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Abstract

This instrumental case study of Manor New Tech High (MNTH) provides insight and understanding of a trend in U.S. education to create new STEM schools and increase the achievement of students underrepresented in STEM. MNTH was an inclusive, STEM-focused high school, in Manor, Texas. The creation of the school was stimulated by a statewide Texas STEM education policy initiative, seed money from private foundations, and local community support. MNTH was chosen for this study because of its diverse student population and reputation as a successful, innovative STEM school. The case provides an in-depth look at the school's design, implementation, and outcome dimensions, in context. Ten candidate critical components framed the study and illuminate opportunity structures for MNTH students as they learned STEM and built social capital. MNTH implemented a project-based learning instructional environment, ubiquitous integration of technology, and a strong STEM curriculum. Teachers collaborated to create innovative curriculum and instruction, led by an energetic, well-connected principal. A robust network of student supports helped to ensure that students attained the skills and confidence in STEM and for college admission. The positive school culture promoted a sense of family, and the STEM focus enabled acquisition of 21st century skills.

Introduction

There has been a recent growing trend of creating schools with an intensive STEM focus, designed to include students interested in STEM and provide them the opportunity structures to prepare for STEM college majors and careers. The present paper provides a case study of Manor New Tech High (MNTH), an inclusive STEM high school (ISHS) located in Manor, Texas in the United States. MNTH was a small (about 400 students) and unusually enterprising STEM high school outside of Austin, Texas. MNTH was well-regarded and often cited as a positive example of a STEM high school by policy makers and policy influencers. In 2010, U.S. Secretary of Education Arne Duncan highlighted MNTH as an exemplar 21st century school, and cited the school for its success in teaching underserved youth through project-based learning and the integration of technology (Duncan, 2010). MNTH was featured in the NRC report on STEM education in the U.S. (NRC, 2010) and in May 2013, President Obama traveled to MNTH and used it as a setting for a speech about U.S. STEM education needs. The school was featured as a STEM education success story because it consistently produced students with high levels of achievement in STEM fields.

Unlike the traditional highly selective STEM-focused schools that target students already identified as being highly capable in STEM, MNTH is among a new type of school emerging across the U.S.—inclusive STEM high schools (ISHSs). The goal of ISHSs is to develop new sources of STEM talent among underrepresented minority students and provide them with the means to succeed in school and in STEM college majors, jobs, and careers (Means, Confrey, House, & Bhanot, 2008; Riegle-Crumb, Moore, & Ramos-Wada, 2011; Sadler, Sonnert, Hazari, & Tai, 2012; Tan, Calabrese-Barton, Kang, & O'Neill, 2013; Scott, 2012). We define an ISHS as a school that accepts students primarily on the basis of interest in STEM, rather than high aptitude or prior achievement. Such schools provide students with a more intensive STEM program of studies than usually required for high school graduation, as well as STEM experiences designed to engage and inspire students in STEM.

To better understand ISHSs, the purpose of this paper is to describe the design and implementation of organizational, curricular and instructional features of an exemplar ISHS, MNTH, using an instrumental case study approach.

Background

In September 2010, President Obama issued a challenge to the U.S. educational system to create more than 1000 new STEM-focused schools over the next decade, including 200 STEM high schools (Obama, 2010). This was stimulated by a report from the President's Council of Advisors on Science and Technology (PCAST, 2010) that claimed that the success of the U.S. in the 21st century, its wealth and welfare, depends on the ideas and skills of its population. As the world becomes increasingly technological, the value of these assets will be determined by the quality of its STEM education. In order to meet immense challenges in energy, health, the environment, and national security, a greater portion of populace needs to be better prepared in STEM and generally more STEM literate.

The PCAST report pointed out that the U.S. needed to improve both proficiency and interest in STEM in its K-12 education system, especially for groups of students underrepresented in STEM fields: African-Americans, Hispanics, Native Americans, and women. "The United States cannot remain at the forefront of science and technology if the majority of its students—in particular women and minorities underrepresented in STEM fields—view science and technology as uninteresting, too difficult, or closed off to them." (PCAST, 2010, p. 36).

Several U.S. states have incorporated plans for ISHSs into their overall state education policies, including Ohio, North Carolina, and Texas, and more recently, Washington, Tennessee, and Arkansas. These new ISHSs are receiving national attention and enthusiasm from policymakers, business and industry, foundations, and the popular press in the United States. Until recently, however, there has been little systematic research on them.

In general, findings from effectiveness studies show that ISHSs in Texas are somewhat more effective than other high schools, or the results are equivocal. For instance, an evaluation found that T-STEM high schools had slightly, but significantly, higher 9th-grade math and 10th-grade math and science test scores compared to other schools, after controlling for demographic and prior achievement variables (Young et al., 2011). Similar results were found in a series of research studies on ISHSs using hierarchical modeling for a study of 5,113 students graduating from 39 ISHSs and 22 comprehensive high schools in Texas and North Carolina. Means, Wang, Lynch, Peters, and Young (in review) found that, compared with peers from the same demographic groups and with similar grade 8 achievement levels, underrepresented minority and female ISHS students in both states were more likely to undertake advanced STEM coursework and were more college ready. A doctoral dissertation by Oner (2015) concluded that while some results of the comparisons run on a state data set were equivocal, T-STEM academies partially fulfilled their promise for some groups of students, over time, especially for Hispanic and economically disadvantaged students—students who were the target of the TSTEM efforts. Similarly, Erdogan and Stuessy (2015) found that student demographic variables (gender, ethnicity, socioeconomic status, and special education status) may influence the success of students attending STEM schools, but effect sizes were small, although favoring T-STEM schools. Overall, the results for studies of ISHSs in Texas pointed in a positive direction. Most authors agree that the findings warrant cause for optimism and have implications for equity and increased social mobility in STEM fields. ISHSs can serve both national and state/local interests and create new opportunity structures for students underrepresented in STEM.

Theoretical Foundations, Assumptions, and Framing

Theory on Opportunity Structures

In order to learn more about how ISHSs create opportunities for students underrepresented in STEM, we initiated a five-year research program called Opportunity Structures for Preparation and Inspirations (OPSrI; Lynch 2015; Peters-Burton, Lynch, Behrend & Means, 2014). A major goal of the project was to develop a model describing how successful ISHSs work. We began by creating a series of case studies on successful ISHSs, and then conducting cross-case analyses.

Successful ISHSs do more than focus on STEM or use new technologies; they create new "opportunity structures" for their students. This term was introduced in the 1960s by Kenneth Roberts (1968) as an alternative to then current theories of career development that focused mainly on student choice. Roberts suggested, "the momentum and direction of school leavers' careers are derived from the way in which their job opportunities become cumulatively structured and young people are placed in varying degrees of social proximity, with different ease of access to different types of employment" (1968, p.179). In other words, psychological choice did not govern students' success as much as the actual physical and social affordances found in some geographic locations, but not others. Determinants of occupational paths included the home, the environment, the school, peer groups, and job opportunities. Roberts (1984) later expanded his ideas about opportunity structures to include factors such as distance to work (or school), job qualifications, informal contacts in business, ethnicity, gender, and cyclical and structural factors operating within the economy that result in a demand for labor with skill levels.

STEM-focused high schools build opportunity structures for students in STEM that they might not otherwise access through their neighborhoods or families. ISHSs deliberately recruit students when they are in middle school, attracting students who want to study STEM and who have families that wish to support their aspirations (c.f., Riegle-Crumb et al., 2011; Sadler et al., 2012). Their missions are to attract students underrepresented in STEM fields and provide STEM programs that enable them to be successful in STEM. Students further develop their STEM identities and accumulate relevant learning and affective experiences in STEM, both in school and outside of it. The instrumental nature of Roberts' theory is helpful in understanding what it might take for students underrepresented in STEM—who may be less affluent and whose parents may not have attended college—to move into satisfying and rewarding STEM fields. We hypothesize that successful ISHSs, either deliberately or intuitively, create opportunity structures designed to guide and support students toward STEM college majors, jobs, and careers.

This case study focuses one school, MNTH. While this school had a well-known reputation for its students' successes in STEM and as an innovator of project-based learning, less was known about how the various aspects of the school worked together to create opportunity structures for its students.

Candidate Critical Components to Study Opportunity Structures

For the MNTH case (and all of the cases in the OSPrI study), we employed an instrumental case study design (Yin, 2008; Stake, 1995; 2006) that relied on the collection of narrative data and their interpretation *through systematic and consistent means.* To organize this approach, we reviewed the extant literature on STEM schools to locate common constructs or "critical components" seen as important to the schools' functioning and outcomes (Peters-Burton et al., 2014). The review suggested a set of critical components that may work together to form schools that create opportunity structures for students. We eventually arrived at a list of ten candidate critical components, presented in Table 1. These critical components would be used to illuminate MNTH's design, implementation, outcomes, and context, as discussed below. In addition, we expected that other "critical components" would emerge from this case study.

Conceptual Framework

The conceptual framework for this study drew upon and extended the evaluation framework proposed in the NRC Committee that reviewed K-12 Mathematics Curricular Evaluations (Confrey & Stohl, 2004) and modified the survey framework used in the STEM High Schools study (Means et al., 2008). Figure 1 suggests that in order to understand an ISHS as an instructional and educational entity, there are three primary dimensions to consider: the program's design, the program as implemented, and student outcomes. These dimensions interact and are moderated by the school's context.

The elements in a school's design dimension may include the school's goals, governance, academic structure, student recruiting and selection, curriculum and pedagogy, and outside partnerships (Means et al., 2008). The implementation dimension includes the extent to which intended design and critical components are put into practice. For the student outcomes dimension, ISHSs should improve underrepresented students' preparation in STEM in ways that inspire and provide requisite background knowledge and skills, instilling confidence and desire to seek more STEM education, jobs, and careers (Means et al., 2008; NRC, 2004). Outcome goals may vary by school, with some focusing on test results, others on student products or engineering skills designed for local contexts, or still others on the accumulation of college credits. Other school level outcomes may also include student attendance, mobility, and graduation rates; all reflect students' valuing of the school. ISHSs need to demonstrate that their students have improved near-term outcomes (i.e., assessment data, earned STEM credits, and awards), mid-term outcomes (i.e., graduation and drop-out rates, college admissions rates, and STEM-intensive jobs), and long-term outcomes (i.e., college major, STEM credits, college graduation, and STEM careers). All three dimensions in Figure 1 are affected by contextual factors, systemic factors, and unanticipated side effects, including life events, community resources, and environments beyond the typical school day or school building.

Table 1. Critical components (CCs) of inclusive STEM focused high schools
(An expanded online version with references can be found at http://ospri.research.gwu.edu/research-framework)

Critical Component developed through literature review	Definition of Critical Component
CC1. College-Prep, STEM Focused Curriculum for All	Rigorous courses in all four STEM disciplines, or engineering and technology are explicitly, intentionally integrated into STEM subjects and non-STEM subjects in preparation for college.
CC2. Reform Instructional Strategies and Project-Based Learning	STEM classes emphasize instructional practices informed by research for active teaching and learning, immersing students in STEM content, processes, habits of mind, and skills. Opportunities for project-based learning are encouraged and measured by performance-based assessment practices that have an authentic fit with STEM disciplines.
CC3. Integrated, Innovative Technology Use	The school's use of technology connects students with information systems, models, databases, and research; teachers; mentors; and STEM-related social networking resources.
CC4. STEM-rich, Informal Experiences	Learning spills into areas regarded as "informal STEM education" and includes apprenticeships, mentoring, social networks, and engaging in STEM activities outside of school. As a result, the relationships between students, teachers, and knowledge are altered and hierarchies flatten.
CC5. Connections with Business, Industry, and the World of Work	The school boundaries extend beyond the school by creating partnerships with business and industry. The school environment intentionally reflects the workplace; students have the opportunity to think like professionals.
CC6. College Level Coursework	The school schedule is flexible, providing opportunities for students to take classes at institutions of higher education or online.
CC7. Well-Prepared STEM Teachers and Professionalized Teaching Staff	Teachers are highly qualified and have advanced STEM content knowledge and/or practical experience in STEM careers. There are in-house opportunities for professional development, collaboration, and interactions with STEM professionals in the field.
CC8. Inclusive STEM Mission	The school's stated goals are to prepare students for STEM, with emphasis on recruiting students from underrepresented groups.
CC9. Flexible and Autonomous Administration	The school has autonomy from the school district to address the goals of its innovative STEM program The school may have partnerships with charter networks and non-governmental organizations that provide leverage, expertise, leadership, and resources for the school.
CC10. Supports for Underrepresented Students	The school provides supports (tutoring, advisories, and special classes during and outside of school hours) for students to strengthen their STEM content and skills and to prepare them for STEM college majors.

The MNTH case study demonstrates how the critical components listed in Table 1 are manifested in MNTH's design and implementation dimensions in Figure 1. The case also explored contextual factors that enhanced or inhibited design and implementation. The outcome dimension for MNTH relied on staff, student, and community reports and existing databases, and compared the MNTH student outcomes with those of comparable schools or district and state-level statistics. These comparisons do not allow causal claims, but are indicators that students at MNTH were thriving in an innovative STEM environment.

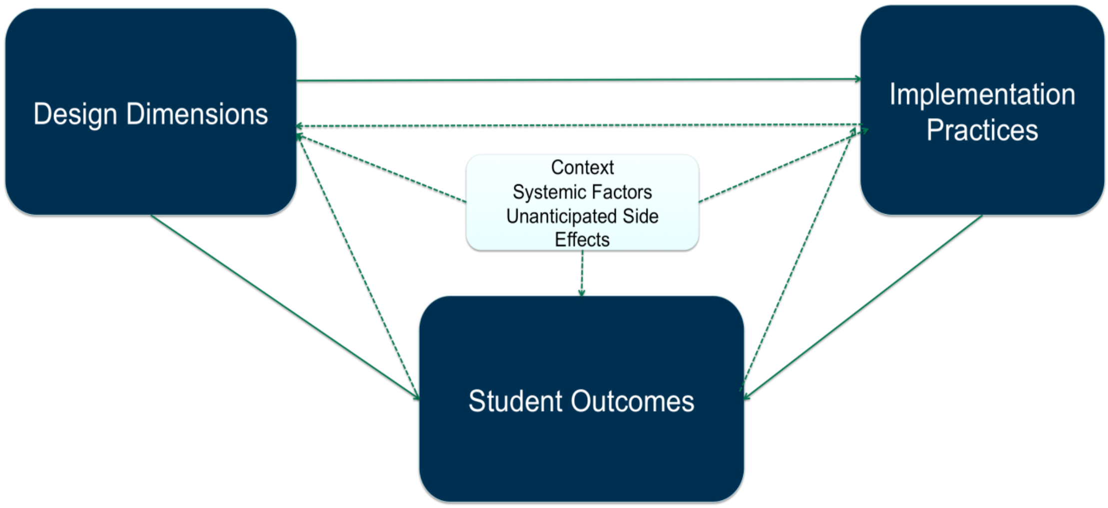

Figure 1. Conceptual framework for the OSPrI study

This diagram represents the interconnections of the different dimensions (design, implementation, and outcomes) and the relevant context. The solid lines with arrowheads represent direct connections between the dimensions represented in the rectangular boxes and the dotted lines with arrowheads represent possible factors that mitigate the dimensions (adapted from Means et al., 2008).

Framing the Study

This instrumental case study of MNTH asks:

1. What was the evidence for the presence of each critical component at the school?
2. How prominent was each critical component at the school?
3. What other themes emerged from the analysis not included in the critical components?

Method

Study Design

Instrumental Case Study

This study employed an instrumental case study design (Yin, 2008; Stake, 1995; 2006). MNTH was chosen as a critical case (Yin, 2008), with a unique governing structure and academic organization likely to have broad effects on implementation and outcomes. This method is ideally suited to the study because it is a thorough approach to studying new school models such as ISHSs and promises rich results. It provides a means for rigorous case analysis but also is open-ended, allowing new empirical evidence and interpretation to inform the research.

Data Sources

The study used multiple data sources for triangulation (George & Bennett, 2005). The data sources were created to focus on the design and implementation dimensions (see Figure 1) of the ten critical components found in Table 1. Focus groups and interviews with administrators, teachers, curriculum specialists, students, outside partners, and parents were used to inform curriculum design and implementation, technology use, learning opportunities outside of the classroom, the nature of external partnerships, early college coursework, professional development, interpretation of mission, administrative structure, and supports for students. We conducted classroom observations using Reformed Teaching Observation Protocol (RTOP; Piburn, Sawada, Falconer, Benford, & Bloom, 2000) and the Lesson Flow Classroom Observation Protocol (LFCOP; Lynch & Hanson, 2007), as well as artifact analysis of syllabi, lesson plans, and student products. We used these data to describe the level of rigor and types of learning opportunities implemented at the school. We conducted artifact analysis of school websites, application procedures, high-stakes test scores, and other relevant online information to describe design elements of the curriculum, informal learning opportunities, STEM partnerships, early college opportunities, and inclusive STEM mission. We designed and administered an online survey to MNTH teachers to capture information on teacher backgrounds and perceptions. We also gathered evidence that indicated that MNTH was an exemplar ISHS, by accessing data on district and state databases for student attendance and graduation rates, and achievement on STEM-related district and state tests (above or below district and state averages) to provide comparable descriptive statistics for the ISHS.

Data Collection

Prior to visiting the school, we collected public information on MNTH and conducted a series of structured pre-visit telephone interviews with the principal, informed by the critical components listed in Table 1. A six-person team traveled to the school in May 2013 for a 4-day site visit. Each data collection activity was conducted by two researchers working in tandem and was designed to have content specialists present for relevant activities. (See Table 2 for a complete description of site visit activities.)

Table 2. Data collection activities conducted during MNTH site visit

Classroom Observations	
STEM Classes	Non-STEM Classes
Geometry	Spanish IIA
Phylgebrics [a]	ELA Humanities
Biology	English/Economics
Chemistry	English III/American History
Engineering	
Pre-Calculus/Science Research and Development	
Focus Groups	
Teachers	Students/Parents
Teachers of Engineering	12th Grade – Informal Learning
Teachers of Science	11th Grade – Science and Math
Teachers of Mathematics	10th Grade – Technology and Engineering
Teachers of Informal learning	9th Grade
Teachers of Technology	Parents
Interviews	
School Personnel	Non-School Personnel
School District	Business Partners
Dean of Students	UTeach Representative
College Teachers	Samsung Representative
Principal	Alumni Interview
Teacher Mentor/Coach	
Other Activities	
During School Day	After School
School Tour	Key Club
Critical Friends	Robotics Club
Circle Time and Advisory	
Other Conversations —Technology	
Student Astronomy Presentations Panel	
Researcher Activities	
Team Debrief – Day 1	
Debriefing – Completion of Project	

[a] Phylgebrics is an integrated Algebra 2 and Physics class created at MNTH.

Data Analysis

Immediately following the site visit, the data for each activity were checked for clarity, converted to electronic form, and placed into NVivo (QSR International Pty Ltd., 2006). Researchers read the data for each of the activities in which they participated (e.g., focus group, classroom observation), judging the relevance of each activity to the OSPrI codebook (c.f., Smith, 1987) corresponding to the ten candidate critical components listed in Table 1. Coding was done in iterative cycles. Two researchers coded each artifact separately and the team discussed until there was consensus. A second cycle of coding was conducted with similar logistics, but attending to emerging themes not included in the critical components.

We developed themes and occurrences within the critical components that characterized the school and discussed these themes with the research group. Each research member developed a narrative to answer the following questions: (a) What was the evidence for the presence of each critical component at the school? (b) How prominent was each critical component at the school? (c) What other themes emerged from the analysis not included in the critical components?

After completing the data analysis and interpreting the findings, the research team wrote a full case study (Lynch, et al., 2013), over 80 pages long. It can be retrieved from the OSPrI research site (http://ospri.research.gwu.edu). The present paper is a synthesis of the important features of the longer case.

Manor New Tech High Case Study

Context: School History and Design

Manor New Tech High (MNTH) was a public secondary school (grades 9-12) located in a school district in central Texas, about 12 miles outside of Austin. Surrounded by open space with a new infill of housing developments spread over a substantial area, MNTH had a rural feel despite its proximity to Austin. There was no modern central town civic center; amenities were dispersed across the region. Table 3 shows comparison demographics for MNTH, Manor High School, Manor ISD, and the State of Texas, demonstrating that the school was both highly diverse and somewhat representative of the school district and state.

Table 3. 2011-2012 Demographics comparing MNTH, comprehensive high school, district, and state

Group	School, District, or State			
	MNTH	Manor High School	Manor Independent School District (ISD)	Texas
Students Served	333	1,208	7,685	4,978,120
Grade Levels	9-12	9-12	PK3-12	PK3-12
African American (%)	20.1	30.0	23.6	12.9
Hispanic (%)	46.2	58.1	61.02	50.8
White (%)	29.1	9.9	10.6	30.5
Asian / Pacific Islander / American Indian (%)	3.0	1.3	3.3	4.1
Two or More Races (%)	1.5	0.6	1.6	1.7
Economically Disadvantaged (%)	52.0	80.5	80.9	60.4
Limited English Proficient (%)	1.8	11.6	31.2	16.8

Note. Data retrieved from Texas Education Agency Academic Excellence Indicator System Reports (retrieved from http://ritter.tea.state.tx.us/perfreport/aeis/).

MNTH was created in 2007, the result of a unique set of opportunities and incentives. The conceptual architect and leader of MNTH was its principal, Steve Zipkes, who liked to encourage, in his own words, “controlled chaos.” He seemed to relish innovation. However, his most constant message was that of “family.” He hired a teaching staff with shared values as reflected in the school mission. He encouraged teachers to take initiative and to be creative within the curricular and bureaucratic framework of the Texas Board of Education and the state school model that incentivized the creation of ISHSs across Texas. Zipkes had the ear of the superintendent and was encouraged to build a new STEM school model because the large comprehensive high school in the district was struggling to meet Texas state assessment standards, particularly in mathematics and especially for minority students. Zipkes and his staff wanted to create a STEM school that would encourage students to attend every day and eventually graduate—modest initial goals. With private funding from the Bill and Melinda Gates Foundation and others, and encouraged by the district superintendent, MNTH opened the school with its principal, a STEM teaching coach, and a dean of students with a background in high school counseling, and a handful of teachers. The organization of MNTH emerged from a state-wide effort called the Texas High School Project—later called Educate Texas (Communities Foundation of Texas, 2012). This effort required a new ISHS to partner with nearby institution of higher education; MNTH partnered with Austin Community College and the University of Texas-Austin. The University of Texas-Austin helped to prepare teachers for project-based learning (PBL) through their UTeach program. Outside funding did not cover building costs; the school district contributed $3 million to renovate a former middle school and the school eventually became self-sustaining. MNTH was also a member of the New Tech Network, a nationwide network of schools with the goal to transform schools into innovative learning environments (New Tech High Foundation, 2010). The Network provided curriculum and professional development to support a rigorous, relevant, project-based approach. MNTH has implemented and adapted three main components of the New Tech model: project-based instruction, technology that was both instructional and infrastructural, and a school culture that promoted trust, respect, and responsibility. Students were encouraged to be self-directed.

Selection of MNTH as an "Exemplar" ISHS: Outcomes

MNTH was selected for this study because of its reputation and consistent record of noteworthy student outcomes obtained through Texas' public information data, and follow-up post-graduation data from the National Student Clearinghouse Research Center (NSCRC, 2011), provided by MNTH principal. MNTH kept the most comprehensive, consistent, and thoughtful records on student outcomes trends and school-level awards as any school encountered in this study, and could easily demonstrate its accomplishments for its population of students underrepresented in STEM.

Standardized Test Scores

Because MNTH students chose (or had to choose) to enter the school's lottery to gain admission, it would be easy to assume that such self-selecting applicants come to MNTH with more prior knowledge, explaining the school's high outcomes. However, the Texas Assessment of Knowledge and Skills (TAKS) standardized test scores in Table 4 show that incoming MNTH students at 8th grade scores were comparable to those of students at Manor High School and Manor ISD on English Language Arts (ELA) and Mathematics, but somewhat higher in Science and Social Studies. By 11th grade, MNTH students had substantially higher percentages of students who met the *passing standard* in all subjects, with notably higher scores on the Mathematics and Science tests at the more stringent *commended performance* levels. More thorough examination of MNTH's records showed such gains to be consistent, year after year.

Table 4. Comparison of 2007 8th grade assessment scores (% meeting standard) for future MNTH students and district overall

	ELA	Mathematics	Science	Social Studies
8th Graders Enrolling at MNTH (2007)	77	59	65	90
8th Graders at Manor ISD Overall (2007)	78	59	53	78

Note. Data provided by Steven Zipkes, Principal at MNTH and Texas Education Agency Academic Excellence Indicator System Reports (http://ritter.tea.state.tx.us/perfreport/aeis/).

While omnibus test scores can sometimes mask problems for students underrepresented in STEM (such as African American or Hispanic students or students from low SES families), Figure 2 shows comparisons by ethnic group membership and SES for science and mathematics scores, indicating that MNTH well served its diverse student population.

Engagement and Graduation Outcomes

Annually, close to 100% of MNTH students graduated and were accepted into post-secondary education, according to data kept by MNTH. Using the National Center for Education Statistics (NCES) data, which tend to be less accurate, MNTH students' enrollment rates in two and four-year institutions of higher education were well above the national average (Table 5). National Clearinghouse post-graduation follow-up data indicated that MNTH students attended college at higher rates than the national average, staying through the second year. No data were available on their choice of college majors, however.

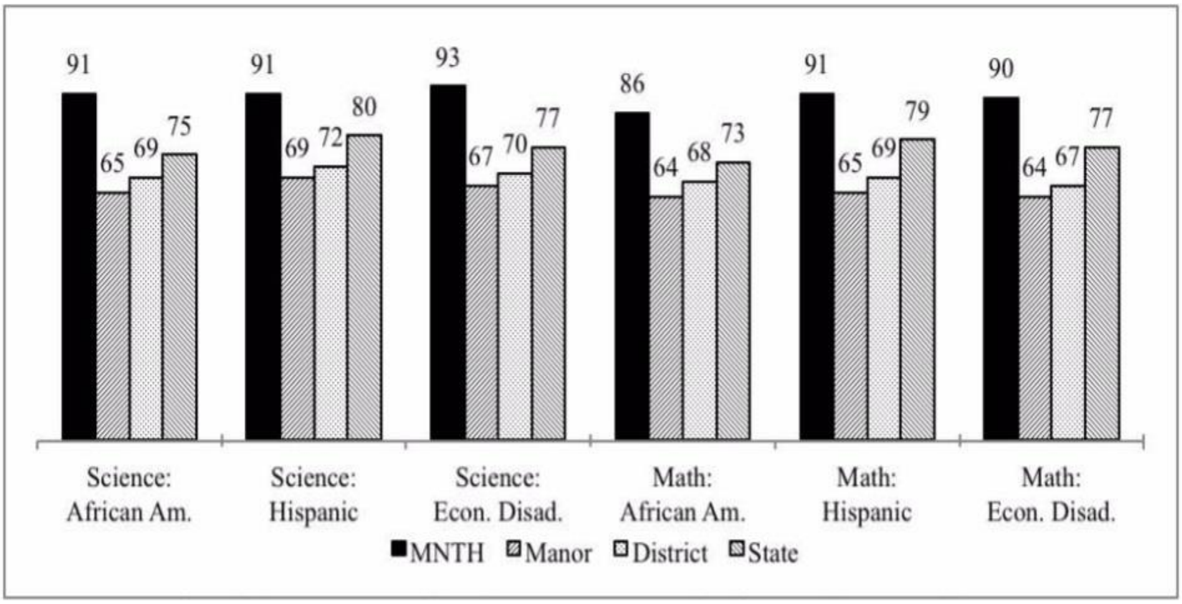

Figure 2. 2011-2012 TAKS assessment results in science and mathematics for MNTH, Manor High School, district, and state (% meeting standard, for all grades tested, disaggregated by ethnicity and economic condition). Data retrieved from Texas Education Agency Academic Excellence Indicator System (http://ritter.tea.state.tx.us/perfreport/aeis/).

Table 5. Comparison of Post-secondary Enrollment Rates (%) for MNTH in 2010 and 2011 to NCES Data

	All Institutions	4-year Institutions	2-year Institutions
MNTH, 2010	74.3	53.8	20.5
Nationwide Rates, 2010	68.1	41.4	26.7
MNTH, 2011	81.4	48.5	32.8
Nationwide Rates, 2011	68.2	42.3	25.9

Note. National Student Clearinghouse graduate rate data provided by MNTH; additional data from 2013 NCES Digest of Education Statistics, Table 302.10: Recent high school completers and their enrollment in 2-year and 4-year colleges, by sex: 1960 through 2012.
(retrieved from http://nces.ed.gov/programs/digest/d13/tables/dt13_302.10.asp on August 19, 2014).

Analyses of Candidate Critical Components at MNTH

Inclusive STEM Mission

In order to be considered for the OSPrI study, an ISHS had to self-identify as a STEM school and serve a student population that included high proportions of students underrepresented in STEM. According to the principal, “the goal of Manor New Technology High School is to prepare students to excel in an information-based and technologically advanced society.” The MNTH application stated, “We are committed to working towards enrolling a diverse student population that is reflective of the greater Manor ISD population,” and the admission letter followed with “Manor New Tech considers college admission the goal for all students.” MNTH’s mission focused on the development of 21st century skills (Partnership for 21st Century Skills, 2009; 2012) and supporting all students to go to college, regardless of major.

Although MNTH fit the definition of an inclusive STEM school and MNTH students took more STEM coursework of greater depth and breadth than the state required, students reported that they were attracted to the school because of the “new tech” focus, and its emphasis on PBL. The principal explained that he did not think that “marketing” the school to students who had not had positive experiences in STEM in the past would attract them to MNTH. Rather, students and their families wanted a school experience that provided the opportunity to learn differently in a challenging new school environment focused on 21st century skills.

STEM-Focused Curriculum

Graduation requirements at MNTH included 5 credits each in science and mathematics, 2 credits in engineering, and 2 technology elective credits. In comparison, the state of Texas required only 4 credits each of science and mathematics for graduation (this has since been further reduced), and no required engineering and technology courses. The curricula for all courses at MNTH were carefully aligned with Texas standards and with the New Tech Network's prescription for cross-disciplinary studies—courses from two different disciplines were often combined and taught with an interdisciplinary focus. For example, there were mathematics and science combinations (e.g., Physics/Algebra II, Environmental Science/Pre-Calculus) or humanities and social studies (e.g., American History/English Language Arts III). Cross-disciplinary courses were facilitated through a trimester system and a five-period school day—each cross-disciplinary course met for two combined time blocks and was taught by two teachers who almost always were in the classroom together. The trimester system allowed students to complete the extra STEM credits required for graduation in four years of high school.

The mathematics needs of MNTH's students were a major driver of the school's curriculum design and approach. Mathematics was the only subject at MNTH where the school struggled to meet or exceed state benchmarks. Teachers reported that some students entered MNTH woefully underprepared in mathematics, so the school tried to move them forward. MNTH teachers designed three-week units using the PBL approach to aim precisely at providing experiences to help students understand the mathematics concepts in the context of science or engineering and real world applications. Students reported receiving help with mathematical aspects of their assigned work from any STEM teacher.

All students completed college preparatory courses in Biology, Chemistry, Algebra I, and Geometry, and then took additional STEM classes. Students who graduated from MNTH could enter college with a broad base in STEM, able to make trans-disciplinary connections with some depth. None of this happened by accident. An interview with the MNTH's first instructional coach revealed the strategies behind the PBL. She pointed out that teachers must first learn the Texas standards and then create projects that covered them, saying:

> We had to use the district scope and sequence [documents]. We could adjust the science sequence because the science was to be integrated with math. Students take all the district benchmark exams every 6 weeks. To do a strong project that gets the student involved and really hits the content, the teacher must know the content well to develop rich projects. We really stress content. We have teachers with degrees in biology and chemistry researching projects, really digging into content knowledge.

MNTH required students to take the equivalent of two years of technology courses and an engineering sequence beginning with Introduction to Engineering and followed by Principles of Engineering, inspired by the Project Lead The Way (2014) engineering curriculum.

Reform Instructional Strategies and Project-Based Learning

A critical component (see Table 1), essential to MNTH was the school's commitment to a Project Based Learning (PBL) instructional approach in every course. PBL has been defined as an instructional method in which students solve complex and divergent problems (Hmelo-Silver, 2004). Rather than just adding projects into traditional teaching and learning, students in PBL schools like MNTH learn content and skills through the problem solving process. As described by the Buck Institute for Education (2003) PBL is "a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks" (p. 4). Savery (2006) defines PBL to include: an interdisciplinary approach, authentic activities, and problems that do not have one answer. The teacher's role in PBL is to structure activities to motivate and encourage reflection and to facilitate instruction through scaffolding (English & Kitsantas, 2013). Students who are engaged in PBL take responsibility for their own learning; work collaboratively in small groups to conduct research, and use logic and reasoning to devise solutions to complex problems (Blumenfeld et al., 1991; Thomas, 2000).

PBL was ubiquitous and embraced by the entire learning community. Each PBL unit lasted about three weeks and closed with an authentic performance assessment to demonstrate student learning. PBL units of instruction at MNTH typically included: (a) teacher designed entry documents introducing students to a new project, (b) assessment rubrics, (c) interdependent group work, (d) effective communication during the project, facilitated by technologies, (e) workshops, and (f) performances that illustrated what students had learned from the projects as well as the products themselves. Entry documents were used to launch a project and consisted of a detailed description of the goals and constraints of the project. They took a variety of formats, ranging from multi-media presentations to white papers such as those used in engineering design. Teachers seemed proficient in generating these entry documents, which established the project's alignment to real-world problems. The rubrics were given to students at the beginning of a project and were clearly aligned with the Texas state standards as well as the socio-emotional habits and values expected at MNTH. An engineering teacher articulated her thoughts about this,

> You need the standards in PBL. If you're not trained in it, it seems formidable. It helps to have training and to be surrounded by people who are doing it.

A key to success was the employment of teacher-centered workshops, combined with student group work. These workshops were segments of direct teaching that could be initiated by either the teacher or students that strategically provided the means for teachers to help students with the skills and knowledge to complete their projects. To finish the projects, groups of students presented their work to members of the community, including experts in the field, in formal presentations. Consequently, students made hundreds of presentations by the time that they graduated from MNTH, and were comfortable explaining their ideas and work to any audience, an important 21st century skill.

The PBL approach required MNTH students to take responsibility for their own learning, and to learn how to communicate. Students understood that they needed to work together to be successful, and made adjustments in group dynamics as a project proceeded. Teachers were available to help with projects, and teacher-student relationships were centered on learning and completing projects (Buck Institute for Education, 2003; Blumenfeld et al., 1991). The technology at MNTH provided a platform for teachers to give frequent and timely feedback, for students to communicate readily with one another, and for scaffolding as needed. For instance, an observation of a Trigonometry/Geometry class showed students participating in a project that required them to work in groups to design their own buildings, given certain parameters. Most groups chose to design homes, but one group designed a music and media shop that could be used by the community not only to purchase instruments but also to produce music. During the course of this 80-minute class, students engaged in a variety of activities. First, they individually rated the productivity of other students in their groups, using a rubric designed by the teacher. They took this very seriously. Then they turned to working in their small groups on their designs. They had rough drawings of their initial concepts on their desks and more advanced drafts of floor plans on graph paper. During this observation, most groups were transferring the ideas on paper drafts to electronic form, using Geometer's Sketchpad. They encountered the challenge of adjusting their graph paper drawings to more realistic renditions on the Sketchpad that could account for the space between walls. Students seemed proficient with the technology and focused on the task. Once during the class period, the teacher stopped the group work and called students over for a trigonometry workshop. He taught a lesson that would help solve a particular problem and gave students tips on how to work with adjustments to the Sketchpad to build the wall widths into their designs, increasing precision. During this class, only 6% of the time was entirely teacher-centered, and 10% involved the teacher talking directly to some groups, but not all. The vast majority of the time (63%) was spent on student group-centered activities—active learning—and about 19% was spent on individual student work. This instruction was very different from the teacher-centered didactic instruction accompanied by individual problem-solving, which is often encountered in mathematics classes.

If teachers thought that a project they designed needed improvement, they could bring the projects to a weekly "Critical Friends" professional development meeting and get feedback from the entire faculty. These sessions occurred during regular school hours each Monday. Teachers were deliberate in designing PBL projects to maximize student motivation and ownership and to offer a variety of forms for students to demonstrate what they had learned. Because teachers also sought feedback about their own performance as teachers who wanted to improve, they modeled this behavior for their students. This helped to create a culture where assessment was not focused on right and wrong answers, but rather on learning and the improvement of performance by all.

Integrated, Innovative Technology Use

MNTH was purposeful in planning technology use; specifically, technology was used to support the school's mission, culture, and learning environment, but not to drive them. Technology was referred to as an invisible tool, and though the students and teachers seemed very technology-savvy, learning content and skills was the first consideration, with technology employed to facilitate. MNTH's mission was "to prepare students to excel in an information-based and technology advanced society." Technology Literacy was listed among the school's nine core-learning outcomes and every classroom was equipped with a class set of desktop computers and a projector setup. We observed students using desktops, laptops, and cell phones simultaneously, while working with group members or a teacher.

MNTH students and teachers relied on a learning management system called ECCO, which was used in all New Tech Network schools. ECCO allowed teachers and students to share information about PBL rubrics, grades, and project feedback. An 11th grader commented:

> Teachers are always willing to help with homework through the technology, as long as it is during reasonable hours. There are agendas that teachers post [on ECCO] and we are responsible enough to go back and check. The substitute does not even need lesson plans… The technology has made us open. Teacher-student relationships are much closer [than at the comprehensive school]. My parents talk to my teachers a lot through [ECCO] email.

Technology connected students with each other as they employed social networks and Google apps to communicate, plan projects, and delegate tasks. One student commented, “When ECCO went down for a few days last year, we about died.” Students could email teachers with questions and receive feedback on work via ECCO. Students seemed comfortable seeking feedback via ECCO and email, indicating a shift towards a learning goal orientation, and a reflection of the school’s collaborative culture. Technology also connected students with outside research resources, using Internet resources to obtain information to complete projects. For example, students were comfortable using the Science Daily website to find primary sources in science courses and Wikipedia to learn about historical events. Students also had access to online resources such as Khan Academy for independent or supplemental learning.

Technology teachers served as resources to other teachers and to students, suggesting innovative ways to use technology in teaching and learning. The creation of YouTube videos by the students was a way to demonstrate learning at MNTH. Students were expected to use technology to complete projects and to learn independently, for research and multimedia production. At the same time, students learned a bit about programming and making games, and they used various apps to complete their projects.

Well-Prepared STEM Teaching Staff

The principal had the flexibility to hire teachers who are a good match for MNTH, looking for STEM teachers with strong content area skills, usually a Bachelor’s degree or more in a STEM major. He often hired teachers through the nearby university’s UTeach program that selected students who had strong disciplinary backgrounds. He also sought teachers who seemed open-minded, flexible, willing to learn and collaborate with colleagues, and who would seek help from others when needed. Specifically, he wanted teachers who brought “a passion, a desire to change education, to not keep it the same way and who aren’t afraid to take care of business within the box, but still step outside of it or… have other people really critically analyze their projects to make them better.”

The modal age for MNTH’s STEM teachers was about 35-39 years, with a range of 25-55. Most had a major in their primary teaching area, and all STEM teachers held appropriate certifications for assigned classes. Many had previous professional experiences that included positions in industry, computer programming, military service, medical technology, and television news management, coming to teaching as a second career. Four reported having prior research experience.

Classroom observations and interviews provided evidence of typical (e.g., laboratory work) and skilled STEM instructional practice relying on PBL. Every teacher who was observed in class encouraged and supported student use of 21st century skills. On the whole, these teachers reported that they were very confident in their reform-based teaching abilities. Teachers had time within the school day or year to engage in cooperative planning or learning activities and targeted, on-going professional development. One teacher said,

> The administration at MNTH has been highly supportive by providing us with the proper professional development that we, as a staff, feel is more needed for us to be a successful New Tech school that incorporates STEM education.

Many classes were team-taught, and teachers had common planning time. One teacher noted,

> Aside from having a co-teacher, I collaborate well with the other science and engineering teachers in

> my school, and collaborations with these teachers have enabled me to develop integrated projects that connect Physics and Algebra II to engineering applications.

Another said,

> Having the opportunity to work with a highly supportive team of co-workers has given me the chance to learn from their ideas and support about the integration of STEM in my classroom.

Professional development was directed toward subject content areas or content that would enable the integration of STEM disciplines. Teachers attended professional development over the summer such as Project Lead The Way (PLTW) workshops or robotics training, or developed their skills with PBL by teaching workshops to other teachers in the New Tech Network. We observed an atmosphere of collegiality and respect among MNTH teachers. The 21st Century Learning Professional Development Specialist, a former MNTH founding teacher, commented,

> Teachers want to be there, really being analytical about the way they teach, how they teach, how they are reaching their students, and work to design projects for the needs of their specific students.

A student commented,

> The teachers respect us… I came here because of the teachers, who cared that I was learning.

This suggests that MNTH could reconfigure relationships among teachers, students, and knowledge (Coburn, 2003; Elmore, 1996).

Administrative Structure

The MNTH administrative staff was small, as expected at a high school serving fewer than 500 students in grades 9-12. Key personnel consisted of the Principal, an Assistant Dean of Student Services, and an Instructional Coach. In addition, teachers took on administrative functions.

The MNTH principal enjoyed a trusting relationship with the school superintendent and had latitude to make school decisions without interference from the district. The principal was a strong school leader whose vision seemed to capture the imaginations of all involved with MNTH. However, he quite consciously collected a group of teachers who were willing to take the lead on a variety of project and tasks. Teachers were empowered to make decisions from dealing with student discipline to determining software needs. Students were also involved in decision making by organizing social activities and leading student clubs afterschool. They led weekly whole school meetings known as Circle Time. Students were free to move around in the hallways as needed, and disciplinary issues were handled by students and staff in consensus at school meetings. Disciplinary problems were both infrequent and relatively minor—MNTH was known as a safe school, friendly, and inclusive to all types of students. One parent’s comment captured the school culture:

> I can walk through the door and I know 90% of the teachers, and 90% of the students know me. The size of the school makes it more familiar, and you don't have kids acting out or getting on each other; it is like a family, a friendly atmosphere.

The small school size, the visible and dynamic school leader, distributed leadership, and the close relationships between staff and students seemed to foster a school culture characterized by trust, a bit of healthy chaos, and transparency.

Supports for Students Underrepresented in STEM

A goal of MNTH was to provide support services for its diverse student body, getting each student into college and providing them with background and skills to be successful in college. Because students’ needs varied greatly, due in part to the diversity represented at MNTH, the school had to find ways to be responsive to each student. Equal numbers of male and female students attended MNTH, an impressive accomplishment for a school known for its “new tech” and STEM focus. About 50% or more of the students were first generation college goers. The school was viewed by parents as a safe haven for students who might be seen as “nerds” at the comprehensive high school or who had been bullied. One parent pointed out:

> We have a clothes closet that we donate to. For presentations, teachers want kids in business attire. The kids aren't shy about that. If they need clothes, they just go and get them. In other schools, the kids are ashamed to get clothes. If they aren't wearing a brand shoe, the other kids will be mean. Not at this school. They don't make fun of kids.

New students attended a week-long program held the summer before 9th grade, organized primarily by upperclassmen. This program designed to orient students to PBL, technology, the school culture, and graduation requirements. Then, in 9th grade, students were assigned to a teacher-advisor with whom they would stay for four years, a process called "looping." If students were struggling, they could seek help from the advisor, other teachers or the school counselor. Teachers willingly tutored students before and after school, and this was made possible by a special bus schedule.

Mathematics presented particular challenges to some MNTH students. A teacher commented:

> Mathematically, there are gaps like the Grand Canyon… Students often shut down when they see the math and have no confidence in their abilities. They think, "If I pretend that I don't have to do it, maybe it will away." Teachers work to help them see that it's ok to try, to practice. It's okay to not get it perfect.

Because mathematics courses are gatekeeper courses for success in STEM in college, the math gaps were a problem that needed be solved. When a substantial number of 11th graders were found to be struggling in mathematics, the principal intervened:

> I finally went up to all the students who didn't pass the state assessment and said, What can I do to help? What do you need? "We want a basic math class." So I went back into their cumulative folders and found that most students [in the group that struggled] hadn't passed the assessments since 3rd or 5th grade, but they were passed along from grade to grade. You can fake your way through elementary and middle school, but when you get to high school and you start getting to Algebra, if you don't have those building blocks set, you're in trouble. That's all they needed [to get caught up] was a basic math class.

This was not tracking. Students were re-integrated into the regular mathematics sequence once they mastered the basics.

MNTH staff prided itself on its specialized programs aimed at getting 11th and 12th graders into the best colleges possible, to provide a variety of college choices, and help students apply for financial aid. That process began in 9th grade and continued until senior year. A large poster was displayed prominently at the building entrance showing a photo of every 12th grader and announcing where he or she decided to attend college. College admissions occurred through carefully planned programs and behavioral nudges that positioned students for completion of the complicated process. "College Mondays," a class aimed at juniors and seniors, was designed to engage students in discussions about admissions requirements, researching colleges that were a good fit, and completing admissions and financial aid forms. "College Forward" was another college advising program that met after school and was designed for students who were first generation in their families to attend college, and their parents. The teachers who ran the program noted that some of MNTH's best scholars were from first generation families and that College Forward had helped them to understand how to get into good schools. Students were encouraged to apply to at least one four-year college and not settle on the local community college.

Focus groups with 11th graders showed that they were both goal-oriented and well-informed. All reported specific college intentions, and several had ambitions for masters and doctoral degrees. Many of their career goals seemed to be linked to people that the students already knew personally in the community. This STEM high school provided a means to meet STEM professionals, helping students to expand their career horizons.

Early College Coursework and Blended Formal/Informal Learning Opportunities

The state of Texas required that all high school students accrue 12 college credits (dual credit for both high school and college) before graduation. MNTH fulfilled this requirement through humanities courses offered at the high school. Students at MNTH did not take college level courses in STEM, however. The principal explained that with the school already offering 6 mathematics, 6 science, and 2 engineering courses, MNTH students' access to STEM coursework was sufficient for the needs of the students. In addition, MNTH had agreed not to offer Advanced Placement STEM courses that might draw high-performing students away from the comprehensive high school. Students at MNTH had some opportunities to participate in informal learning activities after school or during the summers. About 15% of the senior class engaged in a senior project, and a few students participated in internships, but this aspect of the program was less well-developed because MNTH's location was quite a distance from the city and few students had cars. The Robotics Club at MNTH was very successful and initially aided by a local IT company who sent engineers to help the team with the robotics competition. Eventually, the school gained the capacity to be more independent although engineers still attended team meetings. The community was aware of the noteworthy work that the school was doing and local businesses were likely to hire applicants from MNTH because graduates had the reputation for effective communication, collaboration, and productive behaviors.

Real-World STEM Partnerships

Becoming a part of the New Tech network of schools required a commitment to developing connections with business and community partners for internships and other work-related opportunities. This included developing business community partnerships for financial support, internship opportunities, participation in school projects, and developing key partnerships with the local higher education organizations. Although business and industry partners were not involved in planning the school, MNTH had a number of financial sponsors and donors who supported the school in various ways, including Samsung, Applied Materials, Dell, and Freescale Semiconductors. In addition, MNTH had partnerships with companies to provide students with exposure to their respective fields. Apple Inc. provided professional development to MNTH teachers; Applied Materials, Inc. assisted students with the Solar Car Races event, in addition to financial support such as funding for the solar-powered marquis in front of the school. Professionals from a variety of local organizations participated on panels to review student projects.

Emergent Themes

This research began with the premise that each instrumental case study of an ISHS would not only look for evidence of ten critical components (see Table 1), but would also locate and code the data for additional concepts or themes that seemed important in understanding the workings of the school. There were three such emergent themes derived from the MNTH data.

The first emergent theme was students' development of 21st century skills (Partnership for 21st Century Skills, 2009) that aimed to prepare students for a world altered by advances in technology and a globalized economy. These skills were many, but perhaps could be best captured by the "4Cs"; critical thinking and problem solving; communication; collaboration; and creativity and innovation. MNTH embraced these 21st century skills through its emphasis on PBL and the infusion of innovative technology throughout the curriculum. A pathway to developing 21st century skills at MNTH could be found in the school's immersion in PBL and the ready application of technologies for teaching and learning. Soft-skills, or non-cognitive factors (Farrington et al., 2012), were exemplified by a poster in a MNTH classroom that listed "Sophomore Norms: Be Prompt; Be Prepared; Be Productive; Be Polite; Be Positive." A student at work in this class was overheard asking his teammates, "What do you want me to do so I can be productive right now?" Another student noted that the school's environment affected her approach to learning and furthered her ability to be reflective and self-regulating. Students, families and staff all stressed the importance of developing collaborative and public speaking/communication skills. One student pointed out:

> Before I came to this school, in group projects you would be stuck with all of the work; it helps that everyone has a role and you don't have to do the whole project by yourself. I used to hate speaking in public… During the first presentation everyone would get red in the face and not want to talk, and now it seems like nothing… I had several interviews and it is easier to talk to people.

Students not only frequently discussed 21st century skills, they often demonstrated that they had acquired them, could use them, and could recognize that they were using them. They saw 21st century skills as an advantage for the present and the future.

The second theme was MNTH's positive school culture; it was a place where students wanted to be. School culture has been described as being similar to the air we breathe; it can positively or negatively influence all aspects of a school (Hinde, n.d.). Positive school culture includes norms of collegiality, improvement and hard work, and where there is a shared sense of purpose (Peterson & Deal, 1998). MNTH had rituals and traditions that celebrated student accomplishment, teacher innovation, parental commitment, and a shared ethos of caring, concern, and commitment to helping students learn. Teachers engaged in professional behaviors that focused on high expectations for students while taking into account their academic needs. MNTH students knew when they chose to attend the school that they would be required to do more work, learn in a different way, and commit to more STEM coursework than typical. It was not unusual to find students staying after school or coming early to work on projects. One teacher pointed out that this fed positive teacher-student relationships. "Thirteen kids stayed last night until 9 PM. They didn't want to leave. They like it, but it's not the technology, it's the relationship with the teachers."

The relatively small size of the school and ready use of technology made it possible for teachers and students engage in reciprocal teaching and learning. Students were allowed access to the Internet without the usual firewalls prevalent in many schools, so information available on the Web was accessible to all; the teachers were not the only ones with power due to the universal access to information. MNTH celebrated and acknowledged its unique culture through its use of social media, particularly YouTube (see, for example, *MNTHS: Lip Dub 2012: Bahba O'New Tech* (http://www.youtube.com/user/ManorNewTechHigh). This video was designed as fun, but acknowledged each person in the school and took substantial technical knowledge to produce.

The third emergent theme was that of "family," with the school perceived as "our house." This theme overlaps with school culture, but embodies the sense of place, family, home, house, and community displayed by MNTH students, teachers, and administrators, and that extended to parents and others in the community involved with the school. "Family" was used metaphorically to refer to the school community, and the larger sense of Texas culture, identity, and place. "The culture, familial love, is significant. We are all in this together," said a teacher at MNTH. The goal was to create an extended family concept among students and staff that lived in "our house." The large student-created murals on MNTH building walls showed how students represented themselves on the façade of the school. One YouTube video describes the school well, in the students own words (see https://www.youtube.com/watch?v=pF484niVBNM). In this video, students explained the school's goals and visions in the context of the MNTH notion of family feeling, providing an excellent summary of this theme in the words of students and staff. A student in a focus group pointed out, "This school is very welcoming. All you have to do is apply…This is a big family."

Study Limitations

This study has limitations, although it should be noted that the full case study from which this paper is derived (Lynch et al., 2013) is available on the OSPrI website and is about 80 pages long, with more detail than provided here. One limitation of this study is that, as a school-level case, it does not explore the effect of the existence of a STEM school of choice on the Manor school district as a whole. While the district-level administration was strongly supportive of MNTH, the school was situated in a district where other high schools struggled with graduation rates and school attendance. It was not possible to compare students at MNTH with students at other high schools in the district because students attended the schools for different reasons. This was not the purpose of the study. Second, MNTH is part of the small schools movement, and the interactions among the critical components listed in Table 1 and the emergent themes are probably, in part, due to the small school size. Third, MNTH had a special mission when it was founded as a new school and had funding to accomplish that special mission. MNTH should not be compared with the comprehensive high schools that have different, broader missions. Fourth, this case study is not a deep ethnographic study of MNTH students and their families and their responses to the STEM education. As a snap-shot, school-level case of an exemplar STEM school that was completed in a year, it does not trace the progress of the school longitudinally. Fifth, the follow-up data on students who graduate from MNTH are limited by what can be learned from National Clearinghouse information so the long-term effects are only partial, but positive.

Discussion: How Critical Components and Emergent Themes Build Opportunity

This instrumental case study of MNTH is important for a number of reasons. First, it can be viewed as an existence proof or proof-of-concept for a new type of high school that focuses on inclusive STEM education for a broad range of students. It documents exactly how the school accomplished this. Second, MNTH is an example of new policy initiatives in the state of Texas, and increasingly embraced at the national level and within other states and municipalities. Third, the fact that MNTH students are successful in a challenging STEM-focused environment (see the Outcomes section of this paper) suggests that STEM education, calibrated for the community it serves, can be empowering to students as it democratizes STEM knowledge and skills.

MNTH created opportunity structures specifically aimed at its diverse student population through its STEM focused curriculum, its emphasis on PBL, and students' ready use of technology for learning and for production. MNTH students built social capital in ways that would not otherwise be available to many families in the community; the school mustered resources and created an innovative but rigorous education program accessible to diverse students. Using the PBL learning and instructional model for all classes seemed to change the dynamic of the classroom and of human relationships. The teachers carefully constructed the curriculum through a PBL approach that created an authentic and complex learning environment, and then expertly implemented it. This positioned students to be successful critical thinkers and collaborators. MNTH was a rare example of a place where relationships between students, teachers, and knowledge were altered in a profound way to create a dynamic learning community. The most consistent testimony to the power of PBL was students' abilities to explain their projects in ways that were informed, enthusiastic, and confident. This instructional approach appeared to enhance student self-efficacy for academic learning and a sense of group efficacy among all those involved with the school. PBL activities were glued together by the social media and other forms of technology that enabled the PBL projects to progress. Students seemed not only to learn about 21st century skills, but students adopted and infused them into their projects. Given this unusual instructional approach, it was politically advantageous and reassuring that MNTH's standardized assessment score data were consistently high.

STEM learning experiences offered to students in this school were consistent with Roberts' (1968; 1984) notions of opportunity structures. MNTH provided its students with: a college preparatory education well-aligned with the needs of the local economy and with peers with similar goals and interests. It supplied students with the information, experiences, and behavioral nudges that got them accepted to college, and helped them develop the soft skills for college success. MNTH was a noteworthy exemplar of a 21st century school. The 10 critical components that formed the basis of this study's design help to explain exactly how the school accomplished its goals. The emergent themes further fill out the picture of why students wanted to attend a school focused on STEM and where they would need to work harder and learn differently due to the PBL instructional mode—active learning was the norm. These critical components and emergent themes, together with the description the case provides about how they work together, may be useful to educators interested in starting new schools, improving STEM education, or finding solutions to long-standing equity issues in STEM (Lynch, 2015). This case is important to the movement to create new ISHSs, an increasing interest with the U.S. and other countries. This study set out to identify an "exemplar" inclusive STEM high school and study it systematically so that researchers, policy-makers, and education groups wishing to structure STEM schools in their communities or improve STEM education in comprehensive schools might use the ideas illuminated in this case. We think that MNTH is a highly successful school, and there is a great deal evidence to back that up claim. MNTH does appear to be an existence proof for ISHSs. It suggests some intriguing possibilities to improve STEM education as it closes gaps in achievement and opportunity. MNTH has deliberately built opportunity structures to enable students to access STEM-rich environments and the confidence to succeed in a complex and connected world.

Conclusions

MNTH was an exemplar STEM high school, but one that may be within reach of other school districts or charter school networks that want to improve STEM education for students who are underrepresented in STEM. The genesis of MNTH was stimulated by some start-up funding and the T-STEM network. The school enjoyed the support of a community that wanted better student outcomes. The leadership was willing to experiment with a STEM school model to achieve improved outcomes. It is noteworthy that much of what made MNTH a success story cost nothing in dollars, but was the result of a shared vision among the principal and teachers (distributed leadership) and their will to innovate, risk failure, and improve. The school was thoughtfully designed using the T-STEM blueprint and enhanced by its membership in the New Tech Schools Network and Project Lead The Way. MNTH educators, however, soon expanded the scope of this early curricular guidance to create an educational program could rely the PBL instructional strategy and produce strong results on standardized assessments. MNTH provided a STEM program that students reported was engaging and that prepared them well for college, in a positive learning environment. Some of this would not have been possible without the strategic use of learning platforms and technologies to keep track of PBL work and student learning outcomes. The teaching staff embraced the use of technology and was willing to learn from one another, as well as from students.

Although MNTH was a successful STEM high school that capitalized on PBL, not all schools in this research study relied on PBL to the same extent—other instructional models were employed in other schools (Lynch, Peters-Burton & Ford, 2014; Spillane, Lynch, & Ford, 2016). Successful STEM high schools are best captured by considering all of the critical components listed in Table 1 and how they work together (Lynch et al., 2016). The design and success of ISHSs such as MNTH suggest that a new pattern for school effectiveness in STEM education is emerging in the 21st century.

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