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Abstract

Educators and policymakers in the United States advocate the development of specialized STEM (science, technology, engineering, and mathematics) schools, but little is known about the unique features and practices of these schools. Because no meaningful differences have been found attributable to model type (Tofel-Grehl & Callahan, 2014), the current study purposefully sampled 6 specialized STEM schools in the United States that provided different levels of STEM experiences for students related to highly varied goals and missions using a grounded theory approach. Schools were found to fall into two categories, high and low STEM intensity, based on five major traits. Schools categorized as "higher STEM intensity and focus" had students who reported a stronger interest in a future STEM career, offered substantially more high-level STEM classes, and retained a faculty with a higher number of terminal area content degrees compared to schools categorized as "lower STEM intensity." Although there are significant common themes and programmatic themes and features among different STEM schools, substantial differences exist between the nature and intensity of the STEM experiences of schools. Categorizing STEM schools into higher and lower STEM experience intensity provides a useful mechanism for examining those differences. Students in schools with a higher STEM intensity appear to spend more time on the "doing" of science.

Keywords: Classroom practice; School culture; STEM schools

With increased attention to STEM education has come increased funding for and focus on specialized STEM schools. However, all schools are not created equal; variations in implementation and mission may affect student experiences at these schools. Insights into and understanding of factors that meaningfully differentiate across STEM schools and what makes them successful is key to better understanding any differences in student outcomes. The purpose of this article is to explicate and explore observed variations across specialized STEM schools.

STEM Schools Defined and Described

What Is a STEM School?

No current curricular or programmatic standards currently exist for establishing a specialized STEM school. Common features of specialized STEM schools are amorphous and are based on the mission statements and descriptions of the top-ranked schools. Neither state departments of education nor professional organizations such as the National Consortium of Specialized Secondary Schools in Mathematics, Science, and Technology (NCSSSMST) have established program or curricular guidelines for schools calling themselves STEM programs. NCSSSMST argues that curricular decisions need to be determined by schools alone (Hutchinson & Warshaw, 2011). Hence, course offerings, as well as the goals and length of research experiences, vary as widely as the school demographics do (e.g., Dearborn Center for Mathematics, Science, and Technology, 2011; Massachusetts Academy of Science and Technology, 2011; Stuyvesant, 2011).

One unique feature of specialized STEM high schools that NCSSSMST does articulate is the systematic involvement of students in meaningful research. However, what makes research experiences meaningful is unclear. For some STEM school educators, meaningful research is any research that focuses student learning on the scientific process. Other STEM educators more narrowly define the research experiences as a pure inquiry process, which applies real-world problems in a professional laboratory setting (Hutchinson & Warshaw, 2011). When these two definitions are applied across schools, the implementation of school research programs results in highly variable student experiences.

Types of STEM Schools

For a more complete explanation of various model types of STEM schools refer to Tofel-Grehl and Callahan (2014) or Thomas and Williams (2009). However, briefly, there are roughly five different school models frequently employed for specialized STEM schools.[1] Common model types include school-within-a-school model, pullout programs, stand-alone schools, residential schools, and university-based schools. Each model type possesses unique programmatic features; however, model type has not been observed to be a key variable affecting student learning opportunities (Tofel-Grehl & Callahan, 2014). It bears noting that model types are often not entirely independent; often schools employ mixed model types to best develop a unique learning experience. For example, the Louisiana School for Math, Science, and the Arts provides a hybrid residential- and university-model experience in which students can attend local university classes while living in a high school residential setting.

Current Research

Currently several studies are in process regarding the workings and outcomes of specialized STEM schools. Research in the area falls into two categories: (a) student reflections on the impacts of their school experiences on their decision making and (b) measuring specialized STEM school outcomes (Sullins, 2010). Interviews with college freshmen and seniors who previously attended a specialized STEM high school indicated that as many as 50% of students reported intended to, or had already, declared a STEM major during their college experience (Thomas & Love, 2002). Studies using survey data also indicated that students graduating from specialized STEM schools also reported higher frequencies of declaring STEM area majors (Subotnik, Tai, & Almarode, 2011). During college, these students reported that attendance at a specialized high school impacted their decision to seek a higher education degree in a STEM field (Subotnik, Tai,

[1] For the purposes of this discussion, magnet programs have been subsumed under the overarching model into which they fit depending on their organizational structure.

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Rickoff, & Almarode, 2010). Franco, Patel, and Lindsey (2012) reported that students from STEM schools demonstrated higher interest in STEM careers during career planning exercises than their non-STEM-school counterparts. Work focusing on student perceptions, up until now, presumes students' ability to correctly retroactively explain prior decision-making processes and impacts; however, research indicates that self-report data of this type is not entirely accurate (Bowman, 2010; Ericsson & Simon, 1993).

Limited research assessing predictors and outcomes of specialized STEM schools document that the best predictor of performance is academic achievement at previous schools attended (Feldhusen & Jarwan, 1995) and that students in some STEM programs exhibit small performance increases in mathematics and science compared to students in non-STEM programs (Young et al., 2011). Examining school culture, Rhodes, Stevens, and Hemmings (2011) reported that a STEM school environment resulted in perceptions of students' social and intellectual growth. Meaning from other research on outcomes is difficult to unpack. Although it appears that STEM schools may create more STEM degree seekers, none of the current research decouples the impact of students' prior interest, an observed predictor of future STEM degree attainment, from the programmatic impacts of specialized STEM schools. Further, research on STEM schools is either focused on one school or is based on data across STEM school types without attention to how the many different STEM school models, curricula, goals, or other characteristics may yield differential outcomes. A first step in documenting how schools might differentially impact outcomes is to examine the array of STEM school options to discern patterns of commonalities and differences upon which future research would base hypotheses of differential outcomes. A recent report from the National Academy of Engineers focused on integrated STEM education for facilitating the best learning outcomes in STEM classes through meaningful research opportunities and other integrated approaches (Honey, Pearson, & Schweingruber, 2014). However, even with a compelling argument regarding the value of such integration-driven approaches, a clear delineation of the programmatic implementations within specialized STEM schools remains unexplored.

Research Questions

As noted above, common themes across specialized STEM schools are evident and are not differentiated by model type (full-time residential, pullout, full-time nonresidential or university based; Tofel-Grehl & Callahan, 2014). Yet, there were differences across schools, so the next apparent step was to attempt to discern ways in which the schools might differ according to other categorization schemes. Therefore, the following research questions were posed:

1. If model type is not a significant variable in the distinguishing features of STEM schools, is there another schema for describing the differences between STEM Schools?
2. Do schools differ in the types and intensity of the STEM experiences offered to students?
3. Do students from these potentially different categories of schools report different intentions towards STEM careers?

Methods

This study employs grounded theory in order to discover emergent themes from the collected data. Data sources include classroom observations, field notes, teacher focus groups, student focus groups, administrator interviews, and review of program websites and documents at each of six purposefully sampled specialized STEM schools. Each site included in the study provided the research team full and open access to observe STEM area classes and to interview teachers and students over the course of 2-day site visits. Oversight for this study was provided by the Institutional Review Board under protocol 2011012100.

After the semistructured interviews and focus groups were transcribed, the transcripts and observational field notes were coded along common lines. Codes were grouped along similar concepts to form categories from which themes were derived. From the coded observations, interviews, focus groups, and documents, five categories appeared to be interrelated. A typology (Smith & Krogstad, 1988) was conducted to classify observations by the five attributes identified through the iterative coding process implemented in grounded theory. This process allowed for the structuring and organization of the observational data into the classifiable categories.

Sampling

Prior to selecting sites for inclusion in the study, we conducted a comprehensive search of all STEM schools in the United States. Using the member list of the NCSSSMST as a base list, we had searched each state's department of education website to isolate and identify schools not already included in the 142 member schools of NCSSSMST. This search led to the discovery of 216 additional schools. When Internet resources were not thorough enough to substantiate a school's interest in STEM education, phone calls to administrators determined the educational goals of the school. From this more complete list of 358 schools, six schools were selected for inclusion. In selecting each site for inclusion in the study, diversity of model type (full-time nonresidential, full-time residential, part-time pullout, university affiliated), geographic region (Northeast, Southeast, Midwest, South, Southwest, Northwest), enrollment size (< 300, 300–599, 600–899, 900 +), and admissions criteria (selective or open admission) was sought.

Site descriptions. Schools selected for participation in the study were chosen to maximize diversity across four criteria: geographic location, school model, admissions criterion, and size. Additionally, in order to focus on the schools that prior research implies produce high percentages of STEM workforce, this study focused on specialized STEM high schools. High school populations fit our research questions most directly. Each of the sites visited offered a window into a different model type and school community; some schools were hybrids of model types, taking features from multiple models. Several of the schools visited served only 11th and 12th grade students for a variety of reasons such as model implementation and budget. Profiles relevant to site selection are displayed in Table 1. All site names and locations have been given pseudonyms to prevent identification. For more extensive descriptions of the sites, please refer to Tofel-Grehl and Callahan (2014).

Located in a major northeastern city, Johnson Technical High School (JTHS) is located in a highly centralized urban location. Admissions are highly competitive; the admissions process uses the citywide examinations set forth by the city Department of Education for magnet school admission. JTHS is a full day specialized STEM school with no university affiliation.

The Academy for Science and Mathematics Education (ASME) is a southeastern, rural program representing a pull out program model with competitive admissions criteria for local high performing students. Admission is based on teacher recommendations, prior standardized test

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scores, transcripts, and essays.

Table 1
Site Demographics

School	Geographic location	Community served	Admissions process	School model type
Johnson Technical High School	Northeast	Urban	Restricted	All-day magnet
Academy for Science and Mathematics Education	Southeast	Rural	Restricted	Partial-day magnet
Engineering and Mathematics Day School	West	Suburban	Open	School within a school
Southern School for Gifted Science Students	Southwest	Urban	Restricted	All-day charter
Lockheed Academy for Science and Technology	Midwest	Suburban	Restricted	Residential
Technical Academy for Science and Mathematics	Southeast	Rural	Restricted	University & residential

The Engineering and Mathematics Day School (EMDS) is an urban school that offers one of the few STEM programs in the nation with open enrollment policies. EMDS is located in the western United States. Students need only submit their names to be entered into the admissions lottery Students entering the program vary from high performers to those with significant below grade level abilities. EMDS is a full day school that partners with the local state university.

The Southern School for Gifted Science Students (SSGSS) is a Southwestern school located in an urban setting, but it draws students from several suburban communities. Using highly selective admission criteria, SSGSS seeks to admit high-performing students from a wide array of socioeconomic backgrounds. Test scores and prior achievement drive admissions' decisions.

A midwestern school drawing students from the suburbs of a major city, Lockheed Academy for Science and Technology (LAST) also uses exclusive admissions criterion such as prior academic achievement, standardized test scores, and teacher recommendations. LAST is a residential program, with all students living on campus in dormitories under faculty supervision.

The Technical Academy for Science and Mathematics (TASAM) uses exclusive admissions criteria as well. Located in the Southeast, TASAM is rurally located but draws students from around the entire state while working in conjunction with the state university. TASAM is a residential program, so students live together during the academic year.

Data Collection

Four types of data collection were implemented at each site: classroom observations, teacher focus group interviews, student focus group interviews, and administrator individual interviews.

Two observers from the research team visited each of the six sites to make observations and conduct interviews. At all six sites observational data was collected in mathematics and science classrooms. In addition, whenever possible, technology, engineering, and research classes were observed. At each site, researchers observed biology, chemistry, physics, trigonometry, geometry, calculus, and precalculus classes unless such classes were not offered. If target courses were not available, researchers sought the next closest level taught at the school. Other high-level mathematics and science classes were observed as scheduling permitted. Researchers conducted observations in the same classroom during the same time period until observational consistency was established between team members.[2] Observers focused on teachers' instructional practices and the learning environment within classrooms.

Focus groups were conducted with students at five of the six sites; students were not available at the sixth site due to scheduling. Teachers also participated in focus groups at all six sites. Administrators were not present during focus groups and participants were assured that comments would be held in confidence. Additionally, at each site, one administrator was interviewed for approximately 60 minutes. All interviews and focus groups were conducted using semistructured project protocols. Students were selected for focus groups by the teachers and administrators at their school. Researchers requested that all STEM area teachers be invited to participate in teacher focus groups.

In addition, documents were collected whenever possible. Researchers requested a range of documents focused on school-wide administrative policies surrounding admissions and faculty hiring decisions; however, not all schools provided these documents. When formal documents were not available, many schools referred us to the school's website where policy information was publicly kept. All teachers readily provided their class handouts and several offered copies of lesson plans.

Analyses

Through analytic induction (Erickson, 1986), the researchers integrated the perspectives of multiple informants within and across data collection sites. Collected data were synthesized and holistically analyzed to derive themes for the phenomena observed. Emergent themes were identified and grouped along common lines of thought from which assertions were made. These themes were validated through both member checking and iterative review of data for disconfirming evidence that could point to an alternate explanation of the observed phenomena. For example, some participants ascribed great importance to student performance on standardized assessments, but further discussions with others reflected a more nuanced differentiation between upholding the prestige of the school and the perceived value of the assessments themselves, which were considered to be limited in scope and depth compared to the schools' curriculum. Consideration of all data—field notes, interview and focus group transcripts, and collected policy and instructional documents—were incorporated into a cross-case analysis, which identified the most salient variable for classifying uniqueness across the spectrum of STEM school: intensity of engagement with STEM content by members of the school community.

Analysis was done in multiple phases. The first phase of analysis sought to explore

[2] The administration at Johnson Technical High School, the first school visited, also requested that both research team members conduct observations within the same classes, thus making it ideal for doing joint observations.

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possible novel ways for categorizing the differences between STEM schools beyond model type. Through iterative data analysis, a loosely structured schema emerged from the data revealing that STEM schools appeared to vary greatly in the intensity of the STEM experiences and courses offered. From these initial findings, further deep analysis was done to explore the ways in which these differences in STEM intensity manifested in the observed schools and classes. Disconfirming evidence was sought rigorously throughout all stages of analysis.

Validity Criteria

As a means of strengthening the validity of the analyses, several steps were explicitly taken to address potential bias. Because no one method or source is infallible (Erickson, 1986), multiple data sources were used to triangulate findings. Classroom observations were made at all six sites by two independent observers. Observers jointly observed at initial sites, and those field notes were compared for fidelity of observations. Whenever possible, all assertions were member checked with participants; however, member checking with students proved challenging due to schedules and access and, therefore, was not as complete.

Findings

Although school model type was not found to be predictive of the types of experiences available at specific STEM schools or the attitudes of the students and faculty (Tofel-Grehl & Callahan, 2014), there appeared to be substantial differences in the level of intensity of STEM experience and focus within schools. It is important to note that higher STEM intensity does not mean better STEM experience. The noted differences in intensity are not intended to argue for or against a specific type of STEM experience; no value judgment regarding what intensity of STEM experience is better or more effective for student learning is offered. Rather, the level of intensity indicates only a difference in the intensity of the program and STEM experience offered to students, not in the quality of the STEM experience.

High-Intensity STEM Schools and Programs

Those schools that emerged as high-intensity STEM schools were characterized by: a disproportionately high percentage of STEM faculty relative to other departments[3] and a notably greater number of courses offered in STEM departments relative to other departments in the school or program.[4] The high-intensity schools observed defined themselves as holding an exclusive STEM focus. Their missions identified their goal as developing the next generation of STEM contributors. Several of these schools acknowledged that they screen potential students for a stated personal goal of a STEM career. For example, one administrator stated “look, we can’t say we exclude kids who don’t write about wanting to be a scientist or engineer, but that is how it works.” (Lockheed administrator interview).

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[3] Partial day programs could be deemed low-intensity with all STEM faculty because these schools did not offer classes in non-STEM areas. Therefore, this criterion was not considered in the classification of these schools.

[4] This factor was not considered in the classification of the partial-day program observed because no other classes were taught.

For the most part, these high-intensity programs were located in urban areas proximal to large institutions of higher learning; these locations allowed for schools to draw from a very large applicant pool and admit students with very high scores on admissions criteria. These schools cultivated relationships with the universities nearby, allowing their students access to university faculty and other resources. One of these was an exception to the urban trend; however, even though it was located in a rural area it was in near proximity to the university with which it worked. This school drew from its entire state for its applicant pool, thereby having relatively the same size applicant pool as other high-intensity schools.

For example, at Johnson Technical High School, of the 157 staff and faculty members assigned to departments, 75 are members of the biology, physical science, or mathematics departments, with the remainder spread among six other departments. STEM disciplines and STEM goals were clearly central to the mission statements. A high-intensity school mission statement might state: "We serve the community, providing the highest level of science, mathematics, and technology education possible. With a history of producing Nobel Laureates and STEM industry leaders, our faculty provide students with advanced level courses in mathematics and science." [5]

Low-Intensity STEM Schools and Programs

In contrast, the environments of other programs were less intense and less driven by a focused STEM mission. In these low-intensity STEM schools, statements in documents and on websites and statements from administrators described their STEM mission as less central to the school's identity. Often, STEM experiences were part of a larger mission rather the primary focus of the school. These differences in goals reflected nuanced differences in culture. The STEM mission served as a means to an end in terms of focus and funding. A low intensity school mission statement might state "In seeking to best prepare our students for collegiate success, our school offers opportunities for students to extend their knowledge beyond the typical high school curriculum, particularly into the worlds of technology, math, science and engineering."

STEM programs observed to be of lower intensity were most frequently located in suburban or rural settings and did not offer as many courses within STEM fields as their urban counterparts. These schools tended to be smaller and served significantly smaller populations than their higher intensity counterparts. Additionally, the students at these schools reported a lower level of interest in getting a higher education degree in a STEM-related field. Of particular interest in considering these schools was the focus and value placed on STEM by the school administrators. These school administrators voiced other parts of their school mission that were a higher priority. These schools also presented less rigid and competitive admissions procedures with a stated willingness to take some lower performing students.

Common to both high STEM intensity (HSI) and low STEM intensity (LSI) programs were the types of courses and tasks offered. In addition to course content levels being comparable, the tasks and problems observed within HSI and LSI classes were also equivalent. This parity reinforces the notion that intensity of STEM experience is not inherently related to the quality of the STEM experience.

Using the categories described above (differences in intensity levels) data from observations and interviews were examined to classify each school as HSI or LSI and to examine the five key features that emerged as distinguishing features of these categories:

[5] In order to protect the identity of participating schools, conglomerate missions statements were created.

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length and type of research experience, number and variety of STEM courses offered compared to non-STEM courses, the number of faculty with terminal degrees in STEM disciplines, the level of interest expressed by students in obtaining a degree in a STEM field upon graduation, and the atmosphere of classes. Three of the schools visited were deemed high intensity, and three were deemed low intensity.

Research Experiences

Research experiences for students were available across all schools, regardless of level of intensity. However, HSI and LSI schools differed in terms of the length of these experiences, the autonomy that students were given, and the extent to which the research addressed unresolved scientific questions or focused more on learning the process of research by addressing phenomena that are already well understood in the scientific literature.

Range of STEM Courses

Additionally, all schools offered a range of STEM courses, but the number and variety of the courses offered differed by intensity. For example, at TASAM, of the 37 unique STEM classes offered, nearly 90% of them are college level. Courses such as advanced biogenetics and organic chemistry are available to students annually to provide students with a university level knowledge base. Teachers at TASAM report that they teach all courses except AP level classes at the college level; observations corroborated these teacher statements. In comparison, EAMA, which offers 31 separate STEM area classes, only teaches about 30 percent of them at the college level. The teachers at EAMA report that the variation of course level is due to the differences in skills of students within the school. With an open lottery system for admission, EAMA teachers and administrators report highly variable student skills upon entrance. The courses offered reflect those variable skills, with several remedial mathematics classes being taught.

In terms of the quality of the courses offered, no qualitative difference was noted between courses at HSI and LSI schools. The instruction observed at all schools was of a high caliber. Both types of schools offered non-traditional courses in mathematics and science such as discrete mathematics and organic chemistry. All schools offered advanced course offering covering a wide range of topics. The intensity of course offerings appeared common to all schools, but HSI schools offered substantially more of them.

Faculty Characteristics

Both HSI and LSI schools had faculty with degrees in the content area taught; however, the level of the degree held as well the number of terminal degree holders varied by intensity. HSI school teachers' percentage of terminal degree holders ranged from 47% to 85%, whereas LSI school teachers' percentage of terminal degree holders ranged from 0% to 83%.

Student STEM Interest

Interest in future STEM careers expressed by students in the focus groups broke down along school intensity lines.

Classroom Atmosphere

The atmosphere of classes presented differently in HSI schools compared to LSI schools; both the tenor and the pace of classes showed differences in the dynamics and atmosphere of the schools. Table 2 displays the relative findings, illustrating differences noted above that could be quantified. Schools in bold trended towards the more intensive STEM programs, and those in regular type reflected less intensive STEM programs.

Table 2
Class Types

School	Time for Research	# STEM courses offered	% STEM Faculty w/ PhD in field	% STEM vs. non-STEM faculty	% students w/ future interest
Johnson Technical High School	**Multiple Term Independent Study**	**78 (vs. 37 non)**	**85% (64/75)**	**48% (75/154)**	**89% (8/9)**
Academy for Science and Mathematics Education	Weekly Research classes	20	83% (10/12)	100%[a] (12/12)	0% (0/6)
Engineering and Mathematics Day School	Senior project	31 (vs. 29 non)	0% (0/14)	52% (14/27)	58% (7/12)
Southern School for Gifted Science Students	No formal program	57	8% (2/25)	40% (25/63)	40% (2/5)
Lockheed Academy for Science and Technology	**1 day per week**	**46 (vs. 23 non)**			**100%[b]**
Technical Academy for Science and Mathematics	**Senior Research**	**37 (vs. 14 non)**	**61% (11/18)**	**69% (18/26)**	**73% (8/11)**

[a] This is a partial day program so only STEM area classes are taught there; thus there are no non-STEM faculty members.

[b] It was not possible to conduct a formal focus group at LAST due to scheduling conflicts. Students were asked about STEM intent in one on one conversations between classes which were not formal. Of the four students asked, all four stated they intended to obtain degrees in STEM fields.

Representative Case Examples

Two representative cases illustrate the differences in intensity observed across the STEM schools. Following presentation of the cases, a cross-case analysis further articulates the observed differences in five traits present across the full sample of schools.

HSI Case: Johnson Technical High School

Located in a large Northeastern city, Johnson Technical High School (JTHS) focuses the majority of its educational resources on fostering the science and mathematics interests of its 3000+ students. Roughly 80% of the students are Asian, 10% are white Caucasian, and the remaining 10% are Black, Latino, or other ethnicities. Over 60% of the students are male. Referring to the

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students as "science-ites," the school boasts of seven Nobel laureates among its alumni as well as noted leaders in their fields.[6]

One of the preeminent STEM magnet schools housed within its city public school district, JTHS places high value on its science and mathematics courses and the faculty qualifications. Roughly 85% of faculty members at JTHS possess content area degrees (Master's or PhD) in the fields in which they teach. Of the 157 staff and faculty members assigned to departments, 75 are members of the biology, physical science, or mathematics departments, with the remainder spread among six other departments. With almost half of the faculty in STEM departments, JTHS is able to offer 78 different mathematics and science classes. The remaining six departments offer 37 classes in other core curricular areas

Student perceptions. Students described their motivations for coming to JTHS as based on the reputation of the school. One student stated, "Obviously the history of JTHS is huge. There are quite a few Nobel Laureates -- in physics at least." Students stated that they opted to apply for the specialized STEM magnets schools in the city because the schools "are some of the best in the city" and because of "the fact that they are specialized and very into science." Three factors seemed common contributors to the decision making of nearly all students: (1) a prior interest in mathematics or science within their home, (2) the intention to pursue a higher education degree in a STEM field, and (3) an understanding of the skills that they believed would help them succeed in reaching that goal.

Students noted that their expectations were realized. Of particular note was the recognition by the students of the large number and variety of STEM course offerings and the ability to experience the research process prior to attending college. Students agreed universally that the number of courses offered in STEM subjects combined with the number of AP courses available allowed them to "have so much variety, not only in terms of science where we can dip our feet in biology, chemistry, or physics" but also into higher level areas of science such as organic chemistry. One student with a family member who teaches chemistry in a different location noted, "When I told her [the chemistry teacher] how many AP courses they took here, she was blown away. There is just so much variety, so many things you can go into."

Additionally, students shared their perceptions about their research experiences. Research experiences at JTHS were viewed by students as intense and highly beneficial. Students described a large range of experiences as part of their research training. For example, one student described the multiyear project that he worked on with research scientists at a local university on their development of a new medication for treating depression. The biomedical research that he assisted with was in its second round of trials, and he had participated in the project for the previous two semesters. He worked with the lab technicians to run and record the actual results of the experiments. Additionally, he noted that it was his hope to publish with the scientists in order to improve his college applications. The student felt that his research experience better prepared him for real-world science careers because he felt well prepared for the rigors of working in a lab setting.

Student aspirations. Students also noted their intentions to seek higher education degrees in STEM areas as a means for entering into careers in those fields. When asked, students predicted

[6] Citations to school specific websites have been removed to protect the anonymity of the schools participating in the study.

their attendance at a specialized STEM school would allow them to be better prepared for those future majors and careers. Many students noted that they had family members with STEM careers. One student, when asked about his career aspirations stated that he “want[ed] to be a heart surgeon like my uncle.” Another student noted that his family situation drove him to seek out a career in a STEM field in which he could “become a research scientist so I can help maybe find or introduce a cure because my father has diabetes.” These stories indicate that students’ early life experiences and exposure to STEM careers may fuel their desire to attend specialized STEM schools and seek out careers in STEM.

Student experience. Students work very hard and seek classes that push them to the furthest point at which they can succeed. Some students went so far as to criticize the AP classes because they were made too easy in order to align with the target AP test. One student stated, “One caveat about AP courses, I think at least, is that they are kind of limited in their scope and their rigor, even though they are for high school level . . . . There are other classes beyond AP . . . that go into more depth into certain topics.” In addition to the specialized course offerings, students noted that the research program offered at their school provided them with the most unique and meaningful learning opportunities.

Students greatly value the opportunities to conduct their own research projects or work in conjunction with practicing researchers in an area of interest. One student explained:

> There is a course I know a couple of us are in, research . . . it’s actually a really great program that we use . . . . I built an interest for research in the biomedical field through this because, like, we look for opportunities to research outside of school. Instead of just hearing about it, we are actually working in a lab, and we are actually getting that experience.

The students see these opportunities as unique to the school model in which they are participating. In addition to the novel experience of working on actual research, students also note that the specific skills that they learn at their specialized school better prepare them for their later academic careers. Specifically students noted that they learned better time management and study skills in addition to lab and research skills.

Teacher perceptions. During interviews with the teachers at JTHS, the strong beliefs that they hold about their school community became quickly apparent. Specifically, the teachers spoke of a community of collaborators, the importance of investigative and inquiry-based teaching, the level of motivation characterizing both the students and the faculty, and the role that standards play in the content of courses.

In addition to the value placed on working towards common goals, the teachers at JTHS place high value on inquiry-based learning. The teachers described how important they believed it to be to “teach by applying the scientific method.”

Curriculum and instruction. Students are expected to design, implement, and interpret their own experiments and findings. At many other schools this investigative approach is limited to science, but at JTHS, the mathematics classes include this approach in every lesson. In fact, all STEM lessons observed at the school-required students to derive the lesson’s objective for themselves throughout the class discussion. During this process, students used problems to develop common theories and beliefs about the content from which they could derive a theorem or equation. Competency was clearly not defined as simply being able to plug numbers into a formula. As one teacher stated, she tries “to incorporate a writing problem in each test to encourage math literacy

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and that often gives me a clue as to whether they could really convey to someone else what they think they know."

Great value is placed on peer explanation and metacognition. During classroom observations, many teachers required students to explain their answers to the class. For example, in a geometry class, the students were required to write up various ways to solve a single problem. After class, the teacher explained:

> I often found that when they explain the concepts to their peers, often for some students it will click a lot faster than if I were to do the same explanation. I think a lot of it is their different perspective on how to solve a problem or what ideas are important. And based on the explanations that they give and the presentations that they do, I see how they, how they can explain this.

By using this investigative approach to mathematics and science, the teachers provide themselves with insight into the students' thinking and provide students with a stronger basis for their own understandings.

Administrator perceptions. In talking with the principal of JTHS, a clear picture of what it means to be an administrator at a high-intensity STEM school developed. She described the culture of her school as both competitive and inclusive. Additionally, she shared her thoughts regarding the students and how they shape the school. Of particular note were her values and beliefs about teachers, which drove hiring practices.

The principal described JTHS as a place where individualization around students was paramount, which distinguishes this school from other premiere STEM programs in the area. As she explains, "We need to break down the anonymity, making kids feel that they are not just a number, but that we know who they are . . . you have to individualize education." She notes that JTHS is not the highest ranked STEM program in the city; however, she argues that their program and individualization provides students with more intellectual challenges. She stated, "We are more like Cornell, maybe a little easier to get into, but harder to stay in."

Building community is hugely important to the goals of JTHS's administrator. She stated that she seeks community for both her students and her teachers. She identifies hiring the most qualified people as key to building "a community of teachers who are good at what they do and have niche specialties." In discussing faculty and hiring decisions, the principal noted that the traits she sought were a terminal degree in content area, a willingness to work long hours, and a willingness to collaborate.

> When I got here the bio department was run really well. Um, we looked at data all the time. We shared lesson plans. As a matter of fact, we had gotten [*sic*] a very large grant to write lesson plans, standardized lesson plans for our regions class . . . . The goals are always focused on the classroom and creating a community of teachers who are good at what they do and have niche specialties, now that moves from hiring to professional development . . . . [We] hire an economist, so that we are teaching macro and microeconomics perfectly. Hire political scientist; look at somebody who is social sciences and a data person. I came here with an MS in bio and half way through my Ph.D., I had no education courses, but I was smart and I wasn't resistant to change. And all of that, and you have to have a work ethic that is incredible. I always say to the teachers, "This is a 180 day sprint." You know, there is no rest for the weary. (JTHS administrator interview)

Confirming faculty members' observations regarding the heavy workload that accompanies teaching in the high-intensity JTHS environment, she noted a high rate of faculty burnout and turnover. Teachers, she noted, were expected to work at least as hard as the students.

Additionally, she noted that having teachers observe each other's lessons allowed them to understand their colleagues' approaches as well as improve their own teaching. She also stated that she uses professional development as a means for building faculty sense of community. Noting that there was a NCSSSMST conference the following week, she stated that she was taking several members of her faculty from all various departments as a way to boost their common dialogue around issues of inquiry education and best teaching practices. She believed that activities such as these furthered community dialogue around issues that were important.

The principal described students at JTHS as bright, highly motivated, and involved. She noted that many students at JTHS have been diagnosed with various learning differences. Needing to deal with students with different needs presented new challenges for the faculty and administration, which had previously only dealt with mainstream gifted students. Another issue the principal noted about the students is their involvement in and dedication to the school. She spoke of meeting with students to talk about student club issues and the concerns of the student council. As she explained "the students are driving me crazy in student organization because the just fight with me all the time and it's cool." Describing the school as a place where "it is really cool to be smart," the principal noted that the kids all feel comfortable here because they would be targets for bullying at their home schools.

LSI Case: Academy for Science and Mathematics Education

A small STEM program for 200 high school juniors and seniors, the Academy for Science and Mathematics Education (ASME) seeks to "inspire and empower our community to learn, create, and serve" (ASME mission as stated on website). Located in rural southeastern United States, ASME uses exclusive admissions criterion to admit from three rural school districts. Students in this pullout magnet program, attend the specialized program to fulfill their mathematics and science requirements while completing the remainder of their high school courses at their home high school. The majority of the school's students are Caucasian, roughly 85%, with 10% of the remaining students being of Asian descent and 5% being Latino or African American. The majority of the students attending the school are driven to and from the school's site by their parents.

One of the preeminent STEM magnet schools within the state, ASME places heavy emphasis and value on the number of science and mathematics courses offered by their small faculty. Classes are offered from 7 a.m. until 11:30 a.m., 5 days a week. This provides for four class blocks a day, during which time the school offers seven science classes, five technology and engineering classes, and eight mathematics classes. (Comparatively, JTHS offered 78 unique STEM area classes for students across science, technology or engineering, and mathematics.) All of the science and engineering classes have required laboratory components, which take up at least one hour block a week. All 12 of the faculty members have content area degrees, with all but two possessing terminal degrees in their content area. Several of the faculty work as instructors in their content area at local colleges and universities; outside teaching was observed at HSI schools and would have not been possible given the intense workloads described by those teachers.

Student perceptions. Students seeking admission to ASME begin the admissions process in the fall of their sophomore year. Criteria required for admissions are student essays, teacher

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recommendations, test scores, and transcripts. When asked why they chose to attend the school, students offered multiple responses, which were more broad and less focused on STEM interests and careers. The answer that resonated with the students in the focus group was the importance of surrounding themselves with like-minded peers and teachers. Students at ASME described feelings of not belonging at their home schools and indicated that they were often teased or made to feel uncomfortable for being interested in intellectual pursuits. Additionally, the students were in agreement that the teachers in their specialized program provided them with opportunities to work in an environment of mutual respect. All of the students who were interviewed voiced feeling disrespect from teachers at their home schools. As one student explained, the difference between his home school and his specialized program as "they [teachers] treated us like little kids and like we can't handle ourselves. And here they respect us and expect us to have our own responsibility and stuff" (ASME student focus group).

A key feature of the ASME experience was the school's culture, as created by the faculty. In talking about the culture of ASME, the students described the ways in which they articulated the shared belief supported by the program and teachers. Of particular importance to them was the fact that like-minded individuals surrounded them. As one student explained, "It's not bad to be smart here. It's cool." The students believed that their teachers supported and fostered this environment by their accessibility as well as their high expectations.

The students in the focus group described teachers as highly motivated and highly skilled in their subject areas. They also believed that all the teachers at ASME not only knew their content but also demonstrated that, as a faculty, they were vested in the students' success. Students noted that they were expected to ask questions for themselves and be vocal participants in their own learning. According to one student, "at least for me, if I ask questions, they are glad that you are asking questions and they will take the time out of their day to sit down with you and actually make sure you understand it" (ASME student focus group). Students described a different dynamic at their home schools where they stated that teachers neither cared nor possessed the content knowledge to further student understanding. Students perceived that the heightened expectations of the teachers and the greater level of independence in allowed them to make better choices about how to work on projects. One student noted that the teachers "don't pester you about it" if work is not completed at the due date.

In discussing their research experiences, students at ASME described a strong sense of ownership regarding their projects. Students at ASME are required to complete a one-semester capstone project on a topic of their own choosing. Many students work in professional lab settings at the local university. One student, working on a computer software development project, described his role as "hardly central, but a real part" of the larger project. The student was partnered with the university IT group that had been tasked with evaluating the larger university course scheduling programs. The student described his work in two parts. Firstly he interviewed and queried system users about the previous program. Secondly, he helped design the new program that was to better meet the needs of the diverse set of participating departments. Although the research questions of his project were not entirely his own, the student felt he was able to "work in [his] own ideas about what worked best for students." Working on campus once a week, the student was able to make both professional connections as well as experience the real world applications of a career in technological services and systems engineering. The student described his research project as his favorite part of his ASME education.

Student aspirations. Of the seven students who participated in the focus group, only two stated an interest in going into a STEM related career. The remaining students stated they were either undecided or planning to pursue careers in non-STEM fields. Students saw their time at ASME as a means for preparing for college, both in terms of strengthening their admissions resumes and in terms of the knowledge and skills acquired prior to college. As one student explained:

> We are just taking a lot more challenging courses than we are ever offered at our home school, so that looks good for college, and we are taking some college classes. Like he said, physics is a class at UTA so we are getting college credits so we are already getting a head start for college.

From the student vantage point, these additional college credits improved their standing in the college application process. However, physics was the only university-level course offered at ASME; all other college credit courses were at the AP level. In addition to enhancing their college application, students also perceived that they learned valuable skills while attending ASME noting, for example, that their participation in the school's independent research project helped them learn better time management skills. Describing it as a yearlong independent piece of work, the students believed that their independent research project allowed them to both develop skills they needed for future success and pursue work on their own interests.

Student experience. Students at ASME saw their experiences at school to be challenging and interesting. They stated that the first few weeks attending ASME were challenging due to the increased workload over their home schools. However, students noted that they were able to adapt to the new program and workload with relative ease. Students felt that faculty members were flexible about the dates on which assignments were due which alleviated a great deal of stress from them as students; as one student stated "if you don't get it done, they don't pester you about it." Students at ASME stated that lab experiences at their specialized school were entirely different than the ones at their home schools. As one student explained:

> It is also different from our home schools in that our home school lab [where it was] here is a worksheet, here's all the steps, just do it, that's it . . . . Here [at ASME] it's you get all this data and then you have to answer questions that he gives you based on your data . . . and I had to explain why that might have happened where it was supposed to . . . . It is a lot more like critical thinking as opposed to just do it.

Students expressed their comfort with talking ideas out and having enough time to discuss things with peers and teachers.

Teacher perceptions. The teachers at ASME identified several key features at their school that, in their opinion, made it both a unique and superior learning environment for students. One of the most important features of the school, as described by the faculty, was the school's culture. Specifically they talked extensively about how the school's culture differs from that of the students' home schools. Describing their students as "weirdoes" and "misfits," the faculty said that students who opted into the ASME program tended to feel like outcasts at their home schools. This specialized program allows them to be around other students with similar interests and social issues. The teachers took a great deal of credit for the open and accepting culture of the school. In talking about some of the challenges that students faced at home schools, a teacher used the example of one student who struggled with assimilating because of having Asperger's; his challenging home school experience was not repeated here:

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> Russell, you know, would walk up in the middle of your class and be right here talking to you while you were trying to talk to the rest of the students about something else. Everybody knew Russell, the students did, we did. Everybody would take it in stride.

Another teacher followed up on this explanation, stating: "we are not always the normal high school teacher, either . . . . I think all of us are very enthusiastic about what we teach and therefore, the students see that." The nature of the comments from the teachers denotes ownership over the culture; they allow students to be different and to bring their own interests to their classwork. As one teacher explained teaching there focused on:

> Giving them tools, but letting them use it to express what their interests are something like that. Doing a design program where they can, you know, design some kind of engineering object that they want to or like something they saw like from a TV show. I mean they all have interests and they all want to tell you about them, so providing that a way to do that as maybe part of the curriculum or maybe just a conversation with them. Both of those, I think, let them be able to express who they are, like we were saying.

In probing the faculty regarding their perception that they control the culture of the school, one teacher openly stated, "we didn't care [what anybody thought] when we were in high school," and he perceived his students to hold similar attitudes. The faculty acknowledge that they identify strongly with their students. The combination of an empathic and embracing faculty and being surrounded by like-minded students provided the program with a unique culture, which embraces intellect and differences. Although faculty at the HSI schools showed pride and caring for their students, they did not articulate identifying with their students nor were particularly warm relationships observed.

Another aspect of the ASME program experience, which teachers in the focus group deemed essential for students was the setting of expectations. Focus group participants stated that the students benefited greatly from their ability to set their own goals as well as work independently. Students at HSI schools were encouraged to work independently, but students at ASME were afforded greater freedom to set personal goals. Much of the work prescribed by teachers requires students to work independently and learn additional material on their own. Teachers stated that the expectations that they possess for students represent college-level work. Because the courses offered to students at ASME are dual enrollment with several local universities, the teachers maintain college-level lessons and tests so that the students earn college credit for their work. The teachers noted that the student body is well behaved, they do not lose class time for behavioral issues. However, the high academic and time management expectations are what teachers argued made the students most apt to grow intellectually. As one teacher explained:

> We give them something else too, beyond the academics. They have to learn time management because they are so over whelmed with the workloads in these classes that they can't sit around and waste time. They can't come home and sit in front of the TV for two hours before starting homework. They've got an evening ahead of them. So to me, the most valuable thing that they learn at ASME is how to manage their time and how to organize their work.

The teachers also noted that the schedule of the school encouraged the students to work collaboratively outside of school hours. Although students returned to their home schools midmorning, most students returned to ASME in the evenings to work in groups and get tutoring help from the faculty and older students. Teachers noted that they placed a high value on teamwork and collaboration. As educators, they expected students to work together to solve problems and further their own understanding. Additionally, the teachers noted that students often used social media and other Internet resources such as Moodle pages as a means to connect with each other regarding class work.

Curriculum and instruction. Labs observed within ASME were less independently structured than those seen in HSI schools; students were provided more rigid setups and guidelines to answer predetermined questions. Driving questions for experiments were given by the teacher for the purposes of the content of the courses. For example, one lab observed provided students with the research questions and methods for conducing an experiment; students followed the steps until they had collected their data, at which point students discussed their findings in groups and worked to develop their own explanations and understandings of the differences in findings. At no point in the lessons observed at ASME were students asked to derive the content oriented goals of their class like they were at JTHS.

Teachers were interested in finding the best instructional practices for their classes. Because the school is a partial day program, most of the faculty holds lecturer positions at local universities. Teachers reported using the knowledge that they gained as university professors to identify best practices for their high school students. As one teacher explained:

> There is a guy at Harvard, who is doing what is called Peer Instruction, and so while my curriculum is set by UTA (local college), the way I teach it is what is called Peer Instruction, which is what all the clickers and that was about.

Clickers were observed during physics classes as a way for the teacher to check student understanding as well as to promote class discussion. At one point when students did not have a clear understanding of a concept being discussed, the teacher stopped the teacher-led discussion and turned the class entirely over to the students who spent the remaining portion of class discussing the issue. By using this open discourse approach to classes, the teachers provide themselves with insight into student thinking and provide students with a place to build their own understanding.

Administrator perceptions. Of particular importance to the school administrator were her role in fostering the community of learners and her role in hiring meaningful and capable faculty. In describing the culture of ASME she stated:

> The school becomes a community of learners with students from 7 different high schools working together. All have similar interests and motivations so they "elevate" each other as learners. Staff is delivering college level material with support and teaching students to be responsible for their own learning in addition to content . . . . Students and staff are more involved in program development. For example, a student committee is part of interviews for new staff. The program adapts to meet students needs based on their interest (offering Biophysics) and skills.

She sees her role as supporter of that community. Her description of the students offers insights into the ways in which she offers that support. Describing a student body of high-achieving students, she explained that often in their first year students find themselves under a great deal of pressure, which she tries to alleviate. She also seeks to help students connect with a faculty mentor. In recent years, she developed a journaling program for first year students; these students write weekly journal entries to a faculty mentor as a means for providing faculty insight and access to students' feelings and stress levels. The teachers then use this information to assist students who struggle

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with the new workload and expectations. According to this administrator, a large portion of her job involves developing the students into safe and secure students and not simply high-achieving ones. As she stated, her goal focuses on helping "students learn to operate independently as responsible citizens and learners."

Another major part of her role within ASME focused on the faculty. The principal stated that she sought teachers with a master's level degree in their STEM content area. She stated that this level of degree was required because many of the classes offered at the school were dual enrollment, meaning that the students received actual college-level credit for courses. Therefore, she required the same level of education for members of her staff as would be expected of someone teaching the same course at local college in the area. When probed further for additional hiring criterion, the principal described the teaching approach of teachers at ASME: "We look for the ability to relate to students, to engage students in the curriculum, to translate instructor's knowledge to student, to work collaboratively with staff and willingness for continuous professional growth." She also stated that teachers needed to demonstrate a willingness to devote extended days and times to the students. Making reference to the school's well-established after-school tutoring program, she commented that ".without being willing to stay, you just can't do this job."

Cross-Case Analysis of Distinguishing Traits

Five discrete factors emerged as differentiating the experiences offered at high and low STEM intensity schools. Although variation can be seen on any one trait, looking at them together yielded a stronger sense of the intensity of the STEM experience offered at each type of school.

Research Experiences

Student research experiences were observed at all six sites visited; however, each school implemented student research differently. HSI schools developed rigorous independent research programs and requirements for their students. They set aside significant portions of instructional time for students to conduct their research throughout their years in the program. For example, one HSI school set aside an entire day of the school week for students to attend research opportunities off campus. Additionally, many HSI schools cultivated relationships with industry, allowing them to place their students in labs for real-world research experiences. Alternately, LSI schools often did not have specific research times built into their schedules, nor did they share information indicating relationships with industry members, which might have provided students access to meaningful field experiences. For the most part, these research experiences were independent research papers or projects with few mandated requirements regarding what type of research students engaged in. HSI schools had more formalized processes which often required students to focus on experiment-based research, whereas LSI school administrators stated willingness for students to research social science or historical topics rather than the more traditional "hard sciences."

Another distinguishing feature of the research experiences observed at HSI schools versus LSI schools was the role of an Institutional Review Board (IRB) in student research. All of the HSI schools required students to submit IRB documents for approval in advance of conducting research. Only one LSI school reported a similar process.

Number and Variety of STEM Course Offerings

HSI schools consistently offered more courses in STEM disciplines with classes ranging from optics to molecular genetics. LSI schools offered significantly fewer course choices for students. The total number of unique STEM area courses offered at all three HSI schools totaled 161, whereas the three LSI schools totaled 108 (see Table 2). Additionally, HSI schools referred to AP classes as the minimum course level offered, whereas LSI schools AP classes often offered them as the highest level course. At all three of the HSI schools visited, almost all STEM classes were taught at the college level, although there were fewer observed at the LSI schools.

Faculty With Terminal Degrees in STEM Disciplines

In exploring the differences between HSI and LSI schools, differences in the faculty became clear as well. Because schools spanned six separate states, credentials and licenses did not make for a meaningful point of teacher comparison; given that each state requires unique things for teachers' to gain credential, higher education degrees attainment levels were compared. Sixty-seven percent of the faculty at HSI schools were PhDs in their field, but only 35% of faculty at LSI schools were PhDs. Additionally, the LSI school with an abnormally high number of PhD holders on faculty allows it's faculty to hold faculty positions at local universities due to the nature of the school as a partial day program; if that school were removed from the sample of schools, the other LSI schools would have an average of only 5% PhD holders.

Future STEM Degree and Career Interests

Students at HSI schools and LSI schools reported highly variable levels of interest in obtaining STEM area degrees after the completion of high school. Of the 19 students in HSI schools questioned in focus groups, nearly 85% reported an intent to seek a career or higher education degree in a STEM related field; however, of 23 students in LSI schools questioned, only 42% reported future interest in STEM careers or degrees. When probing this difference further, some HSI administrators indicated that although not technically required for admissions, students not stating an interest in a STEM career in their application are not considered (LAST administrator interview). Conversely, administrators at an LSI school noted that their priority for students was successful entrance into college and interest in STEM was a secondary concern.

Atmosphere of Classes

Classes at HSI schools appeared more intense than those observed at lower intensity schools. The pace of classes in HSI classrooms could be characterized by rapid-fire interactions and extensive content coverage. Teachers asked questions quickly, provided less time for solutions than observed at LSI schools, and moved through material with extreme efficiency. The following is a vignette that captures the nature and experiences of one class at a high-intensity school.

Vignette 1: HSI geometry class.

> As the 30 students hustle into the seats of their freshman honors geometry class, their teacher yells, "Hurry up and get to your seats. We have a lot to cover today. Before I forget to remind all of you midterm examinations are tomorrow. It counts for 50% of your grade. Also, your research proposals are all due to me by the end of school today. Also, please pass

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forward last night's homework, problems 14-115. Now, there's a problem on the board. I am going to give you all two minutes. Go!" As the students frantically work on the problem, the teacher moves around the classroom checking student progress.

"Twenty more seconds; start listing all of the vertical and congruent angles in the diagram," he shouts out.

A student calls out a pair of angles.

"Good, why is angle eight congruent to angle four? These are good terms to be using as you describe your answers, guys. Can you tell me more about what you mean?"

Jimmy takes a deep breath and then delves into a lengthy explanation of the nature of transverse angles and how they relate to the corresponding angles.

"Ok, good. So based on this example problem and the discussion thus far, what do you think that our class aim is for this morning?" asks the teacher.

There is silence from the class.

"Guys, we don't have time to waste. What do we think our aim is for today? Let's build this definition together," the teacher says in a more urgent tone.

Not getting a response from his class, the teacher has one student stand up and act like a line. He then lays himself across his desk and says, "What kind of lines are we? Can we intersect? Are we parallel? Partner up and talk about them dimensionally."

As the students partner up, the teacher remains prone across the desk while yelling out features of their lines. Suddenly, he jumps up and starts writing on the board while talking very quickly. "OK let's do these problems!"

The kids start to groan and whine about the amount of work. Suddenly the teacher puts his hands on his hips and states "Look, I know it's a lot, but that's how it needs to be in here. One of the two mathematics classes you are required to take as juniors covers a unit on advanced geometry focused on plane curves and their applications. The basic stuff we cover this term will prepare you for that. That's why we have so much work in here; we have to cover a chapter every five days now to make sure you are ready for that. *That's* how much ground we need to cover. This is what it means to be a student here."

"We notice that all these angles are congruent. And we notice that these lines are parallel. So we know that the angles are congruent when the transversal cuts thru parallel lines.

So what I would like you to in pairs is please do these two problems and see if it works out. Find out if this is a bi-conditional situation. Discuss, discuss! I want to hear the ideas!"

The students work in pairs to solve the problem. One student raises her hand and asks, "Should we try and make a proof?"

"Sure try and set up a two-column proof even though I haven't shown you how. I think you can do it."

As the bell rings and the students start to pack up their papers, the teacher reminds them "Don't forget the exam tomorrow and reports are due at the end of the day. Next week we need to prep for the (state) testing and we are starting a new unit on tangents. I know some of you will be off campus completing your research project tasks, so email me to catch up."

Classes at LSI schools presented very differently from those of their HSI counterparts. The teachers did not speak as quickly and did not appear to cover as much material in individual class sessions. For the most part, students also presented themselves as less stressed and more relaxed. Class discussions provided significantly more time for group sharing than observed at the HSI schools. The following vignette illustrates the atmosphere in a LSI mathematics class.

Vignette 2: LSI geometry class.

> As the students meander into the classroom, the teacher completes writing the warm up problem on the board. The students all finish their conversations about the past weekend. The teacher says, "Ok, let's focus in. We have two demo problems to get through. I am going to give all of you about ten minutes. When you have finished your own solutions, please share with a partner and then with your table group. You need at least two solution paths to be done."
>
> The students go directly to work. While they do, the teacher moves around the classroom, making herself available to students for assistance.
>
> One student asks to her classmate, "Do you know how to do a two column proof?"
>
> "No," replies her classmate. They continue to talk. One of them takes out the textbook and turns to the index where she looks up the two-column proof. As the teacher walks by she sees them: "Good, I am glad you are using the text. Guys please know you can use your text as a reference. I would like to see everyone working with their materials as well as their classmates."
>
> The students finish up their solutions. As they finish, the teacher calls the group together and has several students come to the board to share their solutions. After all the solutions are written up, the teacher says, "Wow, I see a lot of you chose very different ways to solve this problem. We are going to need to sort out, which ones work and then, which ones work best. Let's group up for the rest of the period. Find yourselves groups of five. Then I want you to figure out, which solutions are most efficient and why. Spend the rest of today's class doing that and we will pick up with the rest of the lesson tomorrow. "
>
> She dismisses the groups to go to quiet areas to work.

Conclusions

Although there are significant common themes and programmatic themes and features among different STEM schools, significant differences exist between the nature and intensity of the STEM experiences of schools. Categorizing STEM schools into higher and lower STEM experience intensity provides a mechanism for examining those differences. Students in schools with a higher STEM intensity appear to spend more time on the "doing" of science. These schools tended to devote more time and resources to student research experiences. Administrators at these HSI programs, compared to their LSI counterparts, placed more importance on teachers holding terminal degrees in their content areas. LSI schools were observed to be less likely to prescreen students for a preexisting interest in STEM field work and, in most cases, offered fewer courses in STEM areas than their HSI counterparts. Students at LSI schools also reported less stress and more sleep than those from HSI schools. Additionally, differences in teacher education levels may impact student opportunities or the depth of content knowledge taught; it can be reasonably argued

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that teachers with PhDs in their content area possess more knowledge to share with their students than those who do not. However, how that plays out for students is still unknown.

Although no conclusions can be drawn regarding outcome differences for students based on school STEM intensity, within the observed sample, students from high STEM intensity programs tended to state more interest in continuing on with their STEM education, a likely finding given the noted screening procedures. This finding supports findings from other studies (Subotnik et al., 2010); however, given the current paucity of research in the area, it cannot be determined whether increased stated STEM interest stems from prior interest or programmatic effect. Given the restrictive admissions policies of most HSI programs, students without early interest may in fact be barred from admissions and further exposure. Further research is warranted to determine the direct impacts of programmatic STEM intensity on future student STEM degree attainment. By better understanding the effects of differently intense STEM programs, a clearer picture of the impacts of these schools and their unique programmatic features can be discerned.

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