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Inclusive STEM High School Factors Influencing Ethnic Minority Students' STEM Preparation

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Abstract: The purpose of this study was to better understand school factors influencing ethnic minority students' science, technology, engineering, and mathematics (STEM) preparation in Inclusive STEM High Schools (ISHSs). The researchers conducted a phenomenological study that used semi-structured interviews with participants (N=13) who graduated from ISHSs in Texas. Participants' STEM high school experiences were classified into nine categories: a) innovative STEM and non-STEM instruction, b) rigorous STEM curriculum, c) integration of technology and engineering in classrooms, d) quality of teachers, e) real-world STEM partnership, f) informal STEM opportunities, g) academic and social support for struggling students, h) emphasis on STEM courses, majors, and careers, and i) preparation for a college workload. These characteristics can be helpful for schools to establish a STEM-focused school environment and have the potential to cultivate positive experiences for ethnic minority students to increase their interest and capabilities in STEM fields.
Keywords: ethnic minority students, inclusive STEM high schools, STEM schools, T-STEM academies, underrepresented students.

Inclusive STEM High Schools (ISHSs)

Since their inception, science, technology, engineering, and mathematics (STEM) schools have aimed to provide advanced STEM coursework to students who are talented and gifted in STEM disciplines (National Research Council [NRC], 2011)). However, a new model of STEM schools known as Inclusive STEM high schools (ISHSs) has emerged. Unlike the original STEM schools, ISHSs accept students regardless of their previous academic achievement in STEM (NRC, 2011). Schools classified as ISHSs share two primary goals: a) developing all students' mathematics and science achievement, and b) reducing the mathematics and science achievement gap between students who come from traditionally unrepresented subpopulations and students who come from traditionally upper-class demographic groups.

Among the STEM education needs addressed by ISHSs, providing access to STEM curriculum and developing mathematics and science competencies of students from traditionally

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underrepresented subpopulations (e.g., ethnic minority students, female, and low SES) is considered one of the most effective approaches for mitigating the existing mathematics and science achievement gap between students who come from underrepresented subpopulations and those who come from traditionally upper-class families. Several characteristics of ISHSs have been already linked with higher achievement of Hispanic and African American students in science and mathematics (Bicer et al., 2014; Bicer, Capraro, & Capraro, 2018; Bicer, Navruz, et al., 2015; Lynch et al., 2017; Means et al., 2017; Means et al., 2018; Navruz et al., 2014; Saw, 2018). These characteristics include, but are not limited to, integrating engineering and technology into science and mathematics classrooms (Bicer, Navruz, et al., 2015; Gnagey & Lavertu, 2016; LaForce et al., 2016; Lesseig et al., 2019), implementing innovative instructional practices such as project-based learning (PBL) (Bicer, Boedeker, et al., 2015; Gnagey & Lavertu, 2016; LaForce et al., 2016; Lesseig et al., 2019; McCorkle, 2020), offering advanced level STEM courses, and arranging informal STEM activities (LaForce et al., 2016; Peters-Burton et al., 2014). When these characteristics are combined in a single educational environment (e.g., ISHSs), it can create opportunity structures for students who may otherwise never have the chance to be exposed to such stimulating STEM environments.

An opportunity structure is defined as the available resources in society, or in this instance, a school, that an individual can use to achieve his/her education or life goals (Roberts, 2009). Lynch et al. (2017) reported that some factors of ISHSs serve as opportunity structures for students who come from diverse student populations. African American and Hispanic students may find chances to increase their science and mathematics competencies, thereby increasing the likelihood that a larger portion of traditionally underrepresented students will become highly qualified and competitive candidates for the STEM workforce. This claim is supported by the socio-cognitive-career theory (SCCT), in which researchers postulate that individuals form their interest in certain subject only if they are previously exposed to stimulating environments associated with that subject area (Lent et al., 1994). This theory has been used in the present study to explain why and how individuals develop STEM academic and career interests, pursue STEM related majors according with their developed STEM interests, and persevere in their educational goals related to STEM (Soldner et al., 2012). According to the SCCT (Lent et al., 1994), students' STEM career development is influenced by environmental factors, thereby the characteristics of ISHSs (e.g., problem-based learning, technology integration, and rigorous science learning) (Gnagey & Lavertu, 2016; LaForce et al., 2016; Lesseig et al., 2019) have the potential to influence underrepresented students' STEM preparation. In other words, students form and develop interests in STEM related subjects and majors if they are exposed to a STEM stimulating environment, such as that of ISHSs (e.g., rigorous STEM curriculum, technology integration, quality of STEM teachers), that foster their early STEM interest. The present study investigated what ISHSs experiences of ethnic minority students play a vital role in leading them to college admittance and success in the light of SSCT framework. Figure 1 contains the SCCT conceptual framework illustrating how characteristics of ISHSs can create opportunity structures for students to become potential candidates for STEM careers. ISHSs provide students access to more STEM opportunities and develop mathematics and science competencies in students from traditionally underrepresented populations with the intent of aiding these students in becoming full participants in their communities' economic growth and prosperity (Bicer & Capraro, 2019; Young et al., 2011).

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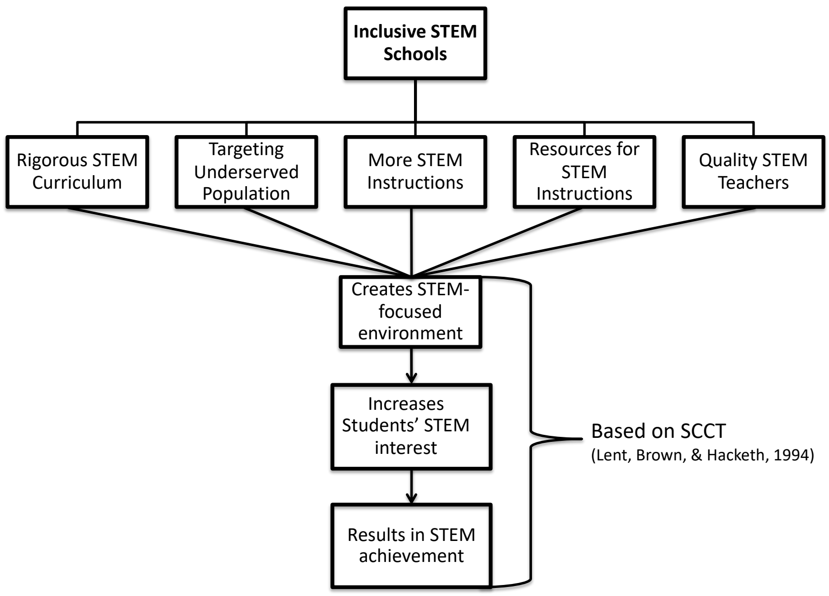

Figure 1. Characteristics of ISHSs

Individual and Societal Characteristics Influencing STEM Major Selection

Both individual and social characteristics have been shown to influence a person's decision to pursue a STEM-related career path. For example, individual characteristics include gender, ethnicity, socioeconomic status (SES), whereas influential societal characteristics related to education may include school quality and funding and access to public libraries (Eisenhart et al., 2015). Researchers have primarily focused on students' individual characteristics to show how these characteristics are associated with students' selection of college major. For example, Arcidiacono (2004) conducted a study to understand whether students' early academic achievement and interest in STEM majors were correlated and found that the two variables were positively correlated. The results from Arcidiacono (2004) revealed that students who demonstrated early academic achievement were more likely to enroll in STEM majors than students who did not. Similarly, students' demographics (gender, SES, and ethnicity) were found to be critical predictors influencing students' major selection. Students who are male, high SES, and White were more likely to enroll STEM majors than students who were female, low SES, and from ethnic minority groups (e.g., African American and Hispanic) (Astin, 1993; Porter & Umbach, 2006). Although researchers have emphasized the importance of the relationship between individual and school characteristics with students' major selection, they have generally not addressed school characteristics (e.g., offering advance STEM courses, arranging informal STEM activities) from ethnic minority students' perspectives. However, these characteristics are closely linked to students' experiences in mathematics and science during high school years (Eisenhart et al., 2015; Ma & McIntyre, 2005). This disregard of potentially influential school characteristics has impeded the development of optimal STEM environments in schools, and this might have adversely affected ethnic minority students' chances of pursuing STEM majors in college (Pyryt, 2000; Subotnik et al., 1993; Tai et al., 2006).

The school characteristics that were found to be highly associated with students' decisions regarding post-secondary STEM matriculation were the following: a) quality mathematics teachers (Bloom, 1985; Ma & McIntyre, 2005; Pyryt, 2000; Subotnik et al., 1993; Subotnik et al., 2010; Tai et al., 2006); b) effective course counseling, including information about informal STEM activities such as STEM summer camps, science fairs, and STEM competitions (Bowen et al., 2009); c) provision of STEM programs such as mathematics clubs and STEM nights (Legewie & DiPrete, 2014); and d) inclusion of rigorous mathematics and science curriculum (Sahin et al., 2012). When these school characteristics are lacking, ethnic minority students' chances of pursuing STEM majors in college diminish (Bicer & Capraro, 2019). Other characteristics such as offering advanced placement (AP) courses and International Baccalaureate (IB) STEM courses were also more closely linked to post-secondary STEM matriculation than were gender, SES, and ethnicity. (Tyson et al., 2007). While school characteristics are helpful predictors, they may be linked to adequacy of school funding. When comparing well-funded schools to their moderately- and poorly-funded counterparts, there is an imbalance in educational opportunities and experiences offered. Students from well-funded high schools experienced higher levels of engagement and academic achievement, had more course options, and were held to more rigorous expectations than their counterparts in schools with lower levels of funding (Anyon, 1981). Expanding the availability of STEM programs to a broader range of students is possible by providing increased STEM opportunities to public and charter schools with high populations of underrepresented students, regardless of students' academic backgrounds (Bicer et al., 2018). However, continuing to ignore and postponing the integration of important school characteristics into schools (e.g., offering advanced STEM courses and providing informal STEM activities) will impede students' chances of improving their academic achievement or attainment in any meaningful way, which may negatively influence any STEM interest they hold. Nonetheless, schools that create environments that include several of these beneficial school characteristics may help to change the current demographics in post-secondary STEM matriculation (NRC, 2011).

Achievement of U.S. STEM Education Goals & ISHSs

Increasing the number of underrepresented students who follow STEM career pathways is essential for achievement of U.S. STEM education goals (NRC, 2011). This is especially important due to the rapid increase in the U.S.'s underrepresented subpopulation demographics (e.g., African American and Hispanic), but their representation in STEM fields is still low (Bicer et al., 2018; Bicer & Capraro, 2019; Bicer, Navruz, et al., 2015; Means et al., 2017; Means et al., 2018, NRC, 2011). Establishing inclusive ISHSs was one of the most promising interventions implemented to achieve the U.S. STEM education goal, which is to increase underrepresented students' representation in the STEM fields (NRC, 2011). What makes ISHSs unique among other school-level interventions is that ISHSs "have open enrollment and are focused on underrepresented youth for the successful pursuit of advanced STEM studies" (Peters-Burton et al., 2014, p. 64). Other critical objectives and components of ISHSs are offering innovative instructional designs (e.g., inquiry-based learning and project-based learning [PBL]), providing students opportunities to participate in informal learning (e.g., science fairs and science Olympiads), networking with universities and local companies, providing early college coursework, and hiring quality teachers (Gairola, 2019; Gnagey & Lavertu, 2016;Laforce et al., 2016; Lesseig et al., 2019; Tarman, 2018). All of these critical components of ISHSs together create STEM opportunities for students to develop their science and mathematics competencies and interest in pursuing STEM careers in college (Gnagey & Lavertu, 2016; Laforce et al., 2016; Lesseig et al., 2019; Peters-Burton et al., 2014). The school factors of ISHSs provide increased exposure to exciting, engaging, and

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challenging STEM content which has been shown to influence students' interest in STEM.

The purpose of this study was to ask graduates of Texas-STEM (T-STEM) academies who were majoring in a STEM field in college to retrospectively report on their experiences during high school that led them to select a STEM college majors. Although the characteristics of ISHSs have been reported, there are no published studies in which graduates of ISHSs from ethnic minority populations have reflected back on their STEM experiences and preparations for college to date. This is relevant because a number of quantitative studies have already been conducted, and their findings have indicated that there are positive effects of attending ISHSs on underrepresented students' science and mathematics achievement (Bicer & Capraro, 2019; Means et al., 2016; Means et al., 2017; Means et al., 2018 Saw, 2018). However, there have been no qualitative studies conducted to determine which characteristics of ISHSs are retrospectively perceived by underrepresented students as important to their STEM college preparation. To understand which of the ISHSs' factors play a critical role in leading underrepresented students to college admittance and success through instilling positive experiences, a phenomenological study was conducted. The participants were members of ethnic minority groups who had graduated from T-STEM academies and had completed between 1-3 years of their undergraduate education when the current study was conducted.

Research Question

Which ISHS factors did post-secondary students from ethnic minority populations retrospectively associate with their preparation for a STEM major?

Method

Participants

Participants were college students in a STEM major who met four criteria: 1) had graduated from an ISHS in Texas, 2) had completed at least one year in their undergraduate program, 3) had not completed more than three years toward their STEM degree, and 4) were members of an underrepresented minority group in a STEM-related major. Two engineering undergraduate students who also graduated from one of the ISHSs were known by a researcher and were asked to deliver notice of this study to their friends who might be interested in being part of the study. The engineering students were asked not to identify potential participants to researcher, but interested participants who graduated from ISHSs and were currently being students in college were requested to contact the researcher through phone or e-mail. A total of 14 students contacted the researcher, nine of them by email and five of them by telephone. As a result, 13 of these students met the selection criteria and participated in the study. These students graduated from 5 different ISHSs located in central and southern Texas.

The selection criteria enabled rich investigation of rich the essence of lived experiences of the target population (Rossman & Rallis, 1998) enrolled in ISHSs rather than a broader investigation of the whole school population enrolled in ISHSs (see Table 1 for participants' demographics). Students who met the criteria and volunteered to participate in this study were asked to sign a consent form that included information about the phases of the present study in their entirety. Participants were then assigned pseudonyms (Student 1, Student 2, Student 3, etc.) and asked to schedule a 45-minute face-to-face interview. The participants' ages ranged from 18 to 21 years old and they were enrolled in various bachelor degree programs at one of the following universities: Baylor University, Texas A&M University, the University of Texas, the University of Houston, the University of California, Berkeley, Princeton University, Rice University, and University of New York.

Table 1
Characteristics of Students Included in the Study

Name	Ethnicity	Socioeconomic Status	Gender	Age	Grade	Major	High School Code	First Language	Passed All College Courses
Student 1	African American	Low	Male	19	Junior	Petroleum Engineering	1	Swahili	Yes
Student 2	Hispanic	Low	Male	20	Junior	Electronic Engineering	1	Spanish	Yes
Student 3	Hispanic	Low	Male	19	Sophomore	Economics	2	Spanish	Yes
Student 4	Hispanic	Middle	Male	19	Sophomore	Genetics	2	English	Yes
Student 5	Hispanic	Low	Female	21	Junior	Biology	2	Spanish	Yes
Student 6	Hispanic	Low	Female	19	Sophomore	Animal Science	3	English	Yes
Student 7	African American	Low	Female	19	Sophomore	Mathematics	3	English	Yes
Student 8	Hispanic	Low	Male	19	Junior	Computer Science	4	Spanish	Yes
Student 9	African American	Low	Male	19	Junior	Mathematics	4	English	Yes
Student 10	African American	Middle	Female	20	Sophomore	Computer Science	4	English	Yes
Student 11	Hispanic	Low	Female	21	Junior	Civil Engineering	5	Spanish	Yes
Student 12	Hispanic	Low	Male	20	Sophomore	Mechanical Engineering	5	Spanish	Yes
Student 13	African American	Low	Female	19	Junior	Molecular Biology	5	English	Yes

1. Student 1 was a 19-year-old male African American college junior majoring in petroleum engineering. His parents were from Tanzania, and his first language was Swahili. He was successful in science and mathematics courses when he was in middle school. His parents decided that he would attend an ISHS after they heard praise of the ISHS system from their relatives.
2. Student 2 was a 20-year-old Hispanic male college junior majoring in electronic system engineering technology. His parents were from Mexico, and his first language was Spanish. In middle school, mathematics and science were his favorite subjects. His parents asked him if he wanted to enroll ISHSs, and he said yes.
3. Student 3 was a 19-year-old Hispanic male college sophomore majoring in economics. His parents were from Mexico, and his first language was Spanish. He was fairly proficient in mathematics and science courses in middle school. His mother received a brochure in the mail from an ISHS and was interested in sending her son to this school because the school had smaller class sizes.
4. Student 4 was a 19-year-old Hispanic male college sophomore majoring in genetics. His first language was English. His mathematics and science successes were at a satisfactory level while he was in middle school. His parents challenged him to accomplish more than what they had in their lives, and with their wish in mind, they chose to enroll him in an ISHS.
5. Student 5 was a 21-year-old Hispanic female college junior majoring in biology. Her parents were from Mexico, and her first language was Spanish. In middle school, she was

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at an acceptable level in her mathematics courses, but was not proficient in science. However, she had a strong interest biology and excelled in classes related to the discipline. One of her relatives recommended ISHSs to her mother, and she encouraged her daughter to enroll in one of the ISHSs.

6. Student 6 was a 19-year-old Hispanic female college sophomore majoring in animal science. Her parents were from the U.S., and her first language was English. She was at a moderate level in her mathematics and science classes when she was in middle school. She provided the following explanation as her reason for enrolling in an ISHS:

> *The neighborhood that my parents live in is not really good, nor are the local public schools. My parents did not want me to go the local public schools, so they enrolled me in an ISHS once they found out that it had a good school system and was science- and mathematics-focused.*

7. Student 7 was a 19-year-old African American female college sophomore majoring in mathematics. Her parents were from the U.S., and her first language was English. She was moderately good in her mathematics classes during middle school and demonstrated greater academic achievement in her mathematics courses than she did in her science and other courses. She made the decision to enroll in one of the ISHSs on her own.

8. Student 8 was an 18-year-old Hispanic male college junior majoring in computer science. His parents were from Mexico, and his first language was Spanish. He was the first in his family to go to college. He was proficient in his mathematics and science while he was in middle school. His mother received a brochure in the mail from an ISHSs, and after reading about the school, she decided to research ISHSs to gather additional information about the schools. After further investigation, she decided to enroll her son in one of the ISHSs because it was the most prestigious school in their district.

9. Student 9 was a 19-year-old male African American college junior majoring in mathematics. His parents were from U.S., and his first language was English. He was not proficient in science when he was in middle school. His parents decided that he would attend an ISHS school after they heard praise of the ISHS system from their relatives. He made the final decision to enroll in one of the ISHSs on his own.

10. Student 10 was a 20-year-old Hispanic female college sophomore majoring in computer science. Her parents were from Mexico, and her first language was Spanish. She was the first in her family to go to college. She was proficient in his mathematics and science while she was in middle school. She made the decision to enroll in one of the ISHSs on her own.

11. Student 11 was a 21-year-old Hispanic female college junior majoring in civil engineering. Her parents were from Mexico, and her first language was Spanish. In middle school, she was at an acceptable level in her science courses, but was not proficient in mathematics. Her parents encouraged her to enroll in one of the ISHSs.

12. Student 12 was a 20-year-old Hispanic male college sophomore majoring in mechanical engineering. His parents were from Mexico, and his first language was Spanish. In middle school, mathematics and science were his favorite subjects. He made the decision to enroll in one of the ISHSs on his own.

13. Student 13 was a 19-year-old Hispanic female college junior majoring in molecular biology. Her first language was English. Her mathematics and science successes were at satisfactory level while she was in middle school. Her parents decided to enroll their daughter in one of the ISHSs because it was the most prestigious school in their school district.

Analysis

A phenomenological study is applicable when "focused on descriptions of what people experience and how it is that they experience" (Patton, 1990, p. 71). A phenomenological study was the preferable method of analysis because the phenomenon under investigation was to address the meanings and perspectives of participants' experiences based on their ISHSs' memories (Creswell, 2012). To determine what institutional (school) factors ISHS students retrospectively identified as beneficial experiences toward their STEM preparation, the research team interviewed participants, collected transcripts, reviewed their schools' websites, and wrote observation notes.

The major data source for phenomenological study is interviewing and the purpose of interviewing is to understand the perception of lived experiences (Patton, 1990). The interviews were semi-structured and included questions designed to initiate the conversation (e.g., How would you describe the experience of taking STEM PBL focused courses?). In this paper, STEM PBL defined as "a well-defined outcome with an ill-defined task" (Capraro & Slough, 2013, p. 2). The interview questions were constructed by considering ISHSs factors reported previously by Peters-Burton et al. (2014). The transcribed conversations were analyzed in three steps. First, the recordings were transcribed and transcriptions were reviewed for accuracy. Next, the transcriptions were read several times, and the research team performed open, axial, and selective coding (Glaser & Strauss, 1967). The final step was selective coding, through which the researchers aimed to determine the essential, central, or core categories. The aim of the selective coding was to validate the narrative.

In order to ensure that the findings can be trusted, the criteria of trustworthiness as credibility, transferability, dependability, and conformability was addressed (Lincoln & Guba, 1985). To address *interrater reliability*, two researchers were assigned to review 30% of the whole transcripts and one researcher's coding agreed with the other one 75% of the time before reconciliation and 92% after reconciliation. Although the interview was originally scheduled for 45-minutes, most of the interviews took longer while researchers were trying to understand the comprehensive picture of participants' ISHSs experiences. Through long-lasting engagement in the field with participants, the researchers became familiar with the setting and context of ISHSs to provide thick, richer and more realistic results of participants' ISHSs experiences. Providing not only individuals' experiences of ISHSs, but the detailed descriptions of the setting and context of ISHSs allows an outsider to understand the meaning of individuals' ISHS experiences.

Triangulation was applied as the themes were established to emerge by converging multiple data sources of information (e.g., interviews, schools' websites reviews, and observation notes during the interview) (Creswell, 2012). We also applied *member checking* to determine the accuracy of our qualitative findings by sharing our major findings with the participants from whom the data were originally obtained (Brownell & Rashid, 2020; Creswell, 2012; Lincoln & Guba, 1985; Sim & Sharp, 1998). Member check is particularly important because researchers and participants look at the data with different perspectives and applying this enabled us to determine the participants feel that their ISHSs experiences were accurately represented.

Researchers in qualitative studies are crucial in data collection and analysis; thus having "theoretical sensitivity" is one of the important dimensions of being qualitative researchers. Theoretical sensitivity includes but not limited to having deep insight and being able to extract meaning from the data (Strauss & Corbin, 1990). The more researchers are familiar with the topics through personal experiences, the more they develop their theoretical sensitivity towards the topics

(Strauss & Corbin, 1990). Researchers in the present study have substantial previous quantitative research experience on STEM schools, particularly ISHSs. One important dimension of theoretical sensitivity is being aware of your own stance toward point to the topic. Before we started collecting data, due to our previous research regarding ISHSs, academic, and personal experiences, we thought that institutional factors may play an important role in students' STEM preparation because students who attend STEM-focused high schools may have positive and constructive STEM experiences, and this in turn lead them to pursue STEM related majors in college. This hypothesis can be supported by the SCCT that individuals choose a certain major only if they were exposed to such stimulating environments (Lent et al., 1994). Reflecting on our own conceptual/theoretical framework (e.g., SCCT) along with the assumptions and values we hold towards the characteristics of ISHSs is important for qualitative research to express how our interpretation of individual experiences of ISHSs is shaped by our background (Creswell, 2012).

Findings

The ISHS experiences that participants considered influential in their STEM preparation and that corresponded to identifiable school factors were classified into nine categories (see Figure 2): a) innovative instruction in both STEM and non-STEM classes, b) rigorous STEM curriculum, c) integrated technology and engineering in STEM and non-STEM classrooms, d) teacher quality, e) real-world STEM partnership, f) informal STEM learning, g) academic and social support for students who need help, h) emphasis on STEM courses, majors, and careers, and i) preparation for a college workload.

Innovative Instruction

Innovative instruction emphasizes active teaching and learning by engaging students in academic content in STEM and non-STEM subjects. Students mentioned that their teachers incorporated newer instructional techniques (i.e., different than traditional instruction) in their classrooms including project-based learning (PBL), problem-based learning, inquiry-based learning, science project competition, group work, hands-on learning, and real-life applications.

PBL. In this study, the most common instructional model students mentioned that their teachers incorporated in the classroom was PBL. Several students stated that their teachers required them to complete a project after discussing each chapter of their textbook. The ISHSs that Students 6, 7, 8, 9, 10, 11, 12, and 13 attended adopted the PBL instructional technique into both STEM and non-STEM classrooms. On the other hand, Students 1, 2, 3, 4, and 5 noted that they conducted projects only in their STEM-related courses. For example, Student 5 said, "We did not memorize scientific and mathematical concepts, but we learned them by applying a project that was hands on and real life oriented". Similarly, Student 12 shared one of his memories by saying,

> *I remember egg drop parachute project that we accomplished by using basic materials. We needed our parachute to have a soft landing to not break the eggs, so it would fall down slower. It was very nice to observe the scientific concepts behind the project. This and similar other projects required me to think outside the box.*

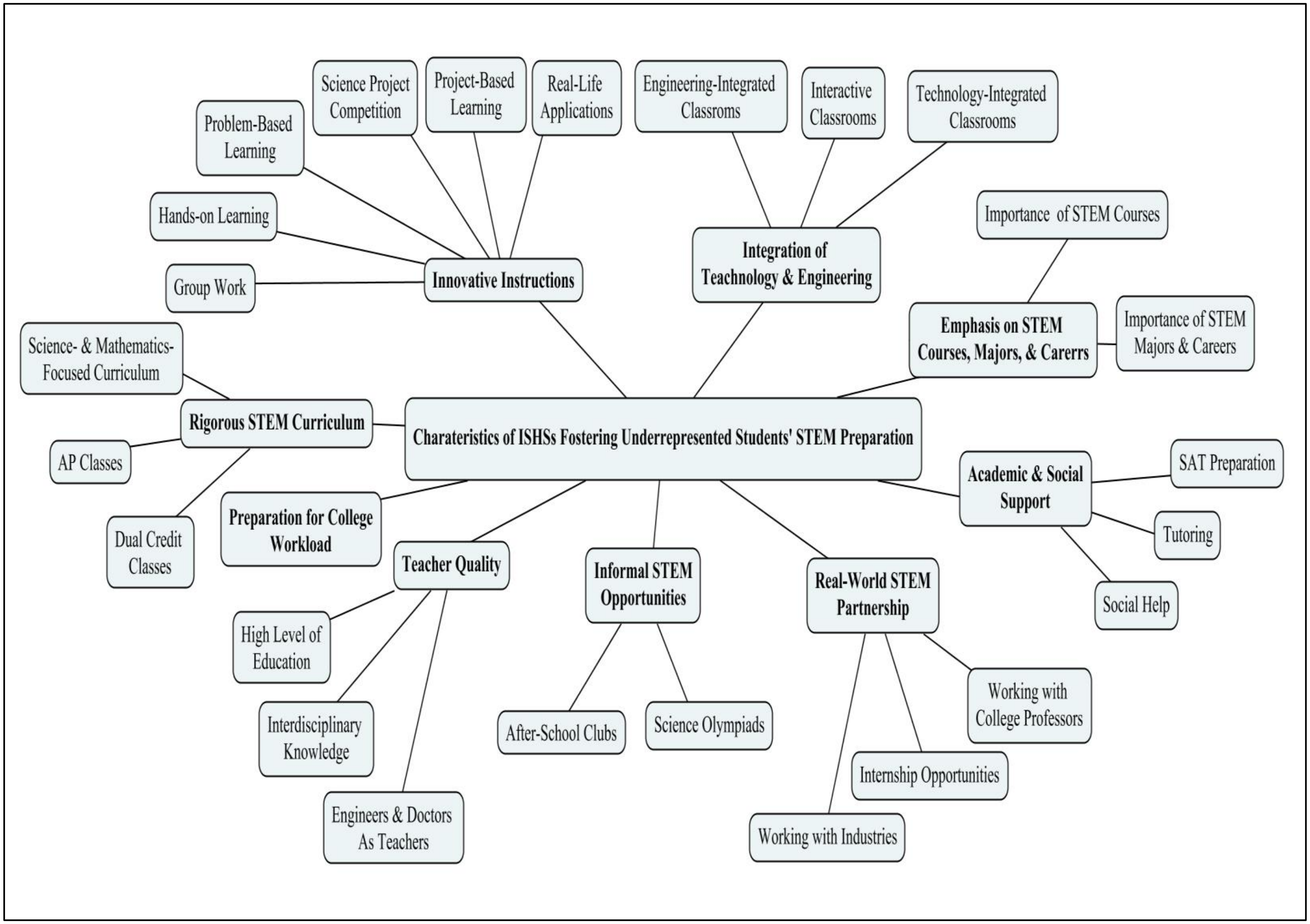

Figure 2. Emerged categories of T-STEM academies

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In general, all students reported that they had positive and constructive experiences with the PBL-oriented classrooms.

Hands-on learning in PBL. Students 1 2, 3, 4, and 5 specified that conducting projects in science and mathematics classes helped them better grasp the concepts they were required to learn in mathematics and science. They mentioned that they learned the majority of mathematical and scientific concepts through using hands on materials. Without having hands-on materials, these students believed that their attempts to learn concepts would have been limited to memorization, which would have allowed them to remember the information only long enough to pass their courses. For example, Student 1' s science and mathematics teachers demonstrated concepts by using hands-on materials. These demonstrations helped him understand concepts in mathematics because he identified himself as a kinesthetic learner. Speaking about his learning process, he said, "I would have to actually see and apply to get it. So, applying hands-on materials helped me a ton". Student 1 provided a specific example by sharing one of his memories as, "I did not understand the Pythagorean Theorem in middle school when my teachers introduced the theorem without using any hands-on materials; however, my high school mathematics teacher provided a hands-on activity through paper folding for me to explain how to apply the Pythagorean Theorem in real-world scenarios. Then, I totally grasped the concept".

Real-life situations in PBL. Students 1, 2, 3, and 5, and Students 9, 10, 11, and 13 stated that when their projects were presented in a real-world context or situation, it made their learning meaningful. They were able to grasp the concepts of science and mathematics that they were attempting to learn with this method. This method also enabled them to apply their prior knowledge when learning the new concepts. For instance, Student 5 pointed out that "applying real-life situations in the projects made mathematics- and science-related concepts clearer and more understandable to me".

Science project competition in PBL. Students 1, 2, 3, 4, and 5 and Students 11, 12, and 13 participated in school competitions with the projects they created as part of their physics, chemistry, biology, and mathematics classes. For example, Student 11 mentioned that "one of my high school projects for a science competition covered topics and concepts I was learning in my science classes. My school's science competition occurred monthly, so I had numerous opportunities to develop similar projects to those I had worked on in my science classes".

Group work. All of the participants indicated that they were required to participate in group work in their courses and felt that working in a group improved their social development. Student 1, Student 4, Student 11, and Student 5 believed that they were more proficient at communicating with people after graduating from ISHSs due to the group projects they had completed during high school. Student 1 pointed out,

> *Group work really helped me learn to communicate with people. I learned how to work with people and get to know different kinds of people. I did not always want to work with my assigned group partners, but we had to use our communication skills to finish the* projects.

Student 2, Student 4, Student 13, and Student 5 attributed their ability to work as a member of a team and adapt to various situations in ways that allow them to use each member's abilities to the knowledge and skills gained during group projects in high school.

Aside from improving the participants' communication and social skills, group work also improved all participants' academic development. For example, Student 7, Student 3, and Student 1 felt that working in a group helped them become academically stronger. Student 1 explained this clearly by saying,

> *Working together rather than alone was better for me as it helped my understanding. My academic performance improved because I was hearing others' ideas and it helped me see various perspectives. Group work made difficult topics more manageable to understand because we could work together to solve and comprehend concepts.*

Furthermore, both Student 1 and Student 7 thought group work helped their understanding because their teachers would form groups that included a mixture of students who excelled in the content and those who were struggling. They liked this type of group formation because they either learned from those who better understood the content or had the opportunity to teach other students who were struggling, to various degrees, to comprehend the new information and concepts.

Problem- and Inquiry-based learning. Student 3, 4, 5, 6 and 10 mentioned that problem- & inquiry-based learning, in addition to PBL, was also used in their high school classes. Student 6's teachers used problem- and inquiry-based learning most often when preparing students for SAT, ACT, and statewide examinations. Student 5 described her teachers' use of problem- & inquiry-based learning to create interactive environments for students:

> *Our courses were super interactive. The teachers, that's all the teachers from that school, would call us out by name and ask us to solve problems as a group. If we couldn't solve, they always helped us along, like gave us hints to understand the concepts more instead of just telling us what the answers were. They were forcing us to think by questioning. In Algebra class, I remember our teacher used to give each group one problem and we would have to solve it with multiple ways. If we were able to solve it by applying one method, our teachers were asking to think other possible solution methods. After we came up with multiple solutions, we would have to go up to the board to explain our mathematical reasoning to others.*

Both Student 5 and Student 10 thought that learning in courses in which teachers used the problem-based learning instructional model helped them attain higher scores on the SAT and Texas Assessment of Knowledge and Skills (TAKS). They had very positive feelings about this instructional model; Student 10 said, "I like that we could help one another solve mathematical problems and then have our teacher assist us". Problem- and inquiry-based learning created a learner-centered environment that provided students with a supportive and interactive environment that benefitted their academic learning experience.

Rigorous STEM Curriculum

All students mentioned that their school curriculum focused more on science and mathematics than on other disciplines like English or history. In addition, their schools offered several challenging Advanced Placement (AP) courses and also designed students' schedules to allow them the option of enrolling in community college courses.

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Science- and mathematics-focused curriculum. All participants felt that their high schools emphasized mathematics and science curriculum more than other courses and that the STEM courses offered were challenging and rigorous. Student 3 explained:

> *I felt our STEM courses were more difficult, extensive, and detailed oriented than other public schools. Other public schools, which my friends attended, focused more on memorization rather than conceptual understanding; I believe my STEM school helped me learn and understand concepts better than their schools would have.*

Student 5 felt that her and her peers' science and mathematics classes were exceptionally competitive when compared to those of her friends in traditional public high schools. When Student 5 studied with her friends from traditional public schools, she solved their problems immediately, which surprised them. Student 5 mentioned that, "My friends' assignments were kind of a joke compared to my STEM school work". Several participants mentioned that it was at times difficult to keep up in their classes due to the academically advanced materials they had to learn and the large workload. Similarly, Student 8 mentioned that the workload in his science and mathematics classes was very demanding and that the higher-level concepts they were learning occasionally overwhelmed him. However, his teachers helped him better understand the concepts by breaking each into subparts; with their assistance, he grasped the concepts fairly easily. Student 5 also mentioned that the STEM curriculum of her school created a challenging workload. She said, "I used to stay up. Everybody, like all my classmates, we used to call each other at 5 am because we would still be up from the night before, studying for our tests. That's how hard it was to keep up".

Advanced placement (AP) classes. All the students mentioned that they had taken an extensive number of either pre-AP or AP classes in high school. Their STEM schools offered both pre-AP and AP classes in STEM and non-STEM subjects. For example, AP course offerings included classes such as AP Calculus, AP Statistics, AP Physics, AP Chemistry, AP Biology, AP English, AP Spanish, and AP History. Due to a mandate in each of their STEM schools that students take a minimum of five AP classes while attending school, these students generally had to work harder to pass their courses (Bittman et al., 2017) Because their schools provided them with many AP class options, they had the opportunity to take as many of the courses as they wanted, based on their interests. For example, Student 8's high school provided more than 10 AP classes. Some specific AP classes such as AP Psychology were offered for students who wanted to continue their career in related fields. For example, Student 5 took AP Biology in high school as she wanted to major in biology in college. She mentioned that her AP Biology class had a large workload and had been intense; however, she felt that it prepared her for college science courses.

Classes at institution of higher education (i.e., Community Colleges) (dual credit). Student 1, 2, 3, 4, 5, 6, and 7 indicated that their high schools provided them with opportunities to take classes at institutions of higher education. Taking dual credit courses was not a requirement, but they had been encouraged to do so in order to obtain experience managing a college-level workload. There were many dual credit course options such as summer, online, and face-to-face classes. In one example, Student 2' s high school collaborated with several professors from a community college. The professors would come to the high school to teach dual credit courses twice a week if there were enough students registered for the offered courses. Student 3 and Student 6 attended on-campus community college courses such as introductory courses in physics, calculus, chemistry, history, and computer science. In doing so, they were both academically and socially exposed to college academics and culture.

Academic and Social Support for Struggling Students

This category primarily pertained to students who were struggling academically or socially. In order to ensure that no students in ISHSs were left behind, teachers implemented tutoring programs to decrease the knowledge gap between students. SAT preparation programs were also available for students who needed to improve their test scores in order to be accepted into particular colleges.

Tutoring. All participants mentioned that their schools had a support program for students who struggled academically and socially. To assist students academically, teachers in their schools provided many tutoring programs such as weekend classes, summer classes, and SAT prep classes. Student 1, 2, and Student 6 and 7's schools limited tutoring to students who were academically struggling. All students attended tutoring programs in the disciplines in which they needed help. For example, Student 2 was struggling in his AP Physics class and attended several AP tutoring sessions in physics after school, in which he was able to grasp concepts that he had not understood during class. Student 1 also struggled in his AP Physics class, but his teacher dedicated additional personal time to give him extra tutoring hours. With his teacher's extended help, along with weekend tutoring programs, he became highly proficient in physics and passed the AP Physics test. He explained his feelings by saying, "I even passed the AP Physics test, and that's something I would have never dreamed of at the beginning of the year when I signed up for AP Physics". Similarly, Student 7 said that, "attending biology tutoring enabled me to pass the class by strengthening my biology knowledge".

Tutoring new students and social help. Students 1, 2, 3, 4, and 5 and Students 8, 9, and 10 indicated that their schools had structured a support community among students in which incoming freshman and sophomores could receive academic assistance from upperclassmen (i.e., 11^{th} and 12^{th} grade students). As new students and freshman, Student 5, Student 4, Student 1, and Student 8 received tutoring in their ISHSs, and as seniors, they tutored younger students who required academic assistance. Student 5 discussed her time as a tutor and mentor, saying, "We had younger students who were quiet and really scared because it was a new school. We used to help them with their homework. Our school was like a small community that helped each other. It was really nice". Several other participants had also experienced a sense of school community similar to Student 5's, receiving social support and guidance from teachers or upperclassmen when they were new students at their ISHS. For example, Student 8 said, "Before I came to my STEM school, I was super quiet and wouldn't talk to anybody. But, when I got there, I was even friends with my teachers. That's how close we all were".

SAT test preparation. Students 6, 7, 8, 9, and 10 noted that they had SAT preparation tutoring programs in their high schools. Student 6 indicated that his teachers covered most of the topics that would appear on the SAT test. Their teachers helped by covering chapters, and providing SAT practice tests. When teachers used this method, they familiarized students with the test. Student 9 commented that, "Our teachers helped us to improve both our SAT test scores and test taking techniques".

Integration of Technology and Engineering into STEM and non-STEM Classes

Integrating technology and engineering into STEM and non-STEM classrooms was another factor that emerged as influencing underrepresented students' STEM preparation. This factor was part of their educational experiences in three types of learning environments: 1) engineering-integrated classrooms, 2) technology-specific classrooms, and 3) interactive classrooms.

Engineering-integrated classrooms (Engineering Design Process). While the schools in which Students 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 were enrolled integrated engineering into both STEM and non-STEM classes, Student 11, 12, and 13's school integrated engineering only into STEM classes. These engineering-integrated STEM classes helped students understand the engineering design process. Student 12 explained this by saying, "Our teachers used engineering stuff in our classroom, which showed what functions related to our classes played a role in engineering design". Student 5, Student 6, Student 1, and Student 2's schools also offered classes such as robotics, in which students grasped the basic principles of robotic movement by building and programming robots. Student 8 mentioned that his experiences in engineering-integrated physics classes were invaluable in furthering his knowledge; these courses helped him understand how force would be applied in constructing a building and how springs work. Student 1 likewise had a positive experience with engineering-integrated classes. He was initially inexperienced in computer programming and engineering, and as a result, he was reluctant to engage in engineering-related class activities. However, with the emphasis placed on STEM-education in his school, Student 1 was continually required to engage in STEM activities, and his computer programming and engineering related abilities (i.e., designing, coding) grew. As his skills increased, he began to enjoy the courses and took programming and robotics classes as electives. In time, he considered himself very proficient at coding due to his engineering-integrated science and mathematics courses in high school.

Technology-integrated classrooms. All the students indicated that their teachers integrated technology and used technology actively in their classes. The students felt that technology aided in their comprehension of concepts and changed their approach to knowledge comprehension. The students' teachers used computers, clickers, digital calculators, lab materials, and iPads in their classrooms. There are multiple ways to integrate such technology, so each student's experience was slightly different. For example, Student 6's physics teacher used a website called Khan Academy to help her with physics and calculus. Student 3's chemistry teacher used lab materials to measure variables like temperature when they were doing experiments. Student 8, Student 3, and Student 7 described themselves as visual learners, so the integration of technology in their classrooms greatly influenced their understanding of scientific and mathematical concepts. Student 7 explained:

> *I am a visual learner, so using technology in science classes made remembering and understanding concepts much easier. Our physics teacher showed physical concepts applied to real life situations by using computers, and learning this way made it much easier for me to understand physical concepts.*

Student 5 experienced one of the most drastic educational differences. Explaining her situation, she said,

> *During my elementary and middle school years, I attended public school, and in our public school, I never touched a computer. I had no idea how to type. When I started at the STEM high school, the first class I attended was very difficult. It was a digital graphics class, and I*

received extra help from my teachers as I was kind of behind. Then, I became proficient in and enjoyed computer science.

Creating interactive classrooms. Student 3, Student 6, Student 1, and Student 5 indicated that technology use in their courses created an interactive classroom setting. Furthermore, they thought that using online resources and browser-based online applications had improved teacher-student communication in their schools as well as their understanding of course subjects. Student 6 pointed out that, with the use of integrated technology, she was more active in class and able to be better acquainted with her teachers. Student 1, Student 6, and Student 7 indicated that they had checked out iPads from their high schools when they needed to work on assignments at home. Once finished with their projects, they would submit their work to their teachers through Google Docs. When they were not in class, group members would communicate and interact with their teachers and peers by e-mail.

Informal STEM Opportunities

The two most common informal learning opportunities participants mentioned were science and mathematics Olympiads and afterschool clubs. Students reflected on the importance of these experiences that led to their current motivation to both pursue and persist in their STEM majors.

Science Olympiads. Student 5, Student 6, Student 7, Student 4, Student 1, and Student 8 mentioned that they had worked in groups at their high schools to submit projects to a science Olympiad known as I-SWEEEP (International Sustainable World Project Olympiad-Energy, Engineering & Environment). However, admission to I-SWEEP is highly competitive and not every student was able to attend the international science Olympiad; students had to first place high within their school competition and then place at the state science Olympiad before they could attend the international science Olympiad or I-SWEEP. Some students received awards from Olympiads and this increased their motivation toward STEM-related disciplines. For example, Student 6 received a second-place creativity award from a college in Texas when she was an 11^{th} grader. An additional benefit of the Olympiad competition and experience came during preparation for the competition. Student 3, Student 6, Student 1, Student 5, and Student 8 indicated that preparing for science Olympiads helped them better understand all science and mathematics-related topics because they worked as a team and this allowed them to learn from and assist one another.

After-school clubs. All students indicated that they had after-school clubs like mathematics club, chemistry club, physics club, and robotics club. Students who wanted to develop their skills in certain fields participated in these after-school clubs. Student 8, Student 1, Student 2, Student 6, Student 9, and Student 13 participated in after-school clubs for this reason. Student 2 strongly felt that participating in an after-school club helped him develop his interest and skills in mathematics and science. He was not really interested in mathematics and science classes until he joined the robotics club; it was due to his experience in the club that he decided to pursue a degree in engineering in college. Some after-school clubs also offered mentoring opportunities for students who excelled in specific subject areas. Student 5, Student 1, and Student 6 mentored students in their clubs.

Several after-school clubs also provided academic mentoring for students in areas that were not directly related to their classes or particular subject areas. Student 6, Student 2, and Student 5 received higher education and career-related mentoring and learned ways to improve their resumes or apply for scholarships for college. Student 5, Student 2, Student 1, Student 8, and Student 9's

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2020, Vol. 7, No. 2, 147-172
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schools also provided summer camps for students in which they could participate in SAT preparation classes, robotics classes, and several other STEM PBL focused courses.

Real-World STEM Partnership

Participants also noted the importance of their schools having established real-world STEM partnerships. The students indicated that their schools had a partnership with universities, industries, and businesses. Through these partnerships, their schools provided them with internships, mentorships, and research opportunities.

Internship opportunities. Student 6, Student 7, Student 2, Student 8, Student 1, and Student 10 indicated that they were given internship opportunities through the assistance of their schools. Student 6 took advantage of her school's assistance and approached her school counselor to discuss internship opportunities. She was accepted as an intern by a research center at one university in Texas, and among other things, learned how to use a 3D printing machine. Student 7 also applied for a STEM-related internship at one of the top universities in Texas and was accepted as a mathematics intern. During her internship, she learned how to conduct research and write a technical paper. Student 1 was accepted as a science intern at another University for a biological engineering project, and he learned how to grow Lycopene cells outside of red fruit and vegetables at a more efficient rate. Student 6 also found an internship opportunity through the science Olympiads her school was hosting. She contacted a professor who was one of the project judges and accepted a position at one of the top universities in Texas as an engineering intern. The students who interned all mentioned that, through their internships, they learned how to use labs and collect data for their own future research interests.

Working with college professors. Student 3, Student 4, Student 7, Student 8, and Student 1 indicated that their high schools contacted college professors and negotiated opportunities for the high school students to work with the professors on projects. Student 3 said, "We met with the professors every week for several hours to work on projects. It was nice to establish relationships with the professors because they wrote recommendation letters for college admission or for internship opportunities". Student 4 thought that one of the biggest opportunities in high school was working with a professor and his PhD students, and he claimed that, had he gone to a different high school, this opportunity would not have been possible. He said, "Staff from my STEM school actually drove me to the one of the top universities in Texas to work with a research group".

Working with industries. Students 5, Student 8, 9, and 10 indicated that their ISHSs brought engineers to speak with the high school students. Student 5 shared one of her experiences:

> *I was working on a project to create a more cost-efficient thermostat, but I did not have enough experience with the topic so my school invited an engineer that had experience with thermostats to come to the school and assist with the project. He taught me how thermostats work.*

Likewise, Student 8 had an opportunity to work on a robot with engineers that came to his school. They helped the students better understand concepts and work through difficulties with their robotic projects. After the students built their robots, the engineers explained how to market them. To assist in teaching the marketing process, Student 10's school also brought a businessman to speak to the students about how to sell and market their robots. Her school organized a trip to companies like NASA and Exxon Mobile. During the trips, she talked to people who were experts in their fields and found a volunteer intern position.

Quality of Teachers

Having quality teaching staff is also a factor that emerged as influencing students' STEM preparation. There were three characteristics most of the students mentioned that their teachers possessed: high levels of education (e.g., masters or doctoral degree), former employment as engineers or doctors, and interdisciplinary knowledge.

High level of education. Student 6, Student 7, Student 1, Student 8, and Student 12 had teachers who possessed masters or doctoral degrees. Because most of their teachers possessed advanced STEM degrees, they were able to teach advanced science and mathematics classes. Student 6 said, "Our teachers who had masters and doctoral degrees had extensive background knowledge in STEM disciplines and were good at teaching science and mathematics classes". Student 8 and Student 6 indicated that their teachers who had higher levels of education truly understood the subjects they taught. Student 13 indicated that one of her mathematics teachers in high school possessed a doctoral degree and had received a job offer from one of the top universities in Texas. She spoke highly of this teacher, saying, "I mean he was that good. He was like a college professor who taught us in high school".

Engineers and doctors as teachers. Student 3, Student 7, Student 6, and Student 11 mentioned that they had teachers in high school who were previously employed as engineers or medical doctors. Student 3 and Student 6 indicated that their physics teachers were engineers, so, as Student 3 explained, "They had practical experience in STEM careers and that may be the reason why they were so good at teaching physics and mathematics". Student 7 had two high school teachers who were previously medical doctors; one taught biology and the other chemistry. She said that her biology and chemistry classes were excellent because her teachers taught biology and chemistry by incorporating real-life experiences of the human body, ecology, and the periodic table into their lessons.

Having interdisciplinary knowledge. Student 5, Student 10, Student 1, Student 8, and Student 7 indicated that their teachers had proficient interdisciplinary knowledge, which allowed them to connect their own disciplines with other disciplines. Student 5 admired her chemistry instructor because, "If he had switched to teaching in another field like mathematics, he could have easily been my mathematics teacher, or he could easily have been my robotics teacher. He knew everything". Student 6 shared a similar sentiment regarding her physics teacher: "My physics teacher knew mathematics, robotics, and chemistry. After he came to our school, students received many awards during science Olympiads because they were actually doing well in physics and science in general". Student 7 was also appreciative of the interdisciplinary knowledge of one of her teachers. She felt her experiences in mathematics and science courses were pleasant because, as she explained, "We did not get left behind on mathematics when our teacher left. Instead, our chemistry teacher stepped in and taught mathematics as well as her chemistry classes". Student 1 liked his mathematics teacher because he was very experienced and knowledgeable in the field of technology and actively integrated technology into their classrooms. He took all advanced mathematics classes and learned numerous complicated concepts as his mathematics teacher used advanced technology to ensure that the complicated concepts were easily comprehendible.

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Emphasis on STEM Disciplines, Majors, and Careers

Giving high importance to STEM disciplines, majors, and careers was another factor that influenced underrepresented students' STEM preparation in ISHSs. This factor had two main subcategories: emphasizing STEM courses and emphasizing STEM majors and careers.

Emphasizing importance of STEM courses. All the participants indicated that they were exposed to the idea that science and mathematics were vital disciplines. Student 6 clearly explained the role of science in her school: "The biggest divergence from regular public high school was our STEM high school's emphasis on science". Student 4, Student 5, Student 8, and Student 10 observed that they felt more motivated to learn and engage in their mathematics and science classes and thought that achievement in these disciplines should be their focus. Student 5 clearly explained this by saying, "Our science and mathematics achievement were super important in our school". All the students also felt that their schools encouraged them to pursue STEM-related careers after high school. For example, Student 4 said, "I felt like they really wanted us to become engineers by the end of high school, as in choosing to pursue an engineering degree by the end of high school".

Emphasizing importance of STEM-related majors and careers. Student 3 indicated that his high school experience shaped his interest in becoming an engineer as his courses and workload primarily dealt with science and robotics. In another instance, Student 2's physics teacher, with whom he was very close and who knew his skills and interests, greatly influenced his career path. The teacher encouraged him to enter the electronic engineering department. Student 7 had a similar situation to Student 2's. She said, "My mathematics teacher really made me love mathematics. I wanted to continue in the field of mathematics, and I thought mathematics was my thing". Student 5 's major decision was shaped by the school courses that she was best in during high school - mathematics and science courses. She felt well prepared for college courses in STEM and because of her demonstrated skill and preparation, thought that studying for a STEM-related career would suit her. Student 8 mentioned that he would not have chosen to pursue a degree in a STEM-related field had he not attended a STEM high school. He had excelled at sports in high school, specifically soccer, but thought that his skills and potential were limited in STEM related fields. However, his teachers encouraged him to become more involved in technology-oriented classes like robotics. Student 8 eventually decided to major in computer science due to the knowledge and experience he acquired in these classes. He said, "If my school did not give importance to STEM disciplines and did not offer robotics classes, I probably would not have majored in computer science during college". Student 1 had a very similar experience. Because he was taking STEM-related elective courses, like robotics, he became interested in engineering majors and careers. He remarked, "I started realizing I liked engineering stuff like building blocks".

Preparation for College Workload

Preparation for college workloads is another factor found to influence underrepresented students' STEM preparation. All participants mentioned that due to their experience with rigorous high school coursework, they have been doing well in college. The participants all worked extremely hard during high school to succeed in their AP classes and projects. That being said, the students have all passed their college courses thus far and have attributed their current success in college to the extensive and rigorous preparation they received during high school. Student 6 mentioned that she passed all her science and mathematics classes in her first year of college because her academic experience in high school helped her become accustomed to the workload.

Similar to Student 6, Student 5 thought her high school prepared her well. She added, “It’s a larger workload, but I am getting through it. I am taking Statistics. I am doing very well. It is mostly what we learned in AP statistics, so it is kind of familiar”. Student 3 also explained his high school college preparation:

> *Now, I am doing very well. The classes in our high school were difficult and challenging, and I think my school prepared me well for a college workload. I took similar level classes when I was in high school, so it helped me to succeed in my college classes.*

In general, the participants noted that they all worked extremely hard during their high school years to succeed in their AP classes and projects and this attributed to their success in college.

Discussion

The nine elements of ISHSs associated with the shared experiences of ethnic minority students emerged from the present study demonstrate that Inclusive STEM high schools in Texas (T-STEM academies) comprise high-quality educational models that integrate engineering and technology into STEM and non-STEM classrooms within a project that includes various teaching and learning practices grounded in social constructivism (Vygotsky, 1978). The nine components of ISHS are critical for underrepresented students not only to attain meaningful science and mathematics understanding during their high school years, but also provide opportunities to develop their early career endeavors in STEM majors and careers (LaForce et al., 2016).

It is important to note that the focus of this paper is not to either identify the common characteristics of all ISHSs or dictate what they all ISHSs should comprise. It is rather about underrepresented students’ shared experiences related to their high schools. Focusing on ISHSs graduates’ high school experiences related to their STEM preparation may potentially offer an important contribution to the ISHSs literature.

In examining the shared experiences of ISHSs’ graduates, it is important to state that not all schools emphasized all the themes emerged from the study at the same level. For example, based on participants’ experiences and their schools’ curriculum investigation, while some ISHSs required PBL to be integrated into all subjects, some required PBL solely to be integrated into mathematics and science classrooms. Although not all students have exactly the same experiences related to PBL in their high schools, PBL integration was represented as one theme in the present study because students from different schools mentioned their positive experiences of PBL integration related to their STEM preparation. Likewise, while some ISHSs heavily emphasized the rigorous science and mathematics curriculum (e.g., providing several AP and IB mathematics and science courses) than what is required at the state level, some ISHSs emphasized the integration of technology and engineering (e.g., Project Lead the Way [PLTW] engineering curriculum) into their curriculum over other instructional practices. However, regardless of their emphasis, both cases of ISHSs offer certain level of AP and IB mathematics courses and integrate engineering and technology into their science and mathematics courses. Because both cases of schools incorporated these practices at a varying degree of emphasis, we presented both as themes in this study to represent a broader perspective of ISHSs’ graduates rather than limiting our focus on the most emphasized practices by a specific ISHS. Representing broader perspectives of individuals allows us to build a consensus of students’ experiences in ISHSs. Consensus-building is vital to create a framework that synthesizes critical components of ISHSs that underrepresented students associate with their STEM preparation (Peters-Burton et al., 2014).

We created a framework that synthesizes shared experiences of ISHSs graduates under nine main themes and these themes together construct a common language around what positive practices of ISHSs that underrepresented students experienced for their STEM preparation. It is important to note that; however, there are various frameworks of ISHSs (e.g., Gnagey & Lavertu, 2016; LaForce et al. 2016, Lesseig et al., 2019) that were constructed to reinforce students' positive STEM experience through emphasizing certain instructional practices. Simply, "there is no one correct model for an inclusive STEM high school" (LaForce et al., 2016). However, the framework from the current study can be helpful for schools to build STEM focused high school models should their goal be to instill their underrepresented students' positive STEM experiences.

The present study, in the light of SCCT (Lent et al., 1994), suggests that incorporating the nine practices coming from underrepresented ISHSs graduates' shared positive experiences to STEM and non-STEM focused schools may have the potential to better prepare underrepresented students for post-secondary STEM pathways. Institutional factors of ISHSs instilling positive STEM experiences to underrepresented students can be considered as critical components of ISHSs that have the potential to create a STEM opportunity structure for underrepresented students (Bicer et al., 2018; Gnagey & Lavertu, 2016; LaForce et al. 2016, Lesseig et al., 2019; Peters-Burton et al., 2014), which can develop their science and mathematics competencies and interest in pursuing STEM careers in college (Bicer, Navruz, et al., 2015; Peters-Burton et al., 2014). While some of the practices that emerged from the present study have been previously reported by current research (e.g., Gnagey & Lavertu, 2016; LaForce et al. 2016, Lesseig et al., 2019; Peters-Burton et al., 2014), such as PBL, problem-based learning, emphasizing science and mathematics content (Gnagey & Lavertu, 2016), emphasizing STEM majors and careers, partnering with business and universities (LaForce et al., 2019), rigorous science and mathematics curriculum, SAT preparation, real world STEM partnership, quality of teachers (Lesseig et al., 2019), some practices are emerged uniquely from this study, such as offering informal STEM opportunities, providing academic and social support for struggling students, and preparation for a college workload. All these previously and newly emerged themes from the present study have their roots from experiential or student-centered learning practices that students learn when they collaboratively work to solve complex problems situated within real-life context by applying hands on materials (Dewey, 1998; Henson, 2003). This also aligns with social constructivism that the emphasis of students learning in STEM is on the collaborative nature of learning and the importance of cultural and social context (Vygotsky, 1978). By looking at the instructional practices of ISHSs which emerged from the present study (e.g., PBL), it is conceivable to say that underrepresented students' experiences were supporting the idea of "learning by making" more than one of Dewey's (1998)' s most popular ideas of "learning by doing". The difference between these two approaches is that learning by making requires individuals to solve problems creatively and critically rather than simply repeating the predominantly well-known applied procedure. For example, many ISHSs graduates associated the classroom practices of solving real life-oriented problems by applying several methods with their enhanced divergent and critical thinking ability. Student 12 specifically shared his memory by saying the projects "required me to think outside the box". Increasing students' divergent thinking ability to solve complex problems of 21st century is essential because creatively solving problems is considered one of the most desired skills by potential employers (Pink, 2006).

By looking in general at all the themes, it is reasonable to conclude that most of the instructional practices of ISHSs students experienced were designed in a way that they found opportunities to increase their the 4C (creativity, critical thinking, collaboration, and communication) of 21st century skills. For example, the theme “providing academic and social support for struggling students” states that positive ISHSs experiences of students related to their communication skills. ISHSs graduates shared that they had opportunities to develop their communication skills to express themselves in a community. Specifically, Student 5 shared her experience by saying, “Before I came to my STEM school, I was super quiet and wouldn’t talk to anybody. But, when I got there, I was even friends with my teachers. That’s how close we all were”. ISHSs established an academically and socially supportive environment that can be one of the most critical features to develop students’ sense of belonging to their schools. For instance, ISHSs created a tutoring center after school time that not only teachers, but upperclassmen also helped freshmen with their homework and projects if they needed support. Through similar programs, most graduates noted that their school emphasized working collaboratively rather than competitively to be successful in STEM and non-STEM subjects.

Participants’ shared experiences related to their ISHSs. They describe that ISHSs have common objectives to develop their 4C of 21st century skills rather than solely emphasizing their mathematics and science achievement. Given that, current studies about ISHSs mostly either focused on how students’ mathematics and science achievement level compared to traditional public high schools or whether ISHSs graduates are more likely to follow STEM majors in college (Bicer & Capraro, 2019; García-Martínez et al., 2019; Means et al., 2017; Means et al., 2018; Saw, 2018). However, revealing the underrepresented students’ shared experiences related to ISHSs, presented here, it is relevant to ask how and what various instructional practices of ISHSs can be helpful for underrepresented students to develop their 21st century skills. It is important to note that the present study’s focus is beyond the scope of all students’ shared experiences of ISHSs. Future research can be conducted to focus what all students’ shared ISHSs experiences are related to their STEM preparation. Future research can also be conducted to understand students’ STEM preparation in ISHSs in terms of students’ 21st century skills development by applying a longitudinal study to observe their trajectories of 21st century skills over years. The findings of the present study can be a helpful resource for researchers to identify items of a survey measuring students’ ISHSs experiences related to the critical components of ISHSs if a quantitative analysis with a large sample is of their interest. This might be conducted by comparing students’ growth of 21st century skills by their school types, as ISHSs or traditional public high schools. The present study may have potential bias as students who attended ISHSs were probably more likely to major in STEM than students who attended traditional public high schools even though some students shared that they participated in ISHSs not due to their prior interest or achievement in STEM, but due to either their parents’ interest or other factors.

Conclusion

The fulfillment of ISHSs’ mission has two primary benefits: 1) the mathematics and science achievement of all students may be developed, and 2) students of traditionally underrepresented subpopulations receive opportunities to participate in STEM activities and become more likely to pursue and be prepared for STEM-related majors (Young et al., 2011). Achieving these two benefits provided by ISHSs are vital to decrease the existing science and mathematics achievement gap between students who come from traditionally upper-class demographic groups and students who come from underrepresented subpopulations. Decreasing the existing mathematics and science achievement gap during high school between these two groups of students can help a growing number of students from underrepresented subpopulations find opportunities to pursue and persist in STEM majors, and finally become highly qualified and prepared candidates for

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STEM careers (Bicer & Capraro, 2019). Furthermore, decreasing the achievement gap between these two groups of students is vital to maintain the United States' status as a scientific leader and economic power due to the rapid growth of traditionally underrepresented subpopulations in the nation (Bicer et al., 2018; Bicer & Capraro, 2019; NRC, 2011). For example, the Hispanic population has been projected to increase from 46.7 million to 132.8 million from 2008 to 2050. Similarly, the African-American population has been predicted to increase from 41.1 million to 65.7 million by 2050. Another statistical prediction by the U.S. Census Bureau projected that by the end of 2050, the percentage of minority students aged between 5 and 17 is predicted to be 62%, raising from 44%. These numbers indicate that today's minorities will be the majority in the United States; thus, providing minority students educational opportunities to increase their STEM interests and competencies should be a priority. The critical components of ISHSs, represented here, can be helpful for both STEM and non-STEM schools to establish a STEM-focused school environment that has the potential to increase underrepresented students' 21st century skills while concurrently delivering positive mathematics and science learning experiences to them.

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