, this population has historically struggled with completion of secondary education (ACLU, 2017). Lack of opportunities to reintegrate into a high school diploma pathway has contributed to the aforementioned phenomenon. In addition, youth are "pushed out for a variety of reasons of which being underserved in the classroom is just one of them." When a student does not receive an education that is engaging and provides them with support to succeed academically, they can become apathetic and lose the motivation to stay in school. For many students who are "pushed out," issues within the science classroom may perpetuate the push out phenomenon. These challenges are exemplified by lower test scores and lower credits earned in science class by Black and Latinx students compared to their White peers (Dalton et al., 2018; National Research Council, 2011). Youth who have been "pushed out" deserve educational opportunities to re-engage in a high school diploma pathway. In addition, they deserve a science education that provides them the opportunity to make meaningful connections and to pursue STEM pathways if they choose to.

Alternative Education Programs

For youth who have been "pushed out," alternative education programs can be essential to their return to education. There is no commonly accepted definition for alternative education/school, but for the purpose of this study, we will use the

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definition set forth by Warren (2016) of the Public Policy Institute of California. According to Warren (2016):

> In California, “alternative school” refers to a set of schools that provide different educational settings for students who are “at risk” because they have dropped out, are pregnant or parenting, exhibit behavior problems, or need an alternative schedule to accommodate outside work (p. 3).

Warren (2016) defined the seven types of alternative schools in California in the following manner. Continuation schools compose roughly half of the state’s alternative schools and about the same proportion of enrollments in alternative schools. These schools serve students in Grades 10–12, aged 16 and older who are at risk of not graduating from high school. District and independent charter “schools of choice” enroll about 29% of all alternative school students. They are considered alternative schools when at least 70% of those enrolled falls under one of the following categories: Expelled, suspended, or dropped out of school; living with a foster family; or habitually truant. Community schools, opportunity schools, and community day schools enroll roughly 19% of all alternative school students. They have been designed to support students with more significant behavior problems, attendance problems, or who have been referred by the county juvenile justice system. A small number of alternative schools serve incarcerated students. Juvenile court schools enroll roughly 5% of all alternative school students. Alternative education programs are spaces of potential, where young people who have been “pushed out” of traditional high schools can re-engage in education and re-engage in STEM pathways.

Future STEM Aspirations

All students, including those that have previously been “pushed out” of high schools, should have the option of pursuing a postsecondary education in STEM or a career in a STEM field if they so desire; however, not all students feel that they have the option or ability to do so. Further, research has found that exposure to and achievement in STEM courses, such as science, improves critical thinking skills, as well as achievement in other classes (Becker and Park, 2011). The previous studies documented the factors that support future STEM aspirations for students in traditional science classrooms (Mau and Li, 2018; Holmes et al., 2017). However, accounting for youth who have been “pushed out,” there is limited literature that focuses on ways this group of students can be supported. Research has identified a wide array of factors that affect individual differences in STEM motivation, performance, and educational and career aspirations. A literature review by Wang and Degol (2013) examined the current knowledge surrounding individual STEM aspirations. In Wang and Degol’s literature review, STEM refers to the physical, biological, medical, health, and computer sciences as well as engineering and mathematics. They found that psychological and sociocultural factors have an effect on individual motivation to pursue STEM. Below is an overview of each factor.

Psychological Factors

Intellectual ability

It has been found that individual differences in beliefs about intellectual ability have been linked to academic performance. According to Dweck (2007), when individuals believe that ability is an innate trait, they find it difficult to confront challenging tasks, give up easily, and use lack of talent as an excuse for failure. However, students who believe that effort and practice are determinants of success and that intelligence is something that can be developed have higher motivation and perform better academically.

Self-concept

It has been found that individuals were more likely to choose activities in which they had a higher expectancy for success (Eccles et al., 1998). Further, students who had lower self-efficacy in STEM courses were less likely to perform well in these courses. As an extension, students who had higher STEM self-efficacy were more likely to take more STEM courses and were more likely to pursue a STEM career (Dweck, 2008). In addition, students who were interested in STEM were more likely to take more STEM courses and by extension were more likely to aspire to a STEM career (Joyce and Farenga, 2000).

Sociocultural Factors

School

It has been found that the school environment – the classroom, learning experiences, and the educator – can play a role in student future STEM aspirations. With regard to the classroom, students in smaller classrooms tended to show more academic growth over time, enhanced positive interactions between teacher and students, and increased opportunity for individual instruction (Arias and Walker, 2004; Deutsch, 2003). With regard to the learning experiences, it has been shown that tracking – where students are placed in prescribed course lists due to perceived ability – may have a negative effect on students’ achievement due to a reduction in self-concept (Mulkey et al., 2005). That is to say, a student may feel that they are not intellectually adequate for certain courses that may contribute to a ceiling on their perceived ability. It has also been shown that curriculum based in a real-world, relevant, and challenging tasks, opportunities to develop self-generated academic work, group learning, and the use of assessments that promote student growth as opposed to judging ability have a positive effect on student motivation and achievement (Wang and Degol, 2014). With regard to the educator, it has been shown that expectations of students may affect students’ self-expectations and performance (Metheny et al., 2008). Further, those educator expectations, if low, may have a more powerful negative effect on students from lower socioeconomic statuses (Jussim et al., 1996). Educators can also have an effect on student motivation through student-teacher relationships. McKown and Weinstein (2008) found greater growth in achievement for students who felt that their teachers were supportive, listened to them, showed interest in them, and gave them praise.

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Stereotype threat

Stereotype threat is a phenomenon that suggests that individuals may conform to negative stereotypes they may feel categorized by (e.g., gender or race) (Steele and Aronson, 1995). Researchers have asserted that when stereotyped individuals feel stressed during a testing situation, their ability may be undermined (Ben-Zeev et al., 2005). This can have a negative effect on student STEM aspirations after repeated failure in STEM-based courses. STEM fields, by and large, tend to be dominated by White males and as an extension of this are seen as a White male domain. This can impact student aspirations in STEM through stereotyping of who should and should not pursue STEM (Makarova et al., 2019) and has a greater impact on women, where a lack of self-identification in a STEM field can negatively impact their self-concept, interest, and motivation to pursue STEM. Makarova et al. (2019) found that among female students in secondary school, a strong masculine image of math and science decreases the likelihood of choosing a STEM major. Further, it was shown that this association of masculine traits to STEM and stereotypical beliefs of STEM as masculine can present an obstacle for the STEM career aspirations of young women.

Positive STEM Identity

According to a study by Vincent-Ruz and Schunn (2018), three conceptualizations drive a positive STEM identity. First is a match between school science and real science, where students must develop an understanding about how school science relates to real science. When their experiences in school science do not align with real science and they do not feel that they can perform well in science, it can negatively affect their science identity. The second conceptualization is consistent extrinsic and intrinsic motivation, intrinsic motivation stemming from student interest in science, and extrinsic motivation stemming from a student's strong perception of the value of science. The third conceptualization is a sense of community and affiliation when students feel part of the science community and when they are seen as affiliates of science by others.

A study by Martin-Hansen (2018) sought to better understand student STEM aspirations and found that a strong and positive STEM identity is a predictor of future career choice in a STEM field. The researcher reviewed four studies and found factors that influence student STEM identity development within educational settings. Certain factors that may contribute to a positive science identity are the way individuals viewed themselves and could be affected by student performance in STEM courses. For example, if a student experiences success in STEM then there is a greater chance of developing a positive STEM identity as an agency, and vice versa. Therefore, it is important for educators to facilitate STEM classrooms with appropriate scaffolds so that students are not overwhelmed and perceive the class expectations as impossible. Other factors found to affect STEM identity were the educator and the curriculum; for example, creating a classroom in which the relevance of STEM to students is allowed to develop; and creating a learning experience that encourages students to engage in inquiry projects tied to authentic problems and allowing autonomy in designing investigations tied to student interests.

Xinaxtli Charter School and Science Education

Xinaxtli Charter School is an alternative education program where youth who have been "pushed out" of traditional high schools can re-engage in their education. XCS practices an interdisciplinary project-based approach to education. In contrast to traditional science education where content tends to be fragmented and compartmentalized, XCS strives to teach science in a multifaceted and integrated manner, through an authentic learning approach. As a school, each XCS location develops a Community Action Project (CAP) in an effort to bridge academic learning with relevant issues that concern students and the communities they live in. The focus of the CAP is developed by the students, staff, and community members through a social investigation. Within each classroom then, XCS educators are charged with the development of curricula that are: (1) Relevant to students' lived realities in their communities, (2) challenge dominant ideologies that are embedded in the humanities, math, and science disciplines, and (3) make learning an authentic and empowering experience that challenges existing inequities. To support the aforementioned charges, the XCS science curriculum is tied to both science competencies and culture competencies (Appendix A). According to XCS, the science competencies are meant to frame a learning environment for young people who are traditionally underrepresented in STEM fields, including women and students of color, to become scientific thinkers who can use STEM to solve 21st century issues, globally and in their communities. They include the following: Questions and defining problems, models, investigations, interpret and analyze data, construct explanations and design solutions, engagement in arguments from evidence, use of tools, and obtain, evaluate, and communicate information. According to XCS, the culture competencies are meant to bridge the gap between the classroom and the community and are essential to fulfilling the school's vision of social justice. They are meant to incorporate consciousness of social issues as well as skills that are needed to build collaboration. They include the following: Love and care, leadership, success, social consciousness and action, support and healing, and collaboration. Together, the science and culture competencies promote a critical science perspective that runs counter to the worldview promoted by traditional secondary schools.

METHODS

The purpose of this study was to better understand what factors may impact XCS student STEM aspirations. Specifically, this study looked at how each of the following areas – the student perception of teachers, critical science education, the student sense of agency to create knowledge, the student engagement in science class, and the relevance of science to the student – impact student STEM aspirations. This study was part of a larger mixed methods study that was conducted with adult students from XCS which focused on understanding the student experience in science class. The following research question guided this investigation: (1) What factors may contribute to future STEM aspirations of XCS students?

Location of Study

The location of this study was Xinaxtli Charter School (XCS) because of the specific demographic it served. XCS is a Western Association of Schools and Colleges (WASC)-accredited alternative, project-based educational program that provides a high school diploma pathway for its students. During the 2019–2020 academic year, XCS consisted of 18 different school sites throughout Los Angeles, San Bernardino, Riverside, Fresno, and San Diego. At the beginning of the 2019–2020 academic year, XCS had 1135 total students enrolled, however, only 621 of those students were adults (students aged over 18) enrolled in the class-based program. This number of students does fluctuate as students enter and exit XCS. The majority of the students enrolled at XCS were students of color; 64.5% Hispanic or Latino, 21.5% Black or African-American, 1.3% American-Indian/Alaskan Native, 0.6% Asian, 0.5% Middle Eastern, 4.3% White, and 7.3% unspecified. With regard to gender, 59.5% of students identified as male, 40.3% of students identified as female, and 0.2% of students identified as non-binary. Roughly, 94.4% of XCS students were classified as socioeconomically disadvantaged, as measured by qualifying for the national free or reduced lunch program. Students classified as English Learners totaled 20.6% across all sites.

A typical XCS student was between the ages of 16 and 24 years old. However, this study focused on XCS students who were 18 or older. A typical XCS student comes from a low-income family, underserved community, and has previously left or been pushed out of the traditional school system without a diploma. Youth who enrolled at XCS are considered "status dropouts" before enrollment, meaning that they have not been enrolled in school and have not completed a high school diploma. Youth who enroll at XCS are generally over-aged, under-credited, or both.

Data Collection

The sampling strategy used in this study was a convenience sample gathered from the 18 locations across the XCS network. The sample consisted of 100 adult students from XCS. The XCS Adult Student Science Survey was used as a tool to measure the student experience in their science classroom. The survey had been previously piloted during the fall of 2017 by distributing to a sample of 79 volunteers. The reliability of the variables was assessed using Cronbach's alpha, as shown in Table 1. Validity of the survey was assessed in two manners; interviewing a set of volunteers about their interpretation of the items and review of the items by a content expert. The distribution of the XCS Adult Student Science Survey was conducted from September 2019 through November of 2019. A list of all current adult students and their school email was provided to the researcher by the XCS administration. The survey was emailed to each adult student individually through an anonymous link and was prefaced with an informed consent form. A follow-up email was sent out every 2 weeks, for a total of four emails to students.

The survey consisted of a total of 52 questions (Appendix B). Of the 52 questions, 44 were statements that asked students to respond on a 4-point Likert scale as to how they felt on topics pertaining to aspects of their science classes at XCS. For this section, students could respond with *strongly agree, agree, disagree*, or *strongly disagree*. Primarily, the statements revolved around student perception of teacher, critical science education, student engagement, sense of agency to create knowledge, and relevance of science to students. Following the statements were four demographic questions that asked for age of student, gender of student, ethnic background of student, and grade point average of student. Finally, the survey consisted of three open-ended questions that asked the students what XCS location they attend, how many science classes have they passed through XCS, and why they came to XCS.

Data Analysis

To analyze the data, a conceptual model was developed that was evaluated using Structural Equation Modeling (SEM). The model links together the factors that are hypothesized to either directly or indirectly affect student STEM aspirations. That model is presented as a before path diagram in Figure 1. A stepwise algorithm was used to determine path coefficients. The conceptual model has six factors. The key variables defining each factor are shown on each conceptual model. To create each factor, a set of items was selected for that factor and a Principal Components Analysis was performed for those items only. Each factor indicated in the structural equation model yielded an eigenvalue greater than 1. All items in the factor yielded a factor loading >0.3. Further, all items in each factor were tested for internal consistency and yielded a Cronbach's alpha greater than 0.8. The six factors and the items used to create them are listed in Table 1. Finally, IBM SPSS Statistics Version 24 was used to analyze this data.

Key variables and their operational definitions are shown in Table 1. *Sense of agency to create knowledge* is operationally defined as the ability one feels they have to create knowledge and contribute knowledge. *Academic achievement* is operationally defined as the number of science classes passed by the student. *Engagement* is operationally defined as a student being actively involved in the class content and activities as well as the student's interest in the course (i.e., You feel that you are gaining from and contributing to the science class). *Student perception of science teacher* is operationally defined by the support, encouragement, and overall positive relationship that a student experiences with respect to their science teacher. *Science relevance to student* is operationally defined as the student's understanding and relevance of science education with respect to their worldview and experiences. *Critical science education* is operationally defined by the XCS science curriculum philosophy and the impact it has

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Table 1: Factors and items used to create them

Factor	Items (factor loadings)	Cronbach's alpha (α)
Student engagement in science class	When I am in my Xinaxtli science class, I am focused (0.803)	α=0.885
	When I am in my Xinaxtli science class, I am interested (0.849)	
	When I am in my Xinaxtli science class, I want to succeed (0.696)	
	When I am in my Xinaxtli science class, I participate (0.771)	
	When I am in my Xinaxtli science class, I feel motivated (0.696)	
	I share my opinion in science class (0.791)	
	I participate in discussions in my Xinaxtli science class (0.779)	
Student sense of agency to create knowledge in science class	I can contribute to science knowledge (0.834)	α=0.863
	When I learn a science topic, I feel I can add what I know to that topic (0.855)	
	I can create knowledge in my Xinaxtli science class (i.e., contribute to what we are learning in class) (0.821)	
	When I am in science class I feel empowered (e.g., I can contribute and have value) (0.856)	
Student perception of science teacher	My Xinaxtli science teacher encourages me (0.824)	α=0.925
	My Xinaxtli science teacher is patient (0.829)	
	My Xinaxtli science teacher wants me to succeed academically (0.863)	
	My Xinaxtli science teacher has high expectations of me (0.788)	
	My Xinaxtli science teacher respects my contributions to science class (0.805)	
	My Xinaxtli science teacher supports all students (0.826)	
	My Xinaxtli science teacher uses content relevant to my life (0.674)	
	My Xinaxtli science teacher is engaging (0.825)	
Science relevance to student	Science knowledge is relevant to my life (0.633)	α=0.895
	I use science outside of school in my everyday life (0.784)	
	When I learn a new topic in science, I can connect it to my life (0.856)	
	I can use science to solve issues in my life (0.886)	
	I can use science to solve issues in my community (0.863)	
	In my Xinaxtli science class, I learn science that I can use to solve problems important to me (0.866)	
Critical science education	In my Xinaxtli science class, I see things from different perspectives (e.g., how people see things differently) (0.801)	α=0.902
	In my Xinaxtli science class, I conduct science investigations (0.786)	
	My Xinaxtli science class is based in social justice (e.g., it encourages a view of equality) (0.799)	
	In my Xinaxtli science class, we use evidence to support conclusions (0.820)	
	In my Xinaxtli science class, my voice and experience is valued (0.823)	
	When I work on APT, I am creating knowledge (0.802)	
	My Xinaxtli science class encourages me to think of social issues (e.g., inequality and oppression) (0.757)	
Student STEM aspirations	I want to study a science in college (0.947)	α=0.885
	I want to work in a science-based career (0.947)	

APT: Authentic performance task

on student's disposition to academics. *STEM future goals* are operationally defined by a student's self-identified future persistence in STEM education and career.

Ethical Guidelines

Ethical guidelines provided by the Claremont Graduate University Institutional Review Board (IRB) were used throughout the entire research portion. Several steps were taken to protect participants' privacy and inform them of the study. First, participants were provided a voluntary informed consent form that explained the purpose of the research and the expected duration of their participation. Second, they received a description of the procedure that explained their role in the study. Third, all participants were informed that their participation was voluntary and that refusal to participate would not result in any repercussions. Participants were also informed that they did not have to answer all questions and that they could stop at any point during the survey. Fourth, participants were assured that their information would remain anonymous for survey respondents. Anonymity was maintained because survey respondents did not have to give their name. The name of the school has been changed for the purpose of this study.

RESULTS

The sample consisted of 100 survey responses. Based on the 100 completed surveys, the demographics of the sample were as follows: With regard to gender (Table 2), the sample was composed of 54 (54%) respondents who identified as "Male" and 45 (45%) respondents who identified as "Female," and 1 (1%) who identified as "Other."

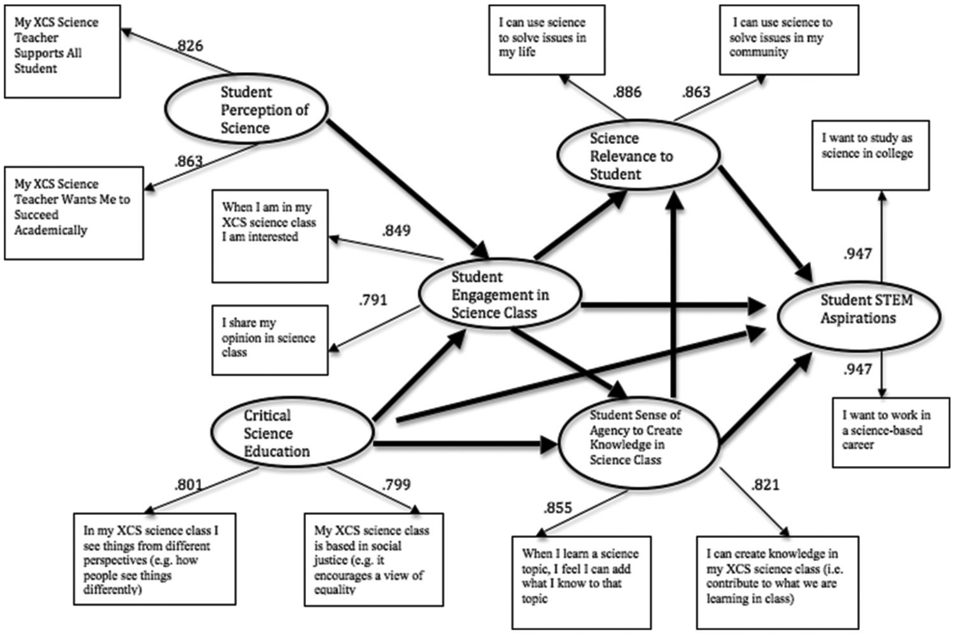

Figure 1: Conceptual model and before path diagram for student STEM aspirations

Table 2: Frequency of gender

Gender	Sample size	Valid %of total
Male	54	54
Female	45	45
Other	1	1
Total	100	100

With regard to age group (Table 3), the sample was composed of 53 (53%) respondents between the ages of 18 and 20; 22 (22%) respondents between the ages of 21 and 23; 19 (19%) respondents age 24 or above; and 6 (6%) respondents provided no response.

With regard to ethnicity (Table 4), respondents were asked to “check all that apply;” further, they were given the option to self-identify or decline to state. The sample was composed of 3 (3%) respondents who identified as “White;” 17 (17.2%) respondents who identified as “Black or African-American;” 2 (2%) respondents who identified as “Asian or Asian-American;” 2 (2%) who identified as “Native Hawaiian or Pacific Islander;” 72 (72.7%) respondents who identified as “Hispanic/Latino;” 2 (2%) respondents who identified as “Other;” and 1 (1%) respondent who declined to state their ethnicity. One (1%) respondent did not respond.

With regard to grade point average (GPA) (Table 5), the sample was composed of 14 (14%) students who self-identified as having a GPA below 2.0; 19 (19%) respondents who self-identified as having a GPA between 2.0 and 2.4; 19 (19%) respondents who self-identified as having a GPA between 2.5 and 2.9; 21 respondents who self-identified as having a GPA between 3.0 and 3.4; and 27 (27%) respondents who self-identified as having a GPA between 3.5 and 4.0.

Table 3: Frequency of age group

Age group	Sample size	Valid % of total
18–20	53	53
21–23	22	22
24 or above	19	19
No response	6	6
Total	100	100

Table 4: Frequency of race/ethnicity

Ethnicity	Sample size	Valid % of total
White	3	3
Black or African-American	17	17.2
Asian or Asian-American	2	2
Native Hawaiian or Pacific Islander	2	2
Hispanic/Latino	72	72.2
Other	2	2
Decline to state	1	1
No response	1	1
Total	100	100

Table 5: Frequency of grade point average

GPA	Sample size	Valid % of total
Below 2.0	14	14
2.0–2.4	19	19
2.5–2.9	19	19
3.0–3.4	21	21
3.5–4.0	27	27
Total	100	100

GPA: Grade point average

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Structural Equation Model for Student STEM Aspirations

The conceptual model presented in Figure 2 used structural equation modeling (SEM) to evaluate factors that were hypothesized to either directly or indirectly affect student STEM aspirations for a sample of XCS students (N = 100). That model is presented as a before path diagram.

As can be seen from the before path diagram (Figure 1), there are four endogenous variables and two exogenous variables. Therefore, to identify the path coefficients, we computed four regressions. Table 6 indicates the dependent and independent variables for each of those four regressions, as well as the Pearson correlation coefficient and other significant statistics for dependent and independent variables. The resulting post-model diagram is presented in Figure 2. This final diagram includes path coefficients for each variable that entered a regression equation as well as the R2. If a variable did not enter an equation, its arrow, reflecting nonsignificant effects, was removed; therefore, those variables were also removed.

Table 6 shows the significant statistics for each regression in the SEM. If no statistics are present for a variable, it means that

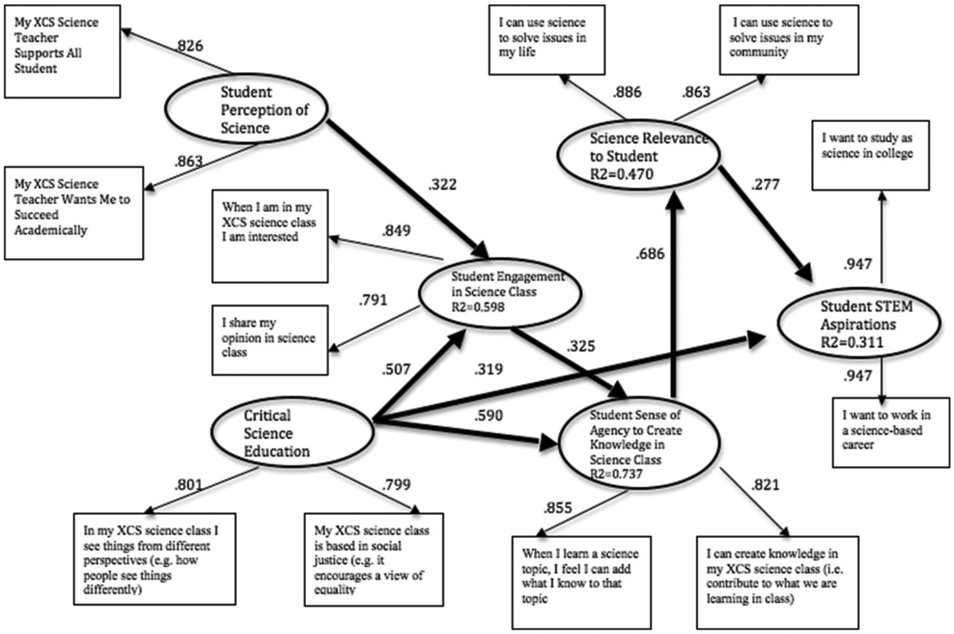

Figure 2: Final path diagram for student STEM aspirations

Table 6: List of regressions and significant statistics for mixed SEM with student STEM aspirations as ultimate endogenous variable

S. No.	Dependent variable	Independent variables	r between DV and IV	Beta	t	Sig t	R	R2	Adj R2	F	Sig F
1	Student STEM aspirations	Science relevance to student	r=+.0517	0.277	2.163	0.033	0.528	0.311	0.297	21.89	<0.001
		Student engagement in science class	r=+0.376	-	-	-	-	-	-	-	-
		Student sense of agency to create knowledge in science class	r=+0.487	-	-	-	-	-	-	-	-
		Critical Science Education	r=+0.527	0.319	2.448	0.015	0.528	0.311	0.297	21.89	<0.001
2	Science relevance to student	Student engagement in science class	r=+0.583	-	-	-	-	-	-	-	-
		Student sense of agency to create knowledge in science class	r=+0.686	0.686	9.322	<0.001	0.686	0.470	0.465	86.89	<0.001
3	Student sense of agency to create knowledge in science class	Student engagement in science class	r=+0.762	0.325	4.197	<0.001	0.859	0.737	0.732	136.20	<0.001
		Critical science education	r=+0.831	0.590	7.620	<0.001	0.859	0.737	0.732	136.20	<0.001
4	Student engagement in science class	Student perception of science teacher	r=+0.689	0.322	3.449	<0.001	0.773	0.598	0.589	72.05	<0.001
		Critical Science Education	r=+0.740	0.507	5.431	<0.001	0.806	0.598	0.589	72.05	<0.001

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variable did not enter the equation. Notice that for regression 1, where "science relevance to student," "student engagement in science class," student sense of agency to create knowledge in science class," and "critical science education" were used to predict "student STEM aspirations," the R^2 was 0.311. This indicates that 31.1% of the variance in "student STEM aspirations" was predicted by the two independent variables that made it into the equation. This R2 indicates a moderately strong fit. Examination of the Betas shows that the best predictor was "critical science education," with a Beta of 0.319. Notice that for regression 2, where "student engagement in science class" and "student sense of agency to create knowledge in science class" were used to predict "science relevance to student," the R^2 was 0.470. This indicates that 47% of the variance in "science relevance to student" was predicted by "student sense of agency to create knowledge in science class," the only independent variable that made it into the equation. This R2 indicates a moderately strong fit. The Beta for "student sense of agency to create knowledge in science class" was 0.686. Notice that for regression 3, where "student engagement in science class" and "critical science education" were used to predict "student sense of agency to create knowledge in science class," the R^2 was 0.737. This indicates that 73.6% of the variance in "student sense of agency to create knowledge in science class" was predicted by the two independent variables that made it into the equation. This R2 indicates a strong fit. Examination of the Betas shows that "critical science education" was the best predictor, with a Beta of 0.590. Notice that for regression 4, where "student engagement in science class" was predicted by "student perception of science teacher" and "critical science education," the R^2 was 0.598. This indicates that 59.8% of the variance in "student engagement in science class" was predicted by the two independent variables that made it to the equation. This R2 indicates a strong fit. Examination of the Betas shows that the best predictor was "critical science education" with a Beta of 0.507.

The decomposition of bivariate covariation based on the post-model diagram is presented in Table 7. The clearest measure of which variables have the greatest impact on student future STEM aspirations, the ultimate endogenous variable, would be the total causal statistic. Note that the two variables that had the greatest impact on student STEM aspirations were "science relevance to student" and "critical science education," with a total causal value of 0.277 and 0.462, respectively. Furthermore, notice that the greatest direct effect (Beta = 0.319) on student STEM aspiration came from "critical science education," and the greatest indirect effect (Beta = 0.190) came from "student sense of agency to create knowledge in science class." The non-causal statistic represents the influence of variables outside of the model. The non-causals from the decomposition of bivariate covariation shows a moderate fit for "critical science education" and some weak fits for "science relevance to students," "student sense of agency to create knowledge in science class," "student engagement in science class," and "student perception of science teacher." Overall, these parameters indicate that the model provides a weak fit.

DISCUSSION

This study found that XCS science classes support students' future STEM aspirations. Through direct and indirect impacts, all factors evaluated in our structural equation model – the student perception of teachers, critical science education, the student sense of agency to create knowledge, the student engagement in science class, and the relevance of science to the student – had some effect on these students future STEM aspirations.

Extant research has shown that a student's STEM aspirations, as an educational endeavor and as a career choice, are directed by a wide array of factors. Some of the factors are belief in intellectual ability, self-concept, and self-efficacy in STEM subjects; school environment, which includes classrooms and educators, and student STEM identity (Arias and Walker, 2004; Dweck, 2007, 2008; Eccles et al., 1998; Wang and Degol, 2014).

The greatest direct effect on these students' future STEM aspirations came from critical science education, followed by science relevance to students. Based on the principal component analysis, elements of critical science education were seeing things from different perspectives; conducting science investigations; being based in social justice; using evidence to support conclusions; valuing student voice and experience; working on authentic performance tasks that encourage student knowledge creation; and encouraging students to think of social issues (e.g., inequality and oppression). In line with Wang and Degol (2013), the XCS science curriculum was grounded in a project-based approach in which students were encouraged to engage in real-world applications of science based on issues of social justice. Through this project-based approach, students were given the opportunity to develop self-generated academic work, work collaboratively with peers on science topics, and be assessed in a manner that promotes student growth as opposed to judging

Table 7: Decomposition of bivariate covariation predicting student STEM aspirations

Factor	Student sense of agency to create knowledge in science class	Science relevance to student	Student engagement in science class	Student perception of science teacher	Critical science education
Original covariation	0.487	0.517	0.376	0.338	0.527
Direct	0.000	0.277	0.000	0.000	0.319
Indirect	0.190	0.000	0.061	0.019	0.143
Total causal	0.190	0.277	0.061	0.019	0.462
Non-causal	0.297	0.240	0.315	0.319	0.065

student ability. Based on our principal component analysis, students identified science as relevant because they learned topics in science class that they could connect to their everyday lives; they could use science to solve issues in their lives; they could use science to solve issues in their community; and they learned science topics in their XCS science class that they could use to solve problems important to them. In line with Martin-Hansen (2018), students who felt that science was relevant to them were more likely to show future STEM aspirations.

The greatest indirect effect on future STEM aspirations came from these students' sense of agency to create knowledge. Based on principal components analysis, students identified a sense of agency to create knowledge in science class when they could contribute to science knowledge; when they learned a science topic and felt that they could add what they know to that topic; and because they felt empowered in science class (e.g., they could contribute knowledge and have value). This finding aligns with a study by Dweck (2008) who found that students who have a higher self-efficacy in STEM are more likely to pursue STEM. Students who felt that they could engage with, contribute to, and create science knowledge may feel more comfortable in science class and experience more success in science class.

Student perceptions of their science teacher also had a weak indirect effect on future STEM aspirations. Based on principal components analysis, students identified positive perceptions of their science educator at XCS. Science educators were identified as encouraging, patient, wanting students to succeed academically, having high expectations of students, respecting student contributions in science class, supporting all students, using content relevant to student's lives, and engaging. Since the teacher is the one responsible for developing, presenting, and engaging students in STEM content, it makes sense that they will have an effect on student STEM perceptions. Students who expressed a positive perception of their science teachers were more likely to express interest in STEM as a future endeavor. In line with Metheny et al. (2008), it has been shown that teacher expectations can affect student self-concept and performance in STEM.

Finally, Martin-Hansen (2018) and Vincent-Ruz and Schunn (2018) posited that positive STEM identity is a predictor of student STEM aspiration. A positive student STEM identity can be inferred based on student feelings of science relevance and student sense of agency to create knowledge in science class.

Implications for Practice

This study provides a framework for STEM classrooms to re-engage youth who have previously been "pushed out" of their traditional secondary schools. This framework can also inform STEM programs at traditional secondary schools. It consists of the following:

1. Culturally Relevant Science that values the student lived experience and using it as a source of generative themes that can ground the science content. When a student views science as a subject that aligns with their lived experience and that provides them strategies, skills, and knowledge that are relevant to them, then, it may be that they are motivated to perform well academically in those classes
2. Student Sense of Agency to Create Knowledge – If a student feels that they have the ability to engage in knowledge creation within a science classroom, then, they may feel that science is a discipline that aligns with their experiences. That is, they understand science, are able to integrate their personal experience with science content, and feel the self-efficacy to contribute to science
3. Critical Science Education – knowledge is not static, but rather is constantly changing and being created, students and educators critically analyze the science content in the reality of the community they live in. The curriculum is student centered and provides students opportunities to engage in knowledge creation through authentic performance tasks. The science curriculum encourages students to use science knowledge and skills to contribute to navigate, critically question, and examine issues related to their social factors.

CONCLUSION

The purpose of this research was to better understand how each of the following areas – student perception of teachers, critical science education, student sense of agency to create knowledge, student engagement in science class, and relevance of science to the student – might affect XCS student future STEM aspirations. This study found that each of the aforementioned factors had either a direct or indirect impact on XCS student STEM future aspirations.

This study was motivated by a few worrisome observations. First, the lack of diversity permeates the current STEM field. The current STEM field is majority White and male (National Science Foundation and National Center for Engineering and Statistics, 2019). Second, the loss of potential through students being "pushed out" of their high schools and the fact that the students experiencing "push out" are majority students of color (Child Trends Databank, 2018; McFarland et al., 2018). Compared to high school graduates, they are less likely to find a job and earn a living wage, and more likely to be in poverty and suffer from a variety of adverse health outcomes (Rumberger, 2011). And third, the traditional approach to science education is one that is not inclusive, equitable, or critical. Traditional science curriculum consists of units, lessons, and assessments often unrelated to experiences of students' everyday life. Traditional science education is reflective of a view of scientific practice that is often too far removed from the students' experiences and the issues or questions they may face in their communities (Brickhouse et al., 2000).

Providing opportunities to re-engage in science education for Black and Latinx youth who have been "pushed out" of their traditional schools are one area that can support the diversity issue in STEM. Alternative education programs have the potential to support youth who have dropped out. XCS is such a program that provides such an opportunity.

However, traditional approaches to science education must be transformed. Through its small classroom setting, project-based approach, and focus on social justice, XCS works to provide an equitable and critical learning opportunity to all students who attend. The XCS science classroom is a space that can re-engage and support youth. In closing, it is important to understand that youth who have been "pushed out" of high schools have potential and value. They are youth of promise who, provided with an opportunity, can re-engage, succeed, and contribute to STEM fields.

ETHICAL STATEMENT

The Claremont Graduate University Institutional Review Board deemed this study exempt from review. The Protocol ID number is 3520.

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APPENDIX

Appendix A: STEM and culture competencies implemented by XCS science educators

STEM competencies	
Questions and defining problems	Learners formulae their own questions or hypotheses (if/then statements) to evaluate empirically testable questions.
Models	Learners construct and revise models to explain phenomena and discuss the limitations and precisions of the model.
Investigations	Learners develop original procedures and protocols to plan and conduct a full investigation to produce data that serve as the basis for evidence.
Interpret and analyze data	Learners independently represent and analyze data to identify patterns, trends, or relationships. They interpret data in light of models and theories.
Construct explanations and design solutions	Learners construct their own explanations for STEM phenomena and develop a design prototype for an evidence-based solution.
Obtain, evaluate, and communicate information	Learners can independently analyze evidence (often in the form of data) and formulate their own conclusions/explanations.
Engage in arguments from evidence	Learners adequately describe content and layout to be used to communicate and justify their conclusions and explanations.
Tools	Learners are sufficiently familiar with tools appropriate for their course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations.
Culture competencies	
Love and care	● Listens with empathy ● Honors and respects the voices of others (staff-student, student-student, staff-community, and student-community) ● Honest and open communication ● Self-love and embracing of various identities ● Unconditional love and support for others ● Respect and genuine relationship building with others
Leadership	● Demonstrates commitment to the space's mission, vision, policies, established agreements, core values, and follows through on expectations ● Sets goals, follows through on action plans, and self-reflects for improvement ● Can envision and apply their leadership abilities in future post-secondary education, career pathways, and their own life ● Can define and demonstrate ethics and integrity ● Demonstrates effective communication, discovers their communication style, and applies in various settings ● Acts as key players in culture building and decision-making in the space
Success	● Develops and implements a plan for emotional, physical, spiritual/secular, intellectual, career, and financial growth and transformation ● Demonstrates intellectual curiosity and humility ● Self-knowledge of identity, positionality, talents, and skills ● Sense of purpose: Apply self-knowledge towards a goal that has a wider impact beyond oneself ● Reframes "success" to counter dominant notions of success
Collaboration	● Works to achieve the program vision, mission, goals, objectives, and outcomes ● Engages in discussion and dialogue for collaboration ● Honors team agreements ● Creates and participates in collective goals, objectives, process, and outcomes with people from diverse backgrounds ● Honors collectively identified benchmarks, scheduled activities, and deadlines ● Inclusive and acknowledging of all stakeholders (community, staff, students, alumni, family, etc.) ● Utilizes resources (technological, material, and human) to maximize collaboration efforts ● Reflects on participation in collaborative projects
Social consciousness and action	● Embraces funds of knowledge: Informs the school community of their lived/community realities ● Participates in collaborative social investigation (needs assessment; asset mapping; power analysis; identifies and understands injustice, oppression, and inequity) ● Able to name key players, power dynamics, privilege, and how it plays out in a setting ● Shows solidarity for self and others through empathy, actions that respect needed support, raising awareness, and advocacy (e.g., lobbying, petitioning, filing a legal challenge, protesting, campaigning, and story-based messaging)

(contd...)

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Appendix A: (Continued)

	STEM competencies
Support and healing	● Promotes self and community autonomy (resource development, budget development, and program development) ● Participates in community action projects to address urgent community concerns ● Understands, upholds, and promotes restorative justice practices of building community and going through a process to restore relationships when people are harmed/experience conflict, violations, offensive behavior, and injustices, they ● Contributes to and upholds collectively created respect agreements and discipline process ● Feels like a valued and appreciated member of the community where they are recognized for their assets, not their challenges ● Feels safe to express their ideas and trusts that they will be supported if they share constructive feedback and/or break community agreements ● Is committed to a transformative justice approach where there is critical reflection and efforts to combat systemic roots of harm and promotes decisions that are grounded in the best interest of the collective ● Upholds the collectively created system that proactively addresses retention and attendance ● Upholds and is committed to cultivating critical hope, critical agents of transformation, and self-determination as referenced in the PCCP framework

Appendix B: Representative question items from XCS adult student science survey

List of Question Items	Strongly Agree (1)	Agree (2)	Disagree (3)	Strongly disagree (4)
My XCS science teacher supports all students (20)	o	o	o	o
My XCS science teacher uses content relevant to my life (21)	o	o	o	o
My XCS science teacher is engaging (22)	o	o	o	o
Science knowledge is relevant to my life (23)	o	o	o	o
When I am in science class, I feel empowered (e.g., I can contribute and have value) (46)	o	o	o	o
My XCS science class encourages me to think about social issues (e.g., inequality and oppression) (48)	o	o	o	o
I can create knowledge in my XCS science class (i.e., contribute to what we are learning in class) (52)	o	o	o	o