Manor New Tech High School: A Case Study of an Inclusive STEM-Focused High School in Manor, Texas

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1. EXECUTIVE SUMMARY

This case study of Manor New Tech High (MNTH) is the first in a set of 12 school-level cases on inclusive STEM-focused high schools (ISHSs). Unlike older, highly selective STEM-focused schools that target students already identified as being STEM gifted/talented, 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. MNTH is one such ISHS located in Manor, Texas; the school was founded in 2007 amidst a confluence of factors including an innovative Texas STEM education policy initiative for new STEM schools, seed money from private foundations, and the desire of the school district and community to improve student outcomes for its diverse student body.

This case study provides an in-depth look at the MNTH's design, implementation, and outcomes, examining the school using a frame of ten candidate critical components culled from the research literature. A team of six researchers visited the school in May 2012 and systematically collected data from classroom observations, interviews, and focus groups, as well as examining public information documents and outcome records. This examination of MNTH revealed valuable insights into a successful ISHS; the school provides an innovative instructional environment, different from that found in traditional, comprehensive public schools. This environment fostered a community of students and teachers who were open to creating opportunity structures and taking advantage of them.

Analyses showed that some of the ten candidate critical components were more salient than others at MNTH. In particular, the project-based learning and instructional environment that existed in all classes at the school, STEM and non-STEM alike, changed the dynamic of the classes, the human relationships, and the ubiquitous role of technology in the school. The learning community supported by this instructional approach appeared to enhance student self-efficacy, and a sense of group efficacy among all those involved with the school. Furthermore, students did not just learn about 21st Century Skills, but rather students adopted and infused them into projects. MNTH has also built a robust network of student supports, or opportunity structures, to help students and families achieve the school's mission. These supports particularly target those student groups who are traditionally under-represented in STEM fields, including those who are first generation in their families to attend college, and help them be confident in their abilities in STEM, projecting their understanding of STEM disciplines by tackling real-world problems. Indeed, virtually all students graduate from MNTH having been admitted to college, and the school has consistently high achievement scores on state measures. Additionally, the positive school culture promotes a sense of MNTH's being "Our House" for all who attend, with the school becoming a strong, supportive extended family for students and staff. Finally, MNTH is led by a dynamic principal whose enthusiasm is contagious and who hired a strong, flexible, collaborative, and creative teaching staff that can execute the MNTH vision and take it to high level of realization in the context of Texas STEM schools.

2. INTRODUCTION

Due to the potential of inclusive STEM high schools (ISHSs) to close achievement gaps and to create opportunities for students under-represented in STEM, our research team initiated a four-year research program, Opportunity Structures for Preparation and Inspirations (OPSrI), funded by the National Science Foundation. The OSPrI team will conduct 12 case studies and a cross-case analysis of well-established ISHSs (Lynch, Means, Behrend, and Peters Burton, 2010). A major goal of the OSPrI research is to develop a model (or models) to describe how successful STEM schools work. Currently, there seems to be no theoretical framework to explain the why ISHSs might be effective and produce graduates with the confidence and ability to succeed in STEM college majors, jobs, and careers. Nor are there published effectiveness studies on ISHSs, although a companion project called iSTEM is taking on this research question. There is a great need to conduct systematic research on ISHSs because they are scaling up, despite the lack of evidence for their impact or a framework to illuminate their critical components.

2.1. FRAMING THE STUDY

This case study of Manor New Tech High (MNTH) asks:

1. Is there evidence for each of the candidate critical components (listed in Table 3, to be explained later) found in the design of MNTH, the school that is the focus of the case study?
2. How are the critical components implemented at MNTH? Do other components emerge from the data collected on-site that are critical to the school's character and success?
3. What are the contextual affordances and constraints that influence MNTH's design, implementation and student outcomes?
4. How do MNTH student STEM outcomes compare with those of the school district and state (e.g., STEM achievement measures, graduation rates, college intentions)?

2.1.1. Selection of Manor New Tech High

The goal of the OSPrI study is to find and characterize "exemplar" inclusive STEM-focused schools. By "inclusive" we mean schools that are non-selective and that do not use demanding criteria for admission that requires that the students demonstrate that they are gifted and talented in STEM or very high achievers. Schools should self-identify as STEM schools, and take in a range of "regular" students who choose to attend a STEM-focused school. In some instances, parents make this decision. A second characteristic is that the school is well-established within the school district or state and has been planned thoughtfully with community support. The school should have a reputation for success, and is expected to show some unusual successes with its student population in comparison to school district or state averages, given the demographically appropriate comparison groups.

To find such schools, the selection process combines an expert nomination process with screening and categorization according to promising elements in their design and outcomes. Each school is chosen as a critical case (Yin, 2008), with a unique governing structure and academic organization likely to have broad effects on implementation and outcomes. The nomination process begins by contacting individuals knowledgeable about STEM schools, and state STEM networks, reviewing the OSPrI definition of inclusive stem-focused high schools

with these experts, and asking for their nominations of schools that represented particularly good examples.

A school that came to our attention as fitting these criteria and frequently mentioned by experts was Manor New Tech High in Manor, Texas. The school was gaining a reputation for success, and was featured in a National Research Council publication on STEM education (NRC, 2011). In addition, one of the members of our research team was interviewed on a national webinar with the principal of MNTH, and the principal made a convincing argument that what was occurring at MNTH was exceptional (Robelen, 2012). We approached the principal with a summary of our intended study. He agreed to allow his school to participate and secured the necessary permissions at the school district level. MNTH is a demonstration school, which means that there is a constant stream of visitors interested in the school model. Our request was unusual only in that the proposed work was more extensive and systematic than typical of shorter visits, although there is another case study of MNTH that is quite thorough (Gourgey, Asiabanpour, Crawford, & Fenimore, 2009).

Table 1
Data Collection Activities at Site Visit to MNTH

Classroom observations	
STEM Classes	Non-STEM Classes
Geometry	Spanish II A
Phylgebrics	ELA Humanities
Pre-Calculus/Science Research and Development	English/Economics
Biology	English 3/American History
Chemistry	
Engineering class - solar cars	
Focus Groups	
Teachers	Students/Parents
Teachers of Engineering	12th Grade – Informal learning
Teachers of Science	11th grade – Science and Math
Teachers of Mathematics	11th grade – Science and Math
Teachers of Informal learning	10th Grade – Technology and Engineering
Teachers of Technology	9th grade
	Parents
Interviews	
School Personnel	Non-School Personnel
School District	Business Partners
Dean of Students	UTeach Representative
College Teachers	Samsung Representative
Principal – Partnerships	Alumni Interview
Teacher Mentor/Coach	

Other Activities	
During School Day	After School
School Tour Critical Friends Circle time and Advisory Other conversations —Technology Student Astronomy Presentations Panel	Key Club Robotics club
Researcher activities	
Team Debrief – Day 1 Debriefing – Completion of Project	

3. MANOR NEW TECH HIGH: A CASE STUDY

3.1. CONTEXT

3.1.1. School district and locale.

Manor New Tech High (MNTH) is a public secondary school (grades 9-12) located in a school district in central Texas, about 12 miles outside of Austin. It is part of the Austin-Round Rock metropolitan area, and has characteristics of both suburban and rural environments. The "city" of Manor has a population of about 5,500. The town center consists of a couple of blocks of early 20th Century storefronts (some vacant) and small businesses. The Manor School Intermediate District offices, MNTH, and a large comprehensive high school are located nearby. The neighborhoods range from older small houses, some in disrepair, to new medium-sized attractive suburban houses. The area has a lot of open space with housing developments spread over a substantial geographic area with lots of undeveloped land, giving the area a rural feeling despite its proximity to Austin. There is no large central town civic center to accommodate the population. Amenities are dispersed across the region.

The Manor Independent School District (ISD) serves 7,173 K-12 students. There are three high schools in Manor ISD. One, Manor High School is a comprehensive high school, another is a small alternative public school offering a special program for students with discipline referrals, and the third is Manor New Tech High School. Table 2 (next page) shows comparison demographics for the ISD, the comprehensive high school, MNTH and the State of Texas.

MNTH sits on a flat plain close to the highway, surrounded by sunny parking areas. A large solar-powered digital sign next to the road proclaims the MNTH news of the day to anyone driving by. The OSPrI research team's visit was announced in blazing letters to the community in this way. The school is situated next to the Manor ISD offices, separated only by a wide stretch of parking lot. The school was created from older buildings that were once a middle school and the ISD original offices, as well as an additional new building, all connected by open-air, red-roofed walkways that students traverse as they change classes. Notably absent are playing fields or the set of bleachers that announce most high schools. Students at MNTH who wish to participate in sports teams are bussed over to the newly constructed, very attractive comprehensive high school just down the road.

Table 2
2010-2011 Demographics Comparing MNTH, Comprehensive High School, District, and State

	MNTH	Manor High School	Manor Independent School District (ISD)	Texas
Students Served	332	1,155	7,173	4,912,385
Grade Levels	9-12	9-12	PK3-12	PK3-12
African American (%)	19.0	31.5	24.2	12.9
Hispanic (%)	44.3	55.6	60.2	50.3
White (%)	32.2	11.0	11.3	31.2
Asian / Pacific Islander / American Indian (%)	2.4	1.3	2.8	4.0
Two or More Races (%)	2.1	0.6	1.5	1.6
Economically Disadvantaged (%)	51.8	77.0	79.4	59.2
Limited English Proficient (%)	3.6	13.9	31.6	16.9

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

One long structure that houses science and humanities classes for MNTH is festooned by a building-length, lively mural of a lush green, budding Texas countryside populated by huge fantastical animals (long-horns, pigs, birds, tortoise, and a musical rabbit with an IPOD) and graffiti-style lettering. The caption above the mural is: "Manor New Tech: Unity Between Nature and the Environment." The mural was designed and executed by MHTH students. Another edgy graphic mural on one of the other buildings is done in shades of cool blues and grey. It depicts semi-formed (young) human boy and girl shapes entering a chemical apparatus and bubbling out of a pipeline. An adjoining wall shows the apparent product; building-sized depictions of adult figures labeled "Andrew" and "Selena", with both their brains and hearts graphically displayed. Among these murals in the shaded central courtyard, MNTH students chat in small groups as they travel from the building to building to their classes. The atmosphere is relaxed, cheerful, and business-like, with no teachers or administrators obviously on patrol.

When visitors enter the main building, they immediately see a large poster display of photos of each graduating senior, with a description of the college or university that he or she plans to attend and the intended major. Throughout MNTH, there are posters with information and exhortations about college admissions, college opportunities, and financial aid. Another poster, "My College Checklist" is divided into a highly specified list of things to do for juniors in the fall and spring semesters, in order to gain entry into "safety," "match," and "dream schools" by the end of the year. Although directed at juniors and seniors, the posters are displayed throughout the school for students in all grades to see. Other posters are about the pillars of character that are part of the MNTH philosophy and the New Tech High School model. These pillars include: "be a person of character, caring, responsibility, trustworthiness, citizenship and fairness."

The MNTH physical structure is modest in size and appearance, and the student population is not large. It is not an obviously flashy school. But its messages, displayed for

public view, are clear: students should go to college, and a caring community of persons of character is the means to get there.

3.1.2. School history and design.

Principal and administration. The conceptual architect and leader of MNTH is the principal, Steve Zipkes who likes to encourage, in his own words, "controlled chaos." His academic background is in media, but he has turned his head toward innovation in education and clearly has built the school to value individual students and their families. The constant message of MNTH is that of "family," and the students are exhorted to think of the school as "our house." He has carefully chosen a teaching staff that shares these values. Zipkes is charismatic, open and engaging. He encourages his teachers to take initiative and to be creative within the curricular and bureaucratic framework of the Texas Board of Education and the school model that undergirds MNTH.

MNTH was opened the school in 2007-08 school year with a 9th and 10th grade class. The school has since doubled in size and includes grades 9-12. Zipkes had the ear of the superintendent and was encouraged to build a new STEM school model because the large comprehensive high school was having difficulties meeting the Texas state assessment standards, particularly in mathematics and especially for some subgroups of students. There was an eagerness to take advantage of the several new school models being systematically introduced in Texas. Private funding through the Gates and other foundations stimulated the use of the new models. Then, another superintendent was hired in the midst of the MNTH planning, and fortunately for Zipkes, this superintendent saw STEM education as a means to improve student performance in Manor ISD. He embraced the developing MNTH STEM model, giving Zipkes the support he needed. Zipkes started the school with a with a few key staff members, including a STEM teaching coach (a science teacher who has since moved into an administrative position at Manor ISD), and a dean of students with a background in high school counseling and a handful of teachers. It was their vision, energy, values, and entrepreneurial spirit that energized MNTH's launch and its growing reputation as a desirable school with an innovative model. MNTH was born in 2007 from a confluence of opportunities and incentives, discussed below.

Texas TSTEM Schools. MNTH's conception was stimulated by funding from the Texas High School Project, now called Educate Texas. This initiative relies, in part, on funding from private foundations to establish a new network of STEM-focused schools throughout the state (Communities Foundation of Texas, 2012). MNTH received $4 million from the Texas High School Project to start a T-STEM Academy. MNTH is one of the original 32 T-STEM Academies of the current total of 54, plus five blended T-STEM/Early College High Schools. The initial grant was for five years. According to the principal, the school is now self-sustainable. (This fund did not cover building costs; Manor ISD contributed $3 million for building renovations to a former Manor ISD middle school. New construction, if it were required, would necessitate additional funding.) MNTH remains a TSTEM Academy under Educate Texas, and follows a "blueprint" set out in the original funding requirements. The school must reapply annually for grant moneys and demonstrate continued growth in the TSTEM program. Seven TSTEM centers throughout the state to offer professional development to teachers in the TSTEM networks, evaluate school programs, and conduct research.

Funded TSTEM schools are also required to partner with a nearby Institute of Higher Education (IHE) in STEM fields. MNTH has partnerships with Austin Community College and

the University of Texas-Austin. The community college offers courses to MNTH students at the school site during the school day. The University of Texas-Austin has a partnership with MNTH to prepare new teachers focusing on a Project-Based Learning (PBL) instructional model, and also supplies a pool of potential teachers to MNTH.

New Tech Network. In addition to being a TSTEM school, MNTH is part of the New Tech Network, a nationwide network of schools that has its roots in the initial transformation of a Napa, California high school through cooperation of local business, community and educational leaders, and subsequently expanded with funding by the Bill and Melinda Gates Foundation. With the goal to "transform schools into innovative learning environments" the New Tech Network provides curriculum and professional development support that enables learning through a project-based approach. MNTH attempts to maintain fidelity to the New Tech model that prescribes three main components: Project-Based Instruction, technology that is both instructional and infrastructural, and a school culture that promotes trust, respect, and responsibility. A rubric from the New Tech website specifies what these components should look like when implemented successfully. There should be a 1:1 computer ratio, and projects should be implemented and managed as if students conducted them in an actual workplace. Students are encouraged to be self-directed. The model also emphasizes a positive association with the school and its culture. This should complement the project- based instruction and provide students and teachers alike an environment that enables the successful execution of the projects (New Tech Network, 2010).

Funding from local business. Corporate partnerships provided some modest support for the school's startup. Samsung contributed $1 million to create a scholarship endowment, and also supports Manor ISD more broadly. Other corporate partnerships are not primarily financial, but provide teaching and learning support. Corporations do not donate equipment or provide major financial backing, though they may sponsor small projects on occasion (e.g., Freescale Electronics purchased the school's electronic marquee; Whole Foods donates bottled water at events).

3.1.3. Admissions

The admission process is inclusive rather than selective. A personalized application is mailed out to every eighth grade student in the district, and is made available online in both Spanish and English. The application requires basic information such as name and address, and whether or not a sibling currently attends the school. The school selects its incoming class of 100 students by lottery balancing for males and females, and giving slight advantage to siblings of current students. There is a waitlist according to initial date of application (MNTH Website, Application Information). Thus, the demographics shown in Table 2 reflect the demographics of the students and parents who chose to apply to MNTH, but do not exactly mirror those of the ISD. The principal noted that the school does admit students classified as eligible for special education or ESL services, but requires parents to sign a waiver of services. He conjectured that the relatively low percent of English language learners in the student body may be related to the newcomer status of these students in the school district. Some may not have matriculated to Manor ISD schools at the time of the application process; others may have formed new friendships and chosen to stay with these friends as they transitioned to the regular high school.

3.2. EXPLORING THE DESIGN AND IMPLMENTATION DIMENSIONS AT MNTH

This study seeks to explore MNTH's design by examining various documents and website materials and interviewing the principal and founder of the school. Guiding this exploration of the school's design were the 10 "suspected" critical components listed in Table 3 acknowledging that a school's design might not be limited to these 10 critical components. To understand implementation, the OSPrI study team visited the school employing observation instruments and focus group and interview protocols. Design and implementation, intention and action, are influenced by the school's context. In the next section, the 10 critical components in their design and implementation and implementation are discussed.

Table 3
Candidate Critical Components

1. ***STEM-Focused Curriculum.*** Strong courses in all 4 STEM areas, or, engineering and technology are explicitly, intentionally integrated into STEM subjects and non-STEM subjects (Atkinson, Hugo, Lundgren, Shapiro & Thomas, 2007; Brody, 2006 as cited in Subotnik, Tai, Rickoff, & Almarode, 2010; Kaser, 2006 as cited in Means et al., 2008; Means et al., 2008; Rosenstock, 2008; Scott, 2009).
2. ***Reform Instructional Strategies and Project-Based Learning.*** STEM classes emphasize instructional practices/strategies informed by research found in *Adding It Up* (NRC, 2001), *Taking Science to School*, (NRC, 2007), *Learning Science in Informal Environments* (NRC, 2009), *Restructuring Engineering Education: A Focus on Change* (NSF, 1995), *Fostering Learning in the Networked World* (Borgman, Abelson, Dirks, Johnson, Koedinger, Linn & Szalay, 2008) for active teaching and learning (Lynch, 2008) and immersing students in STEM content, processes, habits of mind and skills (Atkinson et al., 2007; Means et al., 2008; Scott, 2009). Opportunities for project-based learning and student production are encouraged, during and beyond the school day. Students are productive and active in STEM learning, as measured by performance-based assessment practices that have an authentic fit with STEM disciplines (Atkinson et al., 2007; Means et al., 2008; New Tech High, 2010; NRC, 2004, 2005, 2007, 2010; Rosenstock, 2008; Subotnik et al., 2010; Scott, 2009).
3. ***Integrated, Innovative Technology Use***. Technology connects students with information systems, models, databases, and STEM research; teachers; mentors; and, social networking resources for STEM ideas during and outside the school day (Means et al., 2008; NRC, 1999, 2009; New Tech High, 2010; Rosenstock, 2008). The school's structure and use of technology has the potential to change relationships between students, teachers and knowledge (Borgman et al., 2008; Coburn, 2003; Elmore, 1996; Rosenstock, 2008) and flatten hierarchies (Atkinson et al., 2007; New Tech High, 2010; Scott, 2009).
4. ***Blended Formal/Informal Learning beyond the Typical School Day, Week, or Year:*** Learning opportunities are not bounded, but ubiquitous. Learning spills into areas regarded as "informal STEM education" and includes apprenticeships, mentoring, social networking and doing STEM in locations off of the school site, in the community, museums and STEM centers, and business and industry (NRC, 2009; PCAST, 2010, Rosenstock, 2008). As a result, the relationship between students, teachers and knowledge changes (Coburn,

2003; Elmore, 1996), and hierarchies flatten to "*…substantially alter the traditional roles of learners, teachers, and instructional resources in the learning environment"* (NSF-DR-K12, 2010, p. 7).

5. ***Real-World STEM Partnerships***: Students connect to business/industry/world of work via mentorships, internships, or projects that occur within or outside the normal school day/year (Atkinson et al., 2007; Brody, 2006 in Subotnik et al., 2010; Kaser, 2006 in Means et al., 2008; Kolicant & Pollock in Subotnik et al., 2010; Means et al., 2008; Rosenstock, 2008; Stone III et al., 2006 in Means et al., 2008). This is envisioned in DR-K12 solicitation: *"The responsibilities for meeting the goals of formal education will undoubtedly shift to include a broader community of stakeholders, such as informal institutions, STEM professionals, parents and caregivers"* (NSF DR-K12, 2010 p. 7).
6. ***Early College-Level Coursework***: School schedule is flexible and designed to provide opportunities for students to take classes at institutions of higher education or online (Atkinson, et al., 2007; Martinez & Klopott, 2005; Means et al., 2008; Rosenstock, 2008; Subotnik, Rayback & Edminston, 2006 as cited in Means et al., 2008).
7. ***Well-Prepared STEM Teaching Staff***: Teachers are qualified and have advanced STEM content knowledge and/or practical experience in STEM careers (Means et al., 2008; Subotnik et al., 2010**)**
8. ***Inclusive STEM Mission:*** The school's stated goals are to prepare students for STEM, with emphasis on recruiting students from underrepresented groups (Means et al, 2008; PCAST, 2010; Scott, 2009, Obama, 2010).
9. ***Administrative Structure:*** The administrative structure for inclusive STEM education varies (school-within-a-school, charter school, magnet school, etc.) and is likely affected by the school's age (less than a full set of grade cohorts) and the school's provenance, i.e., whether the school was converted from another model or was created "from scratch" as a STEM school (Means et al., 2008; Scott, 2009)
10. ***Supports for Underrepresented Students:*** Supports such as bridge programs, tutoring programs, extended school day, extended school year, or looping exist to strengthen student transitions to STEM careers. Such supports result in altered, improved opportunity structures, i.e., students are positioned for STEM college majors, careers, and jobs; and student social structures and identities change to accommodate new opportunity structures (Carnegie Corporation, 2009; Lynch, 2000; Means et al., 2008).

3.2.1. Critical Component: Inclusive STEM mission.

Definition. In order to be considered for the OSPrI study, a candidate high school must self-identify as having a STEM focus and serve a student population that includes students under-represented in STEM college majors and careers. The school's stated goals should be to prepare students for STEM, with emphasis on recruiting students from underrepresented groups (Means et al, 2008; PCAST, 2010; Scott, 2009, Obama, 2010).

Design. At the time of this study, MNTH did not have an explicit mission statement published on its website or student handbook. But MNTH is aligned with the school district mission published on the District website and are aligned with 21st Century Learning Skills identified as important for all students to develop (Partnership for 21st Century Schools, 2009). 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." However, in a

pre-visit telephone structured interview with the school principal, it was clear that the school has a more specific mission to support all students in attaining post-secondary education. When the school opened, the principal noted, "it was just to get our kids to go to college. I mean we [Manor ISD] had a 40% high school completion rate, and maybe 15% of students go to college." The admissions letter echoes this mission: "Manor New Tech considers college admission the goal for all students."

Considering the relatively low college attendance rate of the school district, this mission can also be considered strongly inclusive. Two documents found on the MNTH website addressed inclusion. The application for admission said, "We are committed to working towards enrolling a diverse student population that is reflective of the greater Manor ISD population." The letter to admitted students contained the following statement: "Manor New Tech is a small, inclusive program that will offer many advantages." To achieve this mission, the principal encourages the development of positive student-teacher relations. Zipkes views this as directly linked to college-going behavior, college preparedness, and the issue of curricular rigor (being prepared for college). In summary, MNTH's mission as stated is less STEM-focused that it is focused on the on development of 21st Century Learning Skills and supporting all students to go to college, regardless of major.

***Implementation*.** MNTH serves a diverse student population (see Table 2) including a high incidence of students who are economically disadvantaged or who would be first generation college goers in their families (50%). Although this does not completely reflect the diversity of the school district, it is a remarkably ethnically and socio-economically diverse school. It does not provide special services for English Language Learners or students with disabilities, but neither does it exclude such students if parents willing to forego the special services. When 11th grade students in a focus group were asked if they would describe their school as "inclusive," they talked about how everyone gets along, the absence of cliques, and MNTH as a place where "nerdy" students are accepted—"nerdy is cool" rather than ostracized. One student attributed this to the project-based learning environment: "We are more likely to eat lunch with different people because we think--hey, this might be a good person to work with on a project team." Students are acculturated into a student body with a shared sense of ownership of their school. Class observations revealed that students do indeed work in diverse project groups comprised of males and females of different ethnic backgrounds. In focus groups, teachers said that the admissions process is open to all, i.e., not selective. One subpopulation that is under-represented at MNTH, however, is English Language Learners. Recent immigrants may not have the opportunity for admissions or supports. This is due to the small size of the MNTH. However, some ELLs do attend MNTH and are supported at an individual level under the watchful eyes of the school's only instructional coach who described how she helped teachers to make adjustments for some students.

One mathematics teacher said that there is some tracking at MNTH based on state mathematics assessment scores, but this is done by assigning students to a special section of a course, rather than creating a low track sequence from which there is no escape. There is a means for all students to be ready for Calculus by senior year because of the trimester system that allows students to take up to 6 mathematics courses during high school. Accumulating college preparatory credits can be seen as an opportunity open to all.

MNTH seeks parent involvement. Recognizing that many parents are Spanish-speaking, translation services, including an interpreter and radio transmitters, are provided. Parents are

encouraged to be active participants in the school. And some parent service is required for helping during and after school. A parent-led appreciation event for teachers was observed and participated in during the research team visit—a delicious breakfast. Other parents are hired to work on the school staff and are active in providing translation services. In addition, the College Forward program includes an evening session to provide opportunities for parental participation in their child's college admissions process. This is especially critical for students whose own parents or family members have no college experience. Parents also receive assistance in filling in financial aid applications. One teacher involved in "College Mondays" said:

> We make them [the students] apply to 4-year colleges even if they at the end say they are going to Austin Community College. But between now and then we explore different options. In their families there isn't a pattern of going to college. That is a huge concern of us in getting them to go to college.

Students at MNTH take a college preparatory course sequence designed to make them competitive as college applicants. According to the principal, this makes them extremely attractive as applicants to four year colleges. He also noted that students' ability to communicate, to represent themselves, makes a powerful difference in admissions success: "Our kids can talk. If they get an interview, they're in." Another factor identified by the principal as critical to the mission to have all students attend college was the quality of student-teacher relationships. Teachers are available to help students before and/or after school to ensure that students are able to master the college preparatory mathematics and science curriculum. One student said, "Our teachers are great! If I need help after school, I can go find any of my math or science teachers and they'll help me."

Summary. Manor New Tech High School is inclusive and STEM-focused, although its mission is more generally to support students in developing 21st Century Skills and attending college. Its mission is not directly focused on creating STEM college majors, however. The emphasis on positive relationships between students and teachers is seen as directly linked to college-going behavior and college preparedness (rigor). Students made connections between "inclusiveness" and project-based learning. The school staff saw the trimester system as an important opportunity structure to support students in attaining MNTH's more demanding STEM graduation requirements. The evidence suggests MNTH has implemented a strong program to inspire and support students to apply to four year colleges; all students in focus groups indicated that they had plans to apply to college, grounded in particular career interests and research into college majors and careers.

3.2.2. Critical Component: STEM-focused curriculum

Definition. Schools in the OSPrI study must self-identify as having a STEM focus as a criterion for inclusion in the study. But there is no single agreed upon definition of "STEM-focused". The research indicates that such schools may have intentionally re-designed courses in STEM areas, or have combined two or more STEM disciplines into single courses. Engineering and technology may be explicitly and intentionally integrated into STEM subjects and non-STEM subjects (Atkinson et al., 2007; Brody, 2006 as cited in Subotnik, Tai, Rickoff, & Almarode, 2010; Kaser, 2006 as cited in Means et al., 2008; Means et al., 2008; Rosenstock, 2008; Scott, 2009). In addition, a strong STEM-focused curriculum may include more STEM

offerings or requirements than typical for the surrounding school district or state, or provide coursework at levels higher than usual for high schools.

Design. MNTH is part of the New Tech School consortium and maintains fidelity to its model that prescribes three main components: project-based instruction; technology—both instructional and infrastructural; and, "a culture that promotes trust, respect, and responsibility" (New Tech Network, 2009). The New Tech School consortium provides a few broad curricular goals for its schools, namely, the use of PBL as the "primary mode of instruction" and the integration of 21st Century skills into "all areas of curriculum and assessment." Cross-curricular approaches, team teaching, and community-based service projects are also emphasized, as is a student leadership role in project development (New Tech Network, 2010). MNTH apparently has developed the model well because it has become a "demonstration site" for the New Tech School network.

Graduation requirements at MNTH include five credits each in science and mathematics, and two credits in engineering. Students are also required to take two technology credits of their choosing. In comparison, the State of Texas only requires four credits of science and mathematics for graduation; engineering and technology courses are electives. MNTH's trimester system allows students to accrue 1.5 times the number of credits in a single year as schools on a two semester system. For instance, students usually begin 9th grade with either Algebra I or Geometry and progress through Pre-calculus or Calculus. Students entering MNTH without Algebra I can take a Mathematics Enrichment course designed to meet the needs of students struggling to pass the Texas mathematics assessments. The flexible trimester system allows students accrue the higher number of math credits required for graduation in this four-year (grade 9-12) high school than typical. Students who began their mathematics studies with Algebra I at MNTH also can "double up" on courses to complete Calculus during high school.

In science, MNTH students complete courses in biology and chemistry, then take additional cross-disciplinary classes in physics (with algebra II), scientific research and design (with statistics), environmental science (with pre-calculus), and astronomy. Consequently, students graduating from MNTH enter college with a broader base in STEM, and one that may be deeper as well, given their experiences with project-based learning (to be discussed in more detail later). Steve Zipkes, Principal of MNTH, discusses his school's goals for students when he points out:

> (…) colleges look at the actual courses you took in high school…If I've got a student and the State requires 4 maths and 4 sciences, and of 7,800 high schools, only 400 offer engineering, and I have a student's transcript with 5 math, 5 science and 2 years of engineering, they're getting in.

MNTH's instructional approach is 100% project-based learning (PBL). Most of the courses for 11th and 12th graders are cross-disciplinary, combining two disciplines. The instructional time allotted for such courses is twice as long as a single subject course. Two teachers, one in each subject area, are assigned to teach them. Teachers plan their curriculum by analyzing the relevant Texas content standards for a course, and then identify relevant project-based challenges that align to the standards. This allows students to learn the material intended by the standard in a contextualized and interdisciplinary way. This is more than a curricular gimmick at MNTH, it is

the dominant curricular and instruction model employed by all teachers, STEM and humanities teachers alike.

Implementation. The mathematics needs of MNTH students seem to be the major driver of the school's curriculum design and approach. Mathematics is the only subject at MNTH in which the school struggles to meet or exceed state benchmarks. Principal Steve Zipkes remarks that "I've got a 73% pass rate in math. We are not where we need to be in math, but I also have a 25 to 28% "commended" rate of students who are high achieving." Nonetheless, the perception is that some students enter MNTH woefully underprepared in mathematics, so the school tries to move them forward. Zipkes notes, "You look at the student cohort and then you see where the students came in and how much growth they've had, that value added…" One way of moving the students forward in mathematics is to provide a curriculum that focuses on areas of need, based upon systematic test data analyses from the Texas state mathematics assessments. Then, teachers design three-week units of instruction using the PBL to aim precisely at providing experiences to help students understand the mathematics concepts in the context of science or engineering, with real world applications. Students can and do frequently request "workshops" (teacher led mini-lessons) during science and mathematics classes that focus on concepts and operations that need to be better understood. Students also reported seeking (and receiving) help with mathematical aspects of their assigned work from any STEM teacher. The STEM teaching staff is willing to support all students in their mathematics learning.

MNTH students take the science courses required by the State of Texas (Biology, Physics and Chemistry), so teachers aim for rigor equivalent to that in any Texas high school because students must take the same end-of-course science tests; projects must have the standards incorporated into the learning goals. Students in the 11th grade described their courses as rigorous, and appreciated the contextualized approach afforded by project-based learning. Students noted that the projects were good for research and design principles, and had to be based upon mathematics calculations that matched and were required by actual PBL activity. For instance, a chemistry teacher teaches Gay-Lussac and Boyles' Gas Laws with a dome project requiring students to design a canister that can carry a gas to the moon or planet or moon that they imagine they will inhabit. The teacher commented:

> I make sure that students keep working on the content they need in order to make progress on their dome project. I need to make sure that they understand and can use the gas laws…The students need to figure out how to manipulate all the variables to solve for what they need…Some of students needed to see that this project can actually happen, so I pulled out models from two years ago to give them a sense of possibility. This made a difference for struggling students. They were inspired and started working.

None of this happens by accident. An interview with the first MNTH instructional coach, now an administrator in this small school district, reveals the strategies behind the PBL. She pointed out that teachers must first learn the Texas standards so the projects will "not be fluff." At the same time, teachers must get through the entire curriculum in a course.

> …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.

The engineering sequence at MNTH is Introduction to Engineering followed by Principles of Engineering. There are also electives in Digital Electronics and a robust Robotics Club. Engineering teachers have had professional development in the Project Lead The Way engineering curriculum, which has been somewhat modified for the PBL and cross-disciplinary curriculum at MNTH. Explaining how this philosophy and approach works, an engineering teacher points out that she sees her job as fitting engineering to the mathematics, science, and technology, integral to this STEM-focused school.

> We score low on testing in math (…) so the question is what do I need to teach in order to improve science and math understanding (…) there is a joint effort to cover the content…Geometry, for example, is used in the roller coaster project in determining the shapes of the coaster, and engineering would work with the structures needed to support these shapes…Engineering represents the application of math and science. All are interconnected. Previous math and science content is reinforced with engineering content whenever possible.

MNTH requires students to take the equivalent of two years of technology courses, out of about eight technology electives that include Theatre/Digital Media Literacy, Digital Animation, App and Video Game, Programming, Web Serial, Marketing PIT/DML/Basic Programming. The technology courses are not interdisciplinary, although there are attempts made to coordinate with other courses. The technology teachers are "batting clean-up for the rest of the school." One technology teacher notes:

> Being the "invisible tool" has the advantage of making you invisible. We don't get the understanding or allowances that core classes are given. This is as it should be. Sometimes we feel disposable or not equal to the other classes. But the other teachers couldn't do the awesome stuff in their classes without us. The students take what they learn with us and shine in the other classes.

Students will leave MNTH with the technology skills used in business and industry. Students point out that this system allows them to understand what they do and do not want to do (for college majors or careers). However, one student said that because few students go on to careers in technology or engineering, that a wider variety of technology classes would be desirable. Students also point out that the name of their school perhaps suggests more of a technology focus than actually exists. In summary, the technology used at MNTH is not a rigorous, in depth sequence of offerings—for instance, there is no computer science offered. Rather its rigor lies in the breadth of technology course offerings and the ubiquity of the use of technology across all courses.

The strong and popular humanities program at MNTH raises questions about the STEM focus of the school. STEM teachers think that it's less STEM-focused then is should be, but the humanities teachers at MNTH say the opposite is true. Humanities courses are cross-disciplinary, use the PBL instructional approach, integrate available technologies, and are regarded by

students as very rigorous and challenging. Students in 11th grade look forward to the higher level humanities courses with mixed trepidation and enthusiasm because these classes carry college credit through the community college. Humanities teachers have been hired because they can meet requirements to teach at the community college level. The humanities classes visited for this study appeared to reflect high standards of rigor, and seem appropriate for the undergraduate level that they target in English/Language Arts.

In contrast, no STEM courses are on offer for college credit. There are no AP courses at MNTH. Principal Steve Zipkes explained that when the school opened six years ago, there was concern that it would "cream off" the best and brightest students, leaving the comprehensive high school with no top stratum of students. Consequently, MNTH was opened with the understanding that the AP courses would remain at the comprehensive high school as a way of retaining academic variation at both the old and new schools. Although college level STEM courses used to be offered at MNTH through Austin Community College, this practice has been discontinued. Thus, in a PBL environment where one sees students working in groups on projects, it is difficult to ascertain the rigor of the coursework being offered as a researcher visiting the school for limited period of time. (This is a current limitation of this study that we are endeavoring to shore up by creating new ways of viewing PBL courses.) When asked about the rigor of the STEM courses at MNTH, Principal Steve Zipkes responded that he focuses on measurable outcomes for students to assess rigor:

> As a data person, the only way I can measure rigor is by looking at what we are accountable for. Students are getting into college and staying in college. I've got a 90% pass rate for the last four years in all of the English Language Arts and social studies. I've got a 73% pass rate in math. We're not where we need to be in math. We are going to meet the standard (in the future). I've got a 25-28% commended rate for high achieving students in math.

Summary. MNTH achieves its STEM focus and rigor through its instructional design (PBL) and the high numbers of STEM courses required for graduation. Although students do not seem to emphasize that they are attending a STEM school as much that they are aware that they are in a New Tech school, they all nonetheless are steeped in a STEM-focused environment. MNTH not only requires them to learn the STEM disciplines and pass the requisite exams, but they participate in projects that help them to understand STEM in context. The Texas T-STEM initiatives, and MNTH participation and leadership role in the New Tech High consortium, and its commitment to PBL through its collaboration with the University of Texas Austin, shape MNTH's STEM commitment. Important to note, these outside forces have been carefully chosen and are coherent with one another and with the design and implementation of the MNTH's STEM-focused curriculum. Students who graduate from MNTH may or may not go on to STEM jobs and careers, but all are well-positioned for college. The 21st Century Skills they have learned through MNTH's STEM-focused curriculum seem likely to serve them well, in college and in jobs and careers.

3.2.3. Critical Component: Reform instructional strategies and project-based learning

Definition. The STEM classes at MNTH emphasize instructional practices and strategies informed by research found in *Adding It Up* (NRC, 2001), *Taking Science to School* (NRC, 2007*), Learning Science in Informal Environments* (NRC, 2009), *Restructuring Engineering*

Education: A Focus on Change (NSF, 1995*), Fostering Learning in the Networked World* (Borgman et al., 2008) for active teaching and learning (Lynch, 2008) and immersing students in STEM content, processes, habits of mind and skills (Atkinson et al., 2007; Means et al., 2008; Scott, 2009). Opportunities for project-based learning (PBL) and student production are encouraged, during and beyond the MNTH school day. Students are productive and active in STEM learning, as measured by performance-based assessment practices that have an authentic fit with STEM disciplines (Atkinson et al., 2007; Means, 2006; Means et al., 2008; New Tech High, 2010; NRC, 2004, 2005, 2007, 2010; Rosenstock, 2008; Subotnik et al., 2010; Scott, 2009). Reform-based classroom practices such as PBL offer rich, alternative approaches to traditional teaching techniques. Students learning in a PBL environment actively construct knowledge by defining learning goals, seeking information to add to their prior knowledge to improve their understanding of the problem, assessing the learning process, and participating in active collaboration with others (Beachey, 2004). This type of student work is likely fruitful in developing life-long learners because students gradually assume more responsibility for their learning. They identify and direct their own learning, deciding which issues are key to advancing the project's goals, as they clear up ambiguities and find the resources needed to solve the problem (Becker & Maunsaiyat, 2004; Blumberg, 2000; Chen Chang & Chiang, 2001; Kassebaum, Averbach, & Fryer, 1991; Kong, Li, Wang, Sun, & Zhang, 2009). In a PBL setting, instructors guide learning by asking students metacognitive questions about their problem-solving and provide just-in-time instruction (or 'workshops' as they are called at MNTH) as needed. Thus, students are constructing knowledge for themselves (Arambula-Greenfield, 1996; Becker & Maunsaiyat, 2004).

Design. The administrators, teachers, and students at MNTH agree that the school's identity is better defined by *PBL* than by STEM education. The "New Tech" in the title of the school is its salient feature, known within the community-at-large as the basis for this school. MNTH, one of the TAP program schools (the System for Teacher and Student Advancement), selected the New Tech Network (The New Tech High Foundation, 2010) as a model for change. All of the teachers initially attended the same PBL training from the New Tech Network and relied heavily on the New Tech Schools' curriculum to provide specific examples of projects and rubrics, as well as the design for their cross-disciplinary courses. As time has gone on, however, MNTH teachers have developed their own projects to better address Texas Standards of Learning and meet the needs of MNTH students. The teachers are increasingly recognized for their expertise as they extend the PBL model of the New Tech Network by leading professional development at other schools. In addition, MNTH serves as a demonstration site for the New Tech model.

Implementation. *Introduction.* At MNTH, PBL approaches to learning are the common instructional practice, embraced by the entire learning community. The PBL units of instruction for all subjects in the school include: (a) entry documents introducing students to a new project, (b) assessment rubrics, (c) interdependent group work, (d) the use of effective communication during the project and to describe the end product, and (e) workshops. The entry documents are used to "launch" a project and consist of a detailed description of the goals and constraints of the project. Entry documents take a variety of formats, ranging from multi-media presentations to White Papers such as those used in engineering design. Teachers seem proficient in generating entry documents, which attempt to set a project's context to real-world problems in all classes,

not just STEM-oriented classes. The rubrics, documents given to the students at the beginning of the project, are clearly aligned with the Texas state standards and with the attitudes expected at MNTH. Teachers work to align the assessment rubrics for and the PBL scenarios with the state standards. 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."

Examples of PBL from classroom observations. In a PBL environment, one would expect that most of the time spent in class would be student-centered. One of the key components to connect PBL to a standards-based curriculum was the process of conducting a "workshop." Workshops were segments of direct teaching that were initiated by the either the teacher or the students, and provided the mechanism for students to be able to move their content learning forward. As Hmelo-Silver (2009) demonstrated, learning goals for PBLs are (a) constructing flexible knowledge, (b) developing effective problem-solving skills, (c) developing life-long learning skills (self-directed learning), (d) being a good collaborator, and (e) becoming intrinsically motivated. MNTH faculty demonstrate cognizance of these goals and seem to be able to implement them well. .

Example 1: Trigonometry/Geometry Class. In one class visited, we observed a trigonometry/geometry project that required students working in groups to design their own buildings, given certain parameters in the size of the building. 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 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 our observation, most groups were transferring the paper drafts to electronic form, using Geometer's Sketchpad. The challenge that they were encountering was adjusting their graph paper drawings to more realistic renditions that would 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 the course of observation, the teacher had the students directed toward on-topic tasks related to the lesson 97% of the time (the prom that occurred the prior weekend got the other 3%). 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, and about 19% was spent on individual student work. In all, 94% of the time was directed toward hands-on activities—the project was truly the basis for the activity in this class.

Example 2: Chemistry Class. In a chemistry class observed, the students were in the middle of a project to design a canister that would be used to deliver a mixture of gases to provide human life-sustaining environment in a "biodome" built on another planet or moon in our solar system. Over the course of the project, students had to learn appropriate gas laws,

consider the chemical reactions and rates for gas consumption and expulsion necessary for life, and understand the environmental conditions on their chosen planet or moon, as well as other collateral concerns such as delivery of the gases and the biodome design. Throughout class, several small groups of students worked on various aspects of their projects, some students working individually, others collectively. During the observation, students requested a workshop because they decided that they needed to better understand the *combined gas law*. The teacher engaged in direct instruction for about half the students, who listened intently and participated actively. The other half continued their group-work on their projects. Many students in this particular chemistry class struggled with, and sought to avoid, math, so the instruction during the workshop was deliberate, patient, thoughtful, and designed to meet the students' needs.

Because there were multiple activities going on in the room at one time, it was difficult to characterize the lesson as singularly teacher or student centered. For about 85% of the time, students worked in student-centered small groups. About half of the class was engaged with the teacher in the student-requested workshop, which lasted about half of the class time, and throughout class, several students worked independently in a variety of capacities. Only 13% of the class time was focused entirely on the teacher and direct instruction.

Example 3: American History/Creative Writing. A third striking example of the use of PBL at MNTH comes from an upper level humanities class, a combination of American History and Creative Writing, taught by two teachers. The Creative Writing portion of the class carried community college credit, and the tone and depth of discussions seemed appropriate for a college-level course. The teachers started off the class with students describing interesting current events, globally, and nationally that had occurred in the last 24 hours. This was followed by a teacher-led whole class discussion of a new project that required students to make a documentary film about a self-selected topic in pop culture. Students were asked to construct a thesis statement because the point of the documentary was to make an argument that could be thoughtful, persuasive or conversational. For the remainder of the class, students worked in small groups developing their thesis statements, and referring back to the entry document (goals for this project) and rubric on the Echo communication system that guided this project. The groups were huddled around computer stations as they searched on-line for information that would serve their project and the immediate assignment. Some of the topics to be explored were helmet rules in football, use of neon colors currently in fashion as throwback to the 1980s, and tattoo culture as art and expression.

While these examples might sound "light," the ensuing discussions that we overheard were sophisticated and substantive. Students were tackling big ideas in social studies in the context of American pop culture. A very small amount of class time, 6%, was focused directly on the teachers and this was primarily to set up the day, transition the students to subsequent activities, and at the close of class. 79% of class time involved students working in small groups, and 13% was spent individually although on work related to group activity. This was an inquiry based humanities class.

Student outcome data at MNTH shows consistently high scores on the state-administered tests, indicating that the PBL approach is suited to teaching the Texas state standards. See Outcome section of this paper for more information.

21st Century Skills and PBL problem-based learning. PBL scenarios at MNTH are designed to develop 21st Century Skills, such as critical thinking, collaboration, creativity and

effective communication. All four components of the learning and innovation skills appeared to be implemented explicitly at MNTH. Communication, collaboration and critical thinking were ubiquitous in the language of the teachers as they spoke about how their students interact with the PBL curriculum. As one teacher pointed out:

> Students learn how to teach and present what they know, which is different from a traditional high school. This process helps students in developing critical thinking skills, as well as other 21st Century Skills.

The PBL units at MNTH are deliberately designed for group members to have interdependence; projects cannot be fully completed without all members having a developed work ethic. The system for interdependence is so elaborate at MNTH that members of the group can "fire" other members if they are not producing their share, although this apparently happens only rarely.

Effective communication techniques are part of the culture at MNTH and are fostered from the moment the students enter the building as freshmen. In focus groups, freshmen tended to be a bit shy and fumbled over words, but the juniors and seniors spoke with great confidence and clarity. It was often noted by faculty and students that by the time a student graduates MNTH, they formally and publically have presented about 65 times per year. Many of the formal presentations can be found on YouTube.com, indicating that the end user is not only the teacher, but the greater public.

Perseverance balanced with time management was a theme that continued to emerge from the data. A 10th grade student at MNTH captures what the school offers her in life-long learning skills:

> They make the work all on you [regarding being an independent learner] and they say this is when you start the project and end the project; they teach you a lot about time management; they help you with organization; when I came here I wasn't very organized and now I am.

Career development is woven throughout the PBL curriculum, often by organizing the problem scenarios from the view of a practicing professional in the field in which the PBL scenario is set. A statement frequently found in many of the entry documents that launched PBL projects had the following format: How can I as a professional do (an action) so that (product). In this way, the students were required to research careers as they learned skills and content knowledge aligned with standards. Even the ninth grade students spoke knowledgably about a variety of careers and the preparation needed to achieve the careers encountered through PBL activities. Student creativity in the PBL environment is seated in real world scenarios. Teachers were aware that the projects, if not facilitated well, could result in mere "decorative creativity." A technology teacher explained:

> Critical thinking is required to find out why you have that scenario that is problematic. [It is] not always a fun thing, but more critical. New Tech academic discussions are a real world thing so we do not always have craft projects and it can be also academic and that for me was a revelation."

It was clear from the artifacts gathered during the school site visit and the ways teachers and students spoke about their projects that there was complexity and variety in the work. It appeared that all of the projects were multidisciplinary in nature, and required students to use a variety of processes and skills to successfully execute them. Methods of learning ranged from self-construction to direct-instruction and the resources needed to understand a problem were varied.

Challenges of PBL. One barrier to the complexity and variety of the projects was the level of math achievement of the students. The classes at MNTH are interdisciplinary but mathematics knowledge in students was sometimes low (compared to other areas such as English/language arts) and might need to be reinforced. Consequently, student math achievement levels tended to drive the cognitive level of instruction. An engineering teacher explained how math, science and engineering work together to increase math knowledge in the students:

> Engineering fits in with math science and technology as a part of the STEM school. We score low on testing in math…so the question is what to do? I need to teach in order to help out science and math understanding. There is a joint effort [in math, science and engineering] to cover the content.

The cognitive and organizational demands made on MNTH students advance in grades; during students' junior or senior year, the mode of instruction changes from project-based learning to challenge-based learning, which gives students more independence in designing their own projects. Students engaged in the PBL projects learned productivity skills, collaboration, communication, and how to grapple with big ideas rather than trivial knowledge. Productivity skills included time management, responsibility, and work ethic. Many of the students spoke about how it was difficult to learn. Because of the learning environment and expectations of PBL, they gradually learn how to manage their time. Students understand that it is their ultimate responsibility to learn the material and it cannot be "told to them." A 10th grade student stated:

> [Teachers] inform you on how you want to make your choice and what you want to desire; how they make the work all on you and they say this is when you start the project and end the project; they teach you a lot about time management.

When students enter MNTH, they do not immediately succeed in the PBL environment. Students and teachers spoke about a high failure rate on projects in the beginning of the freshman year. "Work ethic" is one of the pillars of MNTH's mission. Students, with support from the MNTH system and individual teachers, learn to seek help and ask clarifying question so that they can understand how to produce their work efficiently. Students grow to become independent learners within a group in the PBL environment. Another 10th grade student states, "I didn't know that I could be an independent learner. I see the world more clearly." Students learn how to communicate through a variety of media; choose valid resources for a project; use evidence in making claims; take in feedback and use it to improve; and, not fear making mistakes. The collaboration it takes to complete a PBL project involves communicating to peers and the teacher clearly, which involves the use of logical reasoning skills, providing group rationale for making claims, and distributing the load of work. Although the PBL environment gives students a steep

learning curve at the beginning of the freshman year, over time, the tasks required by PBL yield positive student outcomes.

The school culture that is established requires students to take responsibility for their own learning, to learn how to communicate even if they do not "like" the other members of the group. Students understand that they must work in a group to be successful and to make adjustments to their processes in order to make it work. Teachers emphasize that they will be a part of another group after this project, so they do not move group members around to accommodate difficulties in personalities. This work ethic contributes to the inclusive nature of MNTH. Not only are students engaged with authentic scenarios from the "real world," but they also must engage in the workplace dynamics they will ultimately face upon graduation.

Summary. Teachers at MNTH offer project-based learning projects that emphasize production and give clear goals in the form of entry documents and rubrics. The goals are aligned with state standards, and projects are anchored in objectives. In effect, the teachers give the students the starting point and the end-point in a project, while supporting students through the use of workshops and monitoring their progress, resulting in a balance of direct instruction and student production. The level of cognition of the projects is mainly synthesis and evaluation, and workshops (direct instruction) contribute substantially to the content knowledge of the students. Teachers provide students and groups of students with a personalized learning environment because classes are small and there is a culture of asking any teacher for help. Teacher-student relationships are centered on learning and completing projects, but are enhanced through constant meaningful interactions. The technology at MNTH affords the platform to give frequent and timely feedback to students, allowing teachers to keep in touch with students as they complete their projects, and adjust the amount of scaffolding as needed. PBL projects that are seen as needing improvement can be brought to the "Critical Friends" professional development time for revision with the entire faculty's input. Teachers are deliberate in designing the PBL projects to maximize student motivation, for student ownership, and foster a variety of forms of communication for the students to demonstrate their learning. Because teachers seek frequent feedback about their own performance, they model this behavior for their students, creating a culture where assessment is not focused on right and wrong answers, but encourages learning and improvement of performance.

3.2.4. Critical Component: Integrated, innovative technology use

Definition. Technology connects students with information systems, models, databases, STEM research; teachers; mentors; social networking resources for STEM ideas, during and outside the school day (NRC, 1999, 2009; Means et al., 2008; New Tech High, 2010; Rosenstock, 2008). The school's structure and use of technology has the potential to change relationships between students, teachers and knowledge (Borgman et al., 2008; Coburn, 2003; Elmore, 1996; Rosenstock, 2008) and flatten hierarchies (Atkinson, et al., 2007; New Tech High, 2010; Scott, 2009). Technology is an explicit part of the school's planning.

Design. At MNTH, technology is conceptualized to be an "invisible tool," meaning that it is used as a way to support learning goals and objectives and not as an objective itself. There are no required technology courses, for example. (See STEM-Focused Curriculum for a discussion of the technology curriculum). Rather, students are required to choose two years of technology courses as electives, according to their interests.

Part of the mission of MNTH includes the idea that "The goal of Manor New Technology High School is to prepare students to excel in an information-based and technology advanced society." Further, Technology Literacy is listed among the school's nine core learning outcomes. To serve this mission, every single classroom is equipped with a class set of desktop computers and a projector setup. The technology infrastructure was a one-time cost at the school's inception and no further budget has been allocated towards replacing outdated hardware. Broadband internet access is provided by the district and is intended to be shared between district high schools. ECHO, a learning management system used in all New Tech Network schools, is intended to be the primary means through which teachers and students share information about rubrics, grades, and project feedback. Students are encouraged to email teachers with questions about projects or material.

Technology use policies are fairly lenient. Students are prohibited from using social network sites, downloading illegal files, sharing login information with other students/non-students, and sabotaging other student's online work. Consequences of inappropriate technology use include account suspension. Given the heavy reliance on technology for project completion, this is a significant consequence. On the other hand, cell phones are permitted during the school day. Intended uses of technology at the school (as opposed to student) level include marketing and recruiting through YouTube videos that feature student work and student testimonials.

Finally, technology teachers are meant to serve as a resource to other teachers and to students, suggesting innovative ways to use technology in teaching and learning. The district is active in supporting and encouraging teachers to use technology in the classroom. A representative from the ISD said:

> We have been very thoughtful about setting up classrooms so we can provide things to all teachers ... we provide teachers 5 mac book pros, 4 iPads, projector devices and smart boards. Can't make the technology bundle too large because we will need to support more and more teachers, but do want to give them resources. Need to plan the tech package, what best fits what you're trying to teach. How to be creative on iPad, not just research. They have the mix so they can have research stations and creativity stations in the class, ability to do both and reach more students.

Implementation. *Interconnectivity.* Technology connects MNTH students with each other. Students use social networks and ECHO/Google apps to communicate, plan projects, and delegate tasks. They rely strongly on ECHO. One student commented, "When ECHO went down for a few days last year, we about died." Students also like that ECHO permits them to stay in contact with PBL group members even if one member is sick.

Technology connects students with teachers. Students email teachers with questions and receive feedback on work via ECHO. One student noted that he is able to stay on top of his grades much more now since he can track his progress using ECHO. Students are very comfortable seeking feedback via ECHO and email, indicating a shift towards a learning goal orientation (also due to school's collaborative culture). Technology connects students with outside research resources. Students are independent and collaborative researchers, using Internet resources to obtain information to complete projects. For example, students are comfortable using the Science Daily website to find primary sources in science courses, and Wikipedia to learn about historical events. Students also access online resources such as Khan Academy

independently and under their own initiative when they need to supplement their knowledge for a project.

Technology connects students with the community and world. Students use YouTube and Facebook for external outreach and to document and show their work. YouTube is a repository for student work projects and acts a recruiting tool for future students. For example, in one course, students made videos about MNTH and to highlight how it is different from other schools. This also reinforces the psychological climate of the school. (A recurring theme is that technology reinforces the climate, rather than drives it.) It is important to note that communication is mostly school → world instead of world → students.

Technology connects students with STEM professionals. Though this aspect of MNTH is not as well developed as other STEM resources, students have the ability to connect with STEM professional via technology. However, they do not appear to take advantage of this very often. Nonetheless, this helps students see the connections between what they are learning and how they will use the skills in their future jobs. A 10th grade student recounted:

> Where ever you want to go, with the knowledge you get here now, you will be able to present your advanced technology; you don't have to be an engineer to use what we learn now; most of workplaces are going to have computers. The more advanced we are, the more it helps; I had an engineer talk to me and the owner of a restaurant is an engineer and he uses his skills in his business,

This results in changed relationships between teachers and students and knowledge. Students can function independently of the teacher; they can receive feedback on rubrics while a teacher works with others; they can research independently; they can problem-solve with Internet resources (e.g., debugging a program by using online help manuals). A 10th-grade student reports:

> Teachers are always willing to help with homework through the technology as long as it is reasonable hours; there are agendas that the teachers post and we are responsible enough that the students check, and a substitute doesn't even need plans. There is a lot of communication going on. Technology has made us open. If we emailed teachers in [the other high school], that would be weird, but here it is done everywhere. The teacher-student relationships are much closer. My parents talk to my teachers a lot through email and if my grades are where they want to be, my parents have no difficulty using their emails. They got to know the teacher physically"

Internet as a resource. There is much more reliance on Internet resources instead of textbooks. Students vary in their reaction to this format. Some believe that greater variety of information is a good thing. However, there are some reservations. One student explained that, "In biology we use textbooks too; I like having the textbooks because sometime Google isn't true*."* Some students report wanting more clarity on how to determine trusted resources from untrusted resources on the internet. This indicates that they are developing a critical appreciation for the sources they find as opposed to accepting what they read without examination. Other students do not seem as concerned and one pointed out:

> There are a lot of open sources we can use. When we are assigned a research project - we don't use books. The internet sources tell lots of different things and so it gives information that you can put in your presentation,

Technology as a resource. Technology is not emphasized as a discipline in the curriculum, but an "invisible tool" or "fancy pencil", according to teachers. It is a means to an end. The school's goal for technology to be an "invisible tool" may be *too* effective—some students feel that the school does not emphasize technology enough. When asked what they thought was different about MNTH compared to other high schools, one 10th grade student describes her perception of the school before she enrolled:

> I heard that we used computers instead of books and we have Google and the school website; I thought it was more technology-based than it is because of the name of the school.

Instead, technology is integrated and blended into the fabric of the school. Design and technology teachers act as resources for STEM and non-STEM teachers. Computers are present in every classroom. Students are expected to use technology to complete projects and to learn independently. They use technology for research and multimedia production. They learn a bit about programming and making games. They use various apps to complete their projects. A10th grade students reported:

> I took a class at the beginning of the year with PowerPoint. It helps with science and math. The final product for some classes is a video and so we use the software products we learn in technology classes to make the videos in science and math.

Reliability/Sustainability. There are some challenges with bandwidth and hardware as MNTH grows and equipment ages. Additionally, the reliance on the school district makes some innovative uses of technology difficult because the district blocks many web sites that students need to use. The school will also increasingly require a greater proportion of the overall bandwidth available, and this creates some issues with speed, reliability, and access. However, the district is supportive, and aware of these challenges.

Teacher professional development for incorporating technology into their instruction and communication systems tends to be ad-hoc. The technology teachers assume most of the burden of providing technology support to non-technology teachers. Students also act as a source of support for teachers with regard to web design and troubleshooting, as well as to one another.

Technology teachers have some flexibility in selecting course offerings to suit the needs of students and try to align their offerings to students with what other teachers are trying to accomplish in their courses. For example, one teacher noted:

> I have say-so according to my classes – I started teaching web-design. Seniors have a portfolio at the end of their time here, Now we cannot require students to have a web page, but there are students who don't want to get into coding, and since there are already prebuilt websites—WordPress, for example--that can be used. Better for kids to know what is available and how to use it. Next year Sally [a pseudonym] will be doing graphic

design and illustration for students who like working with illustrator, flash, changing to graphic art and design from web design.

According to teacher survey results (15 out of 28 teachers responded), funding for technology neither inhibited not facilitated effective instruction but access to computer hardware and software greatly facilitated effective instruction. Lack of technical support somewhat inhibited instruction. Student access to technology in their homes inhibits effective instruction. Despite these challenges, the School Technology and Readiness Report Card gave MNTH a rating of "Target Tech" (highest rating) across almost all aspects of long-range planning.

Summary. MNTH has been purposeful in planning the way technology is used in the school. Specifically, technology is used to *support* the school's mission, culture, and learning environment, but not to *drive* them. Technology is consistently referred to as an invisible tool, and though the students and teachers are very technology-savvy, learning comes first and technology comes second.

3.2.5. Critical Component: Well-prepared STEM teaching staff

Definition. Teachers are qualified and have advanced STEM content knowledge and/or practical experience in STEM careers (Means et al., 2008; Subotnik et al., 2010). The need for a "Well-Prepared STEM Teaching Staff" as a condition of effective STEM schools has a strong research base in STEM education (Brewer & Goldhaber, 2000; Monk, 1994; Monk & King, 1994; Rowan, Chiang, & Miller, 1997), and was established as one of the ten Critical Components to be addressed in our study: *Multiple Instrumental Case Studies of Inclusive STEM-focused High Schools: Opportunity Structure for Preparation and Inspiration (OSPrI)* (NSF DRK-12 1118851).

It is anticipated that providing a Strong STEM-focused Curriculum (Critical Component 1 (CC1)) and using Reform Instructional Strategies and Project-Based Learning (CC2) is enabled by a Well-Prepared STEM Teaching Staff, described as teachers who have strong STEM content and pedagogical knowledge as well as the institutional support to effectively teach. Our description of a Well-Prepared STEM Teaching Staff includes teachers who have advanced STEM content knowledge and/or practical experience in STEM careers (Means et al., 2008; Subotnik et al., 2010) as characterized by a solid academic and experiential background in STEM content and process. This enables the teaching of classes with "high cognitive demand" providing academic experiences resulting in both inspiration and confidence, as students become well-prepared for STEM college coursework.

Having a Well-Prepared STEM Teaching Staff implies that a STEM teacher is prepared to carry out the STEM school's mission, from the time the teacher is hired through ongoing professional development. Teacher qualifications include content-specific knowledge based on college-level coursework and relevant career experience, pedagogical coursework and teaching experience, certifications, and authentic science research experience. This requires more than analysis of documents such as CVs. A school's *well-prepared STEM teaching staff* is also characterized by classroom evidence of reform instructional strategies and project-based learning, integrated, innovative technology use, and the making of connections beyond the traditional classroom. In addition, institutional support for teaching in the form of common planning time, ongoing professional development, and a climate conducive to collaborative effort, helps teachers skilled in STEM content and pedagogy to be effective teachers.

Design. The Well-Prepared STEM Teaching Staff at MNTH was captured by a variety of instruments and activities during the study team's site visit. MNTH teachers completed an online survey based in part on the *2000 National Survey of Science and Mathematics Education* (Westat), and the *2006 Teacher Questionnaire: Local Systemic Change through Teacher Enhancement* (Horizon Research, Inc.). In addition, surveys and interviews with the principal provided background on teacher hiring, teacher education, and the collaborative structure of the school.

The selection and maintenance of a well-prepared teaching staff is a conscious goal of MNTH. The principal can select teachers for this school, and is exempted from of the teacher hiring process in the school district. Some teachers were hired because they had training in PBL and were from the UTeach program. The school's participation in the New Tech Network model provides ongoing structure and support for teachers on PBL and the integration of technology. There is structure designed for teacher collaboration and support during the school day. Critical Friends meetings are scheduled weekly to enable teachers to assist each other with design and implementation of projects. Many classes are inter-disciplinary and require teachers to co-teach. MNTH has s a Teacher Coach who supervises, mentors, and assists teachers as needed.

The composition of the teaching staff was, and continues to be, affected by the school's partnership with a nearby teacher education program, UTeach at UT Austin. Half of the teachers in the school's first year of operation came from this program, many with no teaching experience, but with career experience in the field of natural sciences. UTeach specializes in project-based instruction. The MNTH teaching staff is considered so well prepared in this pedagogy that they lead national summer professional development program in PBL.

Implementation. *Solid background in STEM content and processes.* The principal has the flexibility to hire teachers who are a good match for MNTH. For the STEM teachers, the principal looks for strong content area skills, usually a Bachelor's degree in the content area, and often hires UTeach graduates who have strong disciplinary backgrounds. According to the principal:

> [We recruit] from the school of natural sciences, where they take mathematicians and scientists and talk them into becoming teachers. "We have a partnership with UTeach itself where student teachers can come to see PBL in action and we hire some of those teachers when they graduate.

Other characteristics identified as important in teacher selection were: open-mindedness and flexibility, a willingness to continuously learn, to collaborate with colleagues, to seek help from others and a willingness to "say they don't know." The principal seeks teachers who will bring great ideas to MNTH, who don't want to give up the "tool chest [of great ideas] that they've accumulated" but are interested and willing to add to it. Each teacher brings "a passion, a desire to change education, to not keep it the same way;" they aren't "afraid to take care of business within the box, but still step outside of it;" they aren't "afraid to have teachers and other people really critically analyze their projects . . . to make them better."

STEM coursework. Twenty teachers out of 28 teachers completed the online teacher survey, including ten STEM teachers: two engineering, three mathematics, three science, and

two technology. Of the STEM teachers, the average teacher had taught for 7.1 years (range 2-18) and had been at MNTH for 4.1 years (range 2-5). The mean age was in the 35-39 year range, and ages ranged from 25-55. For six of the ten STEM teachers, the position at MNTH was their first teaching experience. Of the six mathematics and science teachers, five held at least a bachelor's degree with a major in their primary teaching area, and all STEM teachers held appropriate certifications to teach the classes they were assigned.

Prior career experiences. Many of the teachers working at MNTH had previous professional experiences that included positions in industry, computer programming, military service, medical technology, and television news management, and came to teaching as a second career. When asked to describe how prior professional careers affected their preparation for teaching positions at MNTH, most STEM teachers cited academic experiences over professional ones. Those who identified professional experiences as important spoke of social interactions as preparation for teaching: "working out at a Crossfit gym helped me maintain and develop compassion that makes it easier to relate with my students while they struggle to learn new things," and "I worked in television news management . . . [where] I developed [social skills] in dealing with people in a stressful and emotionally charged environment."

Research experience. Four of the ten STEM teachers said that they had prior research experiences. Two (one mathematics and one technology teacher) had engaged in education research experiences as part of education master's thesis work; and two (one science and one engineering teacher) had engaged in STEM research while completing graduate programs in STEM content areas.

Skilled in STEM pedagogy (and skilled in the implementation of STEM pedagogy). Classroom observations and conversations throughout the site visit provided evidence of typical and skilled STEM pedagogy using reform-based instructional strategies, project and problem based learning, and active learning. 21st Century Skills were encouraged and supported in every classroom, as explicitly acknowledged by MNTH teachers, and articulated by one science teacher:

> Project-based learning is the primary vehicle throughout the school. This enables me to teach content in ways where knowledge, skills, and applications have meaningful contexts to develop in holistic ways.

A former instructional coach reported that the MNTH teachers are "…really 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." Aside from having opportunities for professional collaboration and cooperation, the STEM teachers felt confident in their abilities to engage in variety of pedagogical strategies important in the STEM classroom. Table 4 shows the results from Teacher Survey questions relating to 21st Century teaching strategies.

Table 4
STEM Teacher Data for Pedagogical Strategies

Question - I am confident in my ability to:	Scale 1-5*
Lead a class of students using investigative strategies	4.5
Manage a class of students engaged in hands-on/project-based work	4.8
Help students take responsibility for their own learning	4.4
Recognize and respond to student diversity	4.6
Encourage students' interest in science	4.6
Use strategies that specifically encourage participation of females and minorities in S/T/E/M	4.3
Involve parents in the S/T/E/M education of their students	4.1

*1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree

Institutional support for teaching. Evidence for Institutional Support for Teaching can come in a variety of forms. It can include the existence of learning communities for academic or pedagogical support, the provision of time within the school day or year for teachers to engage in cooperative planning or learning activities, targeted and on-going professional development, and general school culture of common collective focus.

Teachers experience a wealth of professional development opportunities and general support for teaching at MNTH. They recognize the school's structural support: "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."

Within the school day and throughout the academic year, teachers are regularly involved in mutually supportive pedagogical exchange. Weekly, Monday morning, Critical Friends meetings allow teachers to give and receive feedback from other faculty members on lesson ideas, designs, and implementation: "we regularly discuss STEM-type topics in our weekly Staff Meetings." Academic departments provide additional opportunities where "we are always discussing ways to better implement STEM and support the CORE subjects." Many classes are team taught requiring (and facilitating) cooperation and collaboration between teachers of different STEM disciplinary areas "(…) 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 & Algebra 2 to engineering applications." There is a general recognition of collective, collaborative effort where "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." Teachers also collaborate to support informal learning: "I get support from colleagues as several of us join together to mentor the school's FIRST robotics team, which is the school's varsity sport."

The majority of the STEM teachers at MNTH indicated that they had had opportunities to cooperate and collaborate with other teachers within the last year (Table 5) including observing other teachers in their classrooms, having regular opportunities to meet with other teachers to discuss STEM teaching issues, using telecommunications to collaborate with teachers at a distance, and collaborating with the purpose of integrating content within the STEM disciplines, and across the spectrum of high school academic disciplines.

Table 5
STEM Teacher Survey – Opportunities for Collaboration

Question – I have:	Scale 1-4*
Observed other teachers teaching S/T/E/M courses as part of your own professional development (formal or informal)	1.1
Met with a local group of teachers on a regular basis to study/discuss S/T/E/M teaching issues	1.1
Used telecommunications to collaborate on S/T/E/M teaching issues with a group of teachers at a distance	1.1
Collaborated with a group of S/T/E/M teachers with the express purpose of integrating content from diverse disciplines	1.1
Collaborated with a group of non-S/T/E/M teachers with the express purpose of integrating content from diverse disciplines	2.0

*1=current school year, 2=last year, 3=more than 1 year ago, 4=never

MNTH supports master and mentor teachers, a "three-layered structure" to provide guidance and support to the teaching staff. Two master teachers, who don't directly teach students, have adequate time, and the "wide variety of experiences" needed to provide on-going and individual guidance to teachers. Three mentor teachers, who are teaching the same students as the teachers they support, provide day-to-day contact and support in a more detailed course-specific, student-specific way. Continued connections with the New Tech Network provide resources for project-based learning and enable conversations with specialists. The "project planning document includes a problem statement that I use that helps students focus on who they are in a particular role in a project; I got it first from New Tech, from Toby (a pseudonym). Toby is one of our coaches from the New Tech Network."

All classes at MNTH are taught through project-based learning (PBL), and teachers are provided with summer experiences that further develop their skills. "My school is a part of the New Tech Network of schools, which affords me the opportunity to attend the New Tech Annual conference, which is an opportunity for our project-based learning community to meet and share strategies and project ideas" (technology teacher). A technology teacher reported:

> through the New Tech Network, I have been certified as a 21st Century Teacher, and I am in the process of being certified as a 21st Century Trainer of Teachers. This school also organizes a project-based learning institute, and I was selected to be a facilitator and trainer for this institute.

The idea is that the district will build the coaching capacity in the district and be able to move away from "buying the New Tech coaching" An administrator reported, "If I do my job correctly it will cease to exist … there will not be a 21st Century learning PD specialist, all PD specialists will have 21st century learning experience."

Professional development is also supported for educational experiences directed toward subject content areas or content that will enable STEM integration. “My administration supported me while I pursued my master's degree and gives me continuing support in seeking out professional development opportunities outside of school.” All engineering teachers attend Project Lead The Way (PLTW) instruction in the summer—“a 5-day training [where] we walked through the curriculum and experimented with their projects”— a program that prepares and certifies teachers to teach the engineering courses that all students take at MNTH. Several teachers will be going to robotics training this coming summer “but it’s not your engineers, it’s your English teacher, a physics teacher, a math teacher.”

Because it is important that the PBL activities have strong connection with Texas Essential Knowledge and Skills standards, teachers must have a solid understanding of the standards, testing objectives, and state objectives in their content areas. The principal, Steve Zipkes, stated:

> Everyone will go through data driven decisions . . . we do that every year, we look at the state objectives and we look at our scores and our students. It’s important for our teachers to be experts in disaggregating data.

Teachers of classes that take state level end-of-course exams must make sure that their students are prepared and that state standards are met. As such, the teachers have “studied every assessment question that goes with the TEKS” to make sure that their “curriculum matches the state requirements.”

Zipkes also cited the importance of what is called “’restart training,’ for PBL schools that have been established for 4-5 years who have already hit a plateau area” to provide the opportunity to figure out “what’s our next level?” and to work to better integrate teachers who joined MNTH throughout the years since the school’s beginning.

In addition to the obvious institutional support for teachers provided through professional development and common planning time, there is a general atmosphere of collegiality and respect, and a culture of trust that supports the professionalism of every teacher. Zipkes states that even though “we’re very focused on the curriculum” once “things get successful, [the teachers] can do anything [they] want, I don’t care.” The 21st Century Learning PD Specialist commented that the “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.” Outside business partners state that “the staff is dedicated, they know that the people here believe in them.” There is a climate of respect between and among students and teachers, described by one student as “almost a friendship.” Yet there are increasingly high expectations for the students and a determination that students will be responsible for their work. The students comment that “the teachers respect us, care about our learning,” and “I came here because of the teachers, who cared that I was learning.” According to the 21st Century Learning PD Specialist, the teachers “are creative, step back and nourish the learning of students rather than [being] at the forefront of it.” In the OSPrI proposal, it was suggested that ISHSs “can potentially reconfigure relationships among teachers, students, and knowledge” (Coburn; 2003; Elmore, 1996 as cited in OSPrI proposal 2011). These comments about school culture may provide evidence of these changes at MNTH.

Summary. The teachers who come to work at MNTH have strong content area background and a diversity of professional and research experiences. However, it is not solely in prior experiences where the strength of this program lies. The culture of support for continued and ongoing learning and growth applies to both students and faculty. Institutionally supported professional development, along with active engaged professional learning communities aligned with the school's mission of college readiness for all provides structure for targeted curriculum development and redesign. Teachers are encouraged to be responsive, proactive, and creative in their efforts to meet the needs of the student body as a whole, and their efforts are respected and supported.

3.2.6. Critical Component: Administrative structure

Definition. The administrative structure for inclusive STEM education varies (school-within-a-school, charter school, magnet school, etc.) and is likely affected by the school's age (less than a full set of grade cohorts) and the school's provenance, i.e., whether the school was converted from another model or was created "from scratch" as a STEM school (Means et al., 2008; Scott, 2009).

Administrative structure is determined by examination of organizational structure diagrams and other school documents, as well as interviews with school and school district administrators. Typically, a *regular stand-alone high school* has its own building and grounds and has an autonomous administrative structure with the principal reporting to the school district superintendent or official. It plans and runs its own program, has its own staff and students, and receives its own separate budget. A *school-within-a-school* is a separate and autonomous unit formally authorized by the board of education and/or superintendent. It plans and runs its own program, has its own staff and students, and receives its own separate budget. However, it must negotiate the use of common space (gym, auditorium, playground) with a host school, and defer to the building principal on matters of safety and building operation, although it often reports to a district official instead of being responsible to the building principal. Indeed, it may have its own principal. A *magnet school*, in contrast, is typically a public school offering a specialized curriculum to a student body representing a cross section of the community and is characterized by a thematic curriculum (such as arts or technology) or unique method of instruction (such as Montessori); admission to facilitate voluntary desegregation; choice of school by families; and access to pupils beyond neighborhood attendance zones. A *charter school* is a public, nonsectarian school created through a contract or charter with a state-approved granting agency, usually a school district but sometimes a for-profit organization. It operates independently of the local school board, often with a curriculum and educational philosophy different from the other schools in the system.

Design. Opened in the fall of 2007, Manor New Tech High School is a stand-alone high school within Manor Independent School District. It serves grades 9 through 12 students with a curriculum, which is designed to exceed the State of Texas high school graduation requirements, specifically in the areas of mathematics, science, technology and engineering. It was "designed" by the first (and current) principal based on the New Tech Network model. The principal oversaw the retrofitting of a middle school facility in the Manor Independent School District (MISD) in 2006. Major funding was sought and obtained from the State of Texas to be one of the first 32 STEM schools in the State of Texas. The superintendent was the originator of the T-STEM grant which helped fund the school start up process, and was directly involved with many

school design decisions, such as which technology to purchase. MNTH is a Research and Development site for best practices in Manor ISD and is affiliated with the University of Texas UTeach Program, the Texas Education Agency, and Educate Texas (formerly the Texas High School Project). MNTH also has official relationships with the New Tech Network consortium and Project Lead the Way. These partnerships and the conception of MNTH are described in detail in the Context section.

The MNTH administrative staff is small as expected at a high school serving less than 500 students in grades 9-12. Key personnel consist of the Principal, an Assistant Dean of Student Services, and an Instructional Coach. Functions that might be performed at the staff level in large comprehensive high schools are instead quilted together through innovative approaches. At MNTH, this includes counseling, discipline, and special education services.

*Counseling***.** To support its goal of all students going to college, MNTH has structured a tiered college counseling program. All juniors participate in coursework associated with college going in their Humanities classes. One day per week is designated for activities such as researching college majors and colleges with programs in those majors, and writing college and financial aid application essays. In addition, students who would be the first in their families to go to college are served by an after school College Forward program. This program, described in further detail in the section on Supports for Underrepresented Students, also provides information and support services to parents in negotiating the college application and financial aid processes.

*Discipline***.** Personal responsibility is a key norm that supports learning in a project-based environment. At MNTH, however, this responsibility extends beyond classroom learning. In a project-based learning environment, disciplinary issues such as truancy or poor work effort affect the work of project groups and at MNTH students are involved in resolving issues such as these that directly affect them. The weekly schedule incorporates a whole school assembly period (Circle Time) to support student governance not only of extracurricular activities but also of disciplinary issues.

Special Education. Services are limited for students classified as Special Education or English Language Learners: parents need to sign a waiver of services for these students who attend MNTH. The Instructional Coach takes on the role of monitoring the needs of these students and offering guidance to their teachers about instructional strategies that would help them learn.

Implementation. The school has a very strong and supportive relationship with the leadership at the Manor ISD. The school principal reported having both latitude to make school decisions without interference from the district, and the support of the superintendent as the champion of this innovative school within the district. Now that Manor New Tech is demonstrating strong student performance in a range of student assessments, the district is working to integrate the PBL strategies used at Manor New Tech to the elementary, middle and other high school in the district. Certainly, the school complies with district requirements, such as regular student assessments. Yet the school is given freedoms that other schools in the district don't enjoy, including rich technology resources and the ability to hire teachers from outside the district system.

Leadership. The principal at MNTH is a strong and charismatic school leader (see Context section). His vision seemed to capture the imagination of all involved with MNTH. On a video survey of the best teachers at MNTH found on YouTube, many students listed Zipkes as their favorite, and we note that this was a very strong and personable teaching staff. It is worth asking not only if MNTH would have been created without Zipkes, and perhaps more important, whether the school would be sustained if he left. We do not have the answer to those questions. However, Zipkes has quite consciously collected a group of teachers who are willing to take the lead on varied education efforts, and seem effective and dedicated.

The school leadership is quite flat in hierarchy. There is a small administrative team, made up of the principal, vice principal (dean of students), and an instructional coach. But beyond this core group, teachers are empowered to make decisions, e.g., dealing with student discipline or determining software needs. Students are also involved in the running of the school, through their leadership of weekly whole school meetings (known as Circle Time), organizing and hosting social activities at the school such as dances, and leading student clubs afterschool (with the help of staff advisors). Students are allowed to move around in the hallways as needed, issues of discipline and transgressions are dealt with in whole school meetings, and class sessions involve students talking as much or more than teachers. One parent's comment captured the cultural feel of the school well:

> 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 and friendly atmosphere.

Circle time. During our visit, we observed the whole-school assembly, dubbed Circle Time, which marks the beginning of the school week for MNTH students. The gymnasium filled with all of the students sitting on the floor around the main speakers. During Circle Time, a representative from each class, freshman, sophomore, junior and senior, talked to the student body about an issue or a celebration that they felt needed exposure. Students rallied around the principal and the class representatives and the atmosphere was permeated with the pervasive idea that students are at school to learn and it is their main responsibility. We also observed an event at Circle Time called "Opportunity to Grow." During this time, which is not regularly scheduled, a student who has an infraction against the school rules such as truancy or skipping a class presents a well-articulated apology and asks for forgiveness from the school community. Thus, students take an active role in disciplinary issues with direct impact on their group project work.

College counseling. MNTH addresses students' needs for counseling services through a program targeted towards college counseling in line with its mission. MNTH Humanities teachers fill a vital role in the college counseling program. At MNTH, these teachers are uniquely positioned since they are also the teachers of the upper level dual enrollment courses designed to be college level, as described in the discussion of early college-level coursework. At MNTH, students are supported in all phases of the college going process through activities during their Humanities courses one day per week, College Mondays. They research careers and associated college programs, then find and apply to post-secondary programs related to their career choice(s). Students in an 11th grade focus group clearly articulated this process from their own individual perspectives, and shared their knowledge gained from talking with professionals

in their fields of interest and from their own research into post-secondary programs in those fields.

Differentiated instruction. Now that the school is in its 5th year of operation, it is taking on a leadership role within the New Tech Network, helping define and design the support needs for schools more experienced with the PBL approach, to continue to improve their PBL practice. In the first years of the school's operation, a school administrator described implementation of a "three layer structure to support teachers." Classroom teachers are supported by mentor teachers, who also teach their own classes. Mentor teachers (and classroom teachers as well) are supported by master teachers.

This approach is supplemented by an overall instructional approach focused on differentiated instruction: MNTH teachers are encouraged to use student assessment data proactively to engineer learning opportunities for individual students to meet State performance objectives. This work at MNTH is accomplished to a high degree by teams of teachers. Upper level science and mathematics coursework is integrated and team-taught, as are all levels of humanities coursework.

We observed a regularly scheduled (weekly) professional development period for teachers to work as a community on improving instructional strategies using the Critical Friends methodology. The relationship between the Principal and teachers can be characterized as focused on providing support for teachers to exercise considerable autonomy as further described in the section on the Teaching Staff. In the Principal's own words, his role in relationship to the teachers is the "chief cheerleader."

Data-based decision making. MNTH students also have a voice in the school's curriculum extending beyond choice of electives, but many decisions are driven by data from state and other test scores. For example, the Principal described adding a basic mathematics course (8th grade level) because students who were not passing the State 10th grade mathematics assessment required for graduation requested that as a support. This example illustrates the cooperative nature of the relationship between the administration and students:

> I just asked them last year at the end. I said, "Okay, I went back and I looked at everyone's cumulative folder, and looked at the students who didn't pass the tenth grade [mathematics assessment], and I looked through their folder and a lot of those students had not passed the state assessment in third or fifth grade." And so I asked them and said: "What happened?" And they said: "We kept just getting passed on." And I said: "What can I do? Because next year is your exit level, what you have to pass to graduate, to get a high school diploma and walk the stage. What can I do to help you? And they said, "You know what, how about a basic math class? Just a basic 8th grade math class." And what we did actually-- it's customized--what we did is we looked at all the objectives and took it down to the student expectations. Each students gets the folder, they know exactly what objectives they have to know, and what student expectations are in each objective, and when they master that they get to mark that out. So the students know when they start to master it and you can see the confidence build up that now they know this. Instead of me saying, "Okay, you're going into another math class"—which to them seems punitive—I asked them, I said "What do you want?" So this is something they wanted and the class is

> really small, the classes they're in—I think the largest one is ten—and it's really just to help those students understand, master the building blocks that they missed in the past.

Not only was the principal using data to make educational decisions, so was the Dean of Students who kept careful records of students' progress toward the goal of college admission and attendance through the National Student Clearinghouse (see Outcomes section to follow). Teachers sought information from outside of the school on their students' progress and in addition to the performance assessments demanded by the PBL instructional approach. The used Texas and District tests as checks that students were learning the Texas standards, and even brought in assessments from NC, and used retired items from international assessments. This was a data-driven school that actually did not feel like one, because students were learning through PBL and had chosen the school knowing that it would be demanding. In some cases, they chose the school because it was demanding.

Summary. The small school size, the visible and dynamic school leader, and the close relationships between staff and students have fostered a school culture that is characterized by trust, a bit of chaos, and transparency. The pervasiveness of the norm of individual responsibility for learning coupled with the administration's positioning of students as responsible to themselves and other learners contribute to a flattening of administrative hierarchy mirroring the flattening of the hierarchy of knowledge between students and teachers discussed in the sections on Instructional Strategies and Informal Learning. Teachers and students themselves contribute to fulfillment of disciplinary and counseling functions in a small school setting with its associated small administrative staff. The school culture, in which teachers and administrators are resources but students maintain responsibility for their own actions, learning, and resolution of problems, is a critical element enabling this administrative approach. Although MNTH does not serve as large a percentage of special education or limited English proficient students as the comprehensive schools in the district, its focus on differentiated instruction supports those students whose parents are willing to forego traditional special services.

3.2.7. Critical Component: Early college coursework opportunities

Introduction. Opportunities for high school students to take college coursework, either at institutions of higher education (IHEs) or online, are identified as important for building momentum for success in post-secondary education and are therefore included as a critical component in this research study on inclusive STEM-focused high schools. In general, accumulating college credits during high school reduces the time and cost of completing a four-year college major, thus lowering financial barriers for less affluent students to attain a bachelor's degree. Additionally, these opportunities may positively affect attitudes of students and their parents who have not seen post-secondary STEM education as an attainable option. Students under-represented in STEM fields (e.g., ethnic minorities, low SES students, or first generation college goers) may find their way into the STEM pipeline because of successful college experiences while they are still in high school, and can build their confidence and accumulate course credits. They can see themselves in a college environment.

Opportunity structures supporting early college coursework might include flexible school schedules, transportation to/from college campuses or co-location with an IHE, offering college-level courses at the high school (by college or high school faculty certified to teach college level

courses,) tuition waivers, or dual enrollment. This overlaps with the study's Critical Component on systems of support, to be discussed in more detail later.

Definition. "College-level coursework" includes:

- Courses taken for credit at an IHE including community colleges, four-year colleges, etc.
- College-level courses taken for credit at the high school campus and taught by either IHE faculty or by HS faculty who are adjunct faculty of an IHE
- On-line learning for college credit.
- Advanced Placement or International Baccalaureate courses

The impact of college level courses varies depending on the course. To reduce the time and cost of completing a four-year college major, the courses need to correspond to required courses in a college major or at least be awarded credit towards electives required in a college major plan of study. However, *any* college level coursework might affect the attitudes of students (and their parents) who do not think post-secondary education feasible. The impact on student attitudes may vary depending on the composition of the class: high school students only or mixed college/high school students. The Gates Foundation Early College High School Initiative (Gates Foundation, 2009) frames the impact in terms of rigor, relevance and relationship. Relationship includes both with the instructor (support outside class, high expectations, interest in students) and with other students in the class (respect, collaboration).

Design. MNTH is subject to the Texas requirement that all high school students must complete 12 hours of college credit to graduate from high school. In line with this requirement, tuition and fees are waived for high school students for up to 12 hours of college coursework. MNTH has incorporated specific courses to meet this requirement into its curriculum. Specifically, MNTH offers two dual enrollment humanities courses: English Language Arts (ELA) III/American History and ELA IV/Economics. MNTH hired teachers who met the requirements to be adjunct faculty of Austin Community College to teach these courses. Students at MNTH do 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 is sufficient for the needs of the students.

The only college level STEM course offered at MNTH is a calculus class that offers students the opportunity to take the Advanced Placement exam. MNTH operates on a trimester system and this allows g students to take more courses during high school than under a traditional two-semester system. Thus, even students who begin with Algebra in 9th grade have the opportunity to get on the path to take Calculus. A Texas statistics database revealed that about 10% of MNTH students took the AP Calculus exam in 2010 compared to only 2.4% in 2009. MNTH has worked very hard to increase the mathematics achievement levels of their students since the school's inception and this increase in student participation in AP Calculus tests reflects some progress.

Early College Coursework at MNTH is closely linked with the school's mission. The primary mission of MNTH is preparing, supporting and inspiring all their students to go to college. Because MNTH as part of the MISD embraces 21st Century Learning Skills, students are empowered through development of communication and life skills to present themselves as attractive candidates to IHEs and to be proactive in the college selection and application process.

At MNTH, relationship is paramount in the design of coursework. Teachers are expected to be available to support students before/after school and school norms include not only collaboration and respect but also accountability and work ethic. According to the principal, relevance is next in order of importance with project-based learning as the vehicle to make learning relevant to students. Rigor is the least important of the three at MNTH, according to Steve Zipkes.

***Implementation*.** College was a dominant theme for posters and other displays throughout the school. These included college banners and flags, as well as posters with information about the SAT and college financial aid. Prominently displayed in the main entrance hallway was a poster with photos of the seniors and a list of colleges the student was applying to below their photos. Many of the lists included the University of Texas at Austin. Other Texas schools also occurred frequently including Texas A&M and Rice University.

Teams of two researchers observed two dual enrollment (college and high school) humanities classes. These courses employed a PBL pedagogical approach. During one observation the teacher, a former Peace Corps volunteer, provided a project that required students to develop a plan to support women in marketing crafts (baskets) with the proceeds going towards education of the children. The teacher directed students to complete an outline for their plans so that group members could work independently on it the next day.

A majority of the upperclassmen fulfill their college credit requirement for graduation through the dual enrollment humanities courses offered by MNTH, with 89% of the students completing dual enrollment in the 2009-2010 academic year compared to 81% in the prior academic year. In comparison, state-wide and district rates are about 30% and 25%, respectively ("Academic Excellence Indicator System, 2011). Some 11th graders in a focus group described taking online college courses during the summer to fulfill the 12 hour college credit requirement. This allows them to have their afternoons free during their senior year. Students reported taking fine arts courses online to fulfill their fine arts requirement (as well as college credit requirement). One student took a German course online to fulfill her foreign language requirement/college credit requirement, explaining that MNTH offers only Spanish and that students who were interested in other languages could pursue them through other avenues. When asked about what online courses they had taken, none of the 11th graders in the focus group mentioned taking any STEM courses.

***Summary*.** Implementation of early college coursework at MNTH mirrors the design, i.e., students have the opportunity to complete the Texas graduation requirement of 12 college credits through completion of dual enrollment humanities courses. In addition, a smaller proportion of students enroll in the one in Calculus. There were no other reports of students taking college level STEM courses at the community college or online. Admittedly, the extra STEM requirements at MNTH may make college level work in STEM less feasible or desirable than completing the strong STEM core at MNTH. There seems to be little linkage between early college coursework at MNTH and a possible effect on STEM college majors, because so few MNTH students earn STEM college credits. There is also no emphasis on providing students with opportunities to experience college campus life. If they have early college experiences, they are on the MNTH campus or at the community college during the summer (or occasionally during the school year), or through online offerings. The school's success in inspiring first generation college goers in STEM (see Outcome section) is more likely due to its support

systems like College Forward and the College Monday program for all students, than from extensive experiences in college coursework while still in high school. While MNTH follows student college attendance after graduation from high school, the school does currently distinguish between graduates majoring in STEM versus other areas. (See Outcomes section for more information.)

3.2.8. Critical Component: Supports for underrepresented students

Introduction. A goal of the OSPrI research is to study inclusive STEM-focused high schools. By "inclusive", we mean schools for students who want a strong STEM high school experience, but who may not have already demonstrated talent and ability in STEM, i.e., students who are already identified as STEM gifted and talented. Many inclusive STEM-focused schools intentionally focus on students who have been traditionally underrepresented in STEM disciplines, and this may include students from blue collar families or low socio-economic status, usually operationalized in school systems as students who are eligible for free or reduced meal service. Students who are members of ethnic/racial groups such as African American, Hispanic or Native American are also under-represented in STEM fields, as are students eligible for special education or English Language Learner services. Increasingly, we are hearing about high schools that specifically target students who are "first generation to attend college." Targeting students in this way makes a lot of sense and is congruent with this project's goals; it is precisely this group that needs to find the opportunity structures for success in STEM. These students may not understand the complexities and requirements of the STEM pipeline, no matter their abilities or interests. They may also lack information about entering and succeeding in college that is commonplace in middle class families where children are programmed to get into the best possible colleges, and have the social capital to get there through their families, friends and their communities.

Definition. One of the Critical Components studied in the OSPrI project is *Supports for Underrepresented Students*. Such supports may include summer bridge programs designed to get students ready for high school or college; tutoring programs extended school day for more STEM experience; extended school year for more enrichment experiences in STEM or advanced coursework. There are also looping or other kinds of advisor programs to help student navigate a STEM-focused high school or strengthen transitions to STEM college majors, jobs, and careers. Such supports result in altered, improved opportunity structures, i.e., students are positioned for STEM college majors, careers, and jobs. As a result, student social structures and identities change to accommodate new opportunity structures (Carnegie Corporation, 2009; Lee, 2002; Means et al., 2008), contributing to a positive and hopeful school climate, with overt evidence of current and past students' successes on display. Special Supports will be examined by looking at documents that describe the types of supports and the rates of participation; principal interviews; and teacher and student focus groups.

Design. A clear goal of MNTH is to have all students prepared for, and to attend college. While we could find no explicit statement about how MNTH students would receive the support to reach this goal, everything that happens to students from admissions to graduation is focused on supporting each student on his or her journey to college admission, and perhaps more importantly, to finding out his or her place in the right college pursuing studies that the student has carefully considered and chosen. The in-school advising programs are designed for this, as

are afterschool programs. Teachers are hired with the expectation that to work at MNTH, they will need to go beyond preparing and teaching classes; rather, they are becoming part of a family that supports each member of the family.

***Implementation*.**

Inclusive environment. When asked about the inclusive aspects of MNTH, parents pointed out that there were as many males as females, not a small issue for a school known for its "new tech" and STEM focus. Teachers and administrators were likely to note that about 50% of the students are "first generation" college-goers. Ethnically, the school is diverse, with the largest single group being Latino/a, with some students bilingual Spanish/English speakers. There are no ESOL services provided at MNTH, so recent immigrants would not likely be able to be successful. However, one of the teacher coaches does keep an eye on the bilingual students to make sure that teachers are aware of any attendant issues. There are a few students who qualify for special education services, but no in-house services are provided; there is some special education support provided by an itinerant special education teacher. So MNTH is inclusive, but does service the full range of students that would be found in the counterpart comprehensive high school.

MNTH is seen as inclusive and welcoming in another way; it is a safe haven for students who may be seen as nerds at the comprehensive high school, or who have been bullied, according to parents. The Dean of Students remarked:

> There is a wide range of student ability here. Students do weird things—jumping rope, playing Pokemon. In this culture you are not afraid to look like a fool, be a kid…we teach them what it means that this is "our house."

Students engage in play and learn through playful PBL projects, as any trip to MNTH's YouTube offerings will demonstrate. Moreover, 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. Here I can walk up to any kids even if they are upperclassmen; everyone would talk to you.

The parent's description above was consistent with the notes and experiences of the six OSPrI researchers who visited the school. Students were approachable, cooperative, vocal, and eager to explain the culture of the school or what they were learning. The description below shows how the support system that leads to MNTH's school culture is developed, as students move from 9th to 12th grade and beyond.

Supports for 9th and 10th graders: Bridge programs. Rising 9th graders who are selected to attend MNTH through the lottery first come to the school during the summer before 9th grade for a one week orientation, organized by the Dean of Students, who has a master's degree in guidance and counseling. This Dean has worked in three different school districts before coming to MNTH with Principal Zipkes, and has influenced its founding. He also has a disciplinary role, but he sees no conflict with this and his position as guidance counselor. A summer orientation

for rising 9th graders is largely run by rising seniors who take on a filial role with the newcomers. The focus of the orientation is on PBL, technology, school culture and expectations for graduation requirements. During the second week of school, there is a 9th grade class bonding activity led by seniors and teachers. This is a somewhat "secret" event; parents are informed of it, and the rest of the students in the school are released from school early. The activities are designed for team-building and trust among 9th graders and teachers.

Ninth graders are assigned to a teacher advisor and they stay together for four years at MNTH. Every week, on Mondays, there is a student "advisory." The substance of the advisories changes as the students advance in grades. For the younger students, advisories are likely about student adjustments and access to resources; for the older students, the focus in on college selection and the admissions process.

The Dean of Students pointed out that freshmen do have trouble with the new PBL system for the first six weeks of school and sometimes longer, and there is a high failure rate for first units. As time passes, they learn how to better manage their time and how to avoid procrastination. At MNTH, the emphasis is on allowing students to build "their house", and protect its values. There is support for student adjustment to the school from both teachers and peers.

Teachers seemed to be viewed by students differently than they often are at other high schools. A parent pointed out that while her daughter was initially reluctant to attend MNTH, after two weeks she had a brand new attitude toward brand new things. If students are struggling, they can talk with teachers and counselors. A 10th grader said that before she came to MNTH, she made no efforts to talk to her teachers, but at MNTH she does because she knows that the teachers care about the students.

Supports for 9th and 10th graders: Tutoring. All teachers tutor students before and after school, and an early bus and a late bus make some "out-of-school' supports possible. Bus drivers know to wait for students who stay late. Some students will seek teachers who best work with them or a teacher who is available, rather than the teacher is who is actually teaching a given course. Students also meet with one another and with teachers to discuss projects. One teacher pulled out products from projects done in prior years for a particularly challenging assignment that was causing students some stress, saying:

> Some of the students needed to see that this project can actually happen, so I pulled out models from two years ago so they could see a final product, to give them a sense of possibility. This made the difference for some struggling students. They were inspired and started working…

As discussed previously, the entire curriculum is set up on a learning platform from the New Tech High School model called ECHO, or the ECHO-system. Although some teachers were not totally satisfied with ECHO, it is clear that students see the system as a crucial support. ECHO allows them to collaborate after school hours if they have internet access at home. An 11th grader says:

> 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 ECHO) and we are responsible enough to go back and check. The substitute does not even need lesson plans.

> There is a lot of communication going on. 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 (ECHO) email.

Another student said that he is much more on top of his grades because he knows exactly what he is doing now, but that when ECHO went down, he "nearly died." The ECHO communication technology is clearly serving as not only a tool for helping students to learn and be successful through the PBL instructional approach, it is serving as a sort of "nervous system" to connect students with one another and with teachers in order work on the projects and to learn.

Students do not ever have to feel lost or unsupported, given the learning challenges intentionally presented through PBL. Support in various forms is readily available 24 hours per day. Students and teachers have built an active, fully functional learning community. In addition, many parents are connected through this system as well, and use it to communicate with teachers and administrators about any aspect of their children's lives affected by school. Thus, MNTH appears to function not only as a learning community, but also as an extended family, via a warm and positive school culture.

Supports for 9th and 10th graders: Remedial classes and a chance to "catch up."
Compared to other subjects, the discipline of mathematics is the most challenging discipline for students at MNTH. As a consequence, the mathematics curriculum drives much of the school's organization and efforts to provide student support because mathematics courses are the gatekeeper courses for success in STEM. One teacher commented:

> Mathematically, there are gaps like the Grand Canyon. It's difficult. 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 go away." Teachers work to help them see that it's OK to try, to practice. It's OK to not get it perfect.

The teaching and administrative staff have found each year, through data analyses of 10th grade math tests reports of classroom performance that a substantial number of 11th graders were struggling in mathematics. Principal Steve Zipkes describes the situation:

> The students took the exit level test [and did poorly] and 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 struggles] 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.

Moreover, these catch-up classes are staffed by teachers carefully chosen by Zipkes. Students may be double blocked in the catch-up classes, but don't feel punished. Rather, they want it. "It was as simple as asking" says Zipkes. He also notes that he would rather not place the best math teacher in Calculus, but in Algebra I. There are only 10 students in each "catch-up" class. According to Zipkes, the teacher is excellent with students, and they love her. Zipkes says:

> She has student some charts on the wall (in colors according to state learning objectives), and students can tell you the objectives that they have mastered and what they still need to master…When students know where they are, it really helps. They have taken the state assessment (again as 11th graders) this year. Do I think they all will all pass? Probably not, but they all feel really comfortable that they have given it their best and we think that we will see a significant rise (in test scores).

Supports for 11th and 12th graders: College planning, advising, and admissions. Supports for younger students may focus primarily on adjustment and helping students to learn in the PBL environment: such supports are available to all students at any time during their time at MNTH. Similarly, while goal for 11th and 12th graders' supports is to get students into the best colleges possible, the introduction to college admissions begins in 9th grade. When walking the halls of MNTH, most prominently displayed as one enters the building, are posters about the college admission process and timelines for the various tasks that need to be done. Upon entering the building, one sees a large poster with a photo of each 12th grader announcing where he or she has decided to attend college. College admissions rates at MNTH have been near 100% for three consecutive graduating classes (see Outcomes section). Follow-up through the Clearinghouse system shows that about 80% of the students go to four-year colleges and about 70% are retained through their sophomore year. The programs that lead to this high rate of college attendance for MNTH students, many of whom are "first generation in their families to attend college," have been carefully planned by the staff at MNTH. Each year, the staff makes careful improvements to supports for college guidance and advising.

Supports for 11th and 12th graders: College Mondays. Teachers of juniors and seniors use the Monday advisories in spring of junior year and fall of senior year to focus on college advising. Humanities teachers were assigned to take the lead in developing the advising program used by all teachers for College Mondays. The program includes discussion of required tests for college admission, calculating GPAs, researching colleges, and filling out admissions forms and forms for financial aid. The lead teachers point out that MNTH students really need to know more about going to college and to have a plan, with good transitions from grade to grade, as graduation approaches. The goal is to get them first to apply, and then to follow through once they are accepted. The lead teachers reported:

> They love it. Even the freshmen love it. They love the GPA assignment [having each student calculate his/her GPA]. This assignment blew them away. Get the transcript and see how it works. Seeing it is a big milestone.

There is also a senior panel that brings MNTH graduates back to discuss college life. They talk to juniors about what the first year of college is really like. This means more to students than what teachers have to say. In addition, humanities teachers of 11th and 12th graders use class time for college advising and counseling. Although worried about the loss of class time for this, they take on the advising work with energy and creativity, and often use the PBL model for advising as well as teaching. Advising seems to be done across the board at MNTH, with all teachers and administrative staff involved, rather than having one guidance counselor assigned to this role. However, given the school's primary mission of having all students go to college, not having any

STEM teachers assigned to the design of the college advising programs seems surprising. The entire process is led by the humanities teachers.

Supports for 11th and 12th graders: College Forward. College Forward is another college advising program that meets after school. It is specially designed for low SES, first generation students, and requires that students have at least a 2.0 GPA to participate. The humanities teachers who run the program point out that some of the MNTH "all-stars" are first generation and that College Forward helped them to know what to do to enter good colleges. The Dean of Students believes it to be a great program, but would like to see it opened up to all MNTH students. The lead teachers describe some of the activities. One activity gives colleges pseudonyms, and asks students to match colleges with their career goals and academic needs. Then the real names of colleges are revealed, and students find that their horizons have been broadened. They are encouraged to open their eyes to possibilities that are just a plane ride away. Students are strongly encouraged to apply to at least one 4-year college and not settle on the local community college, with teachers saying, "You are so much better than that and need to go to a four year school and you need to do it now." The lead teachers accomplish this by creating new curriculum for College Forward:

> We need to find the scenarios that we keep see happening with our students. We threw out the canned curriculum [for College Forward] and made it more project-based. So a scenario was – my parents said that they would buy me a car if I stayed at home, and I want the car, so what do I do? There is a huge push to have kids stay at home. [We tell them] No, no car. No. There are right and wrong answers here. A lot of students are first time college goers who do not even travel to Austin very often, so there is fear.

The staff at MNTH track the success stories, both the obvious ones – a first generation student who gains admission to an Ivy League school and leaves Texas to expand her horizons – and the less obvious ones – another first generation student who struggled academically at MNTH, but who graduated and worked his way through the local community college, and then went on to a technical school. The teacher who talked about him said that the PBL approach provided him with the ability to keep working through struggles. She thought that his success at the technical school was due to similar experiences at MNTH.

Role Models and College. Student interviews revealed 11th grade students to be goal-oriented toward college and well-informed about the college admission process. All reported that they wanted to go to college, and several had ambitions for masters and doctoral degrees. That said, they aspired to a number of career combinations, such as doctor and criminologist, military and engineering, pediatrics and public media. Upon probing students' aspirations more, it appeared that many of the career goals were linked to the careers of people that the students already knew personally. For all of the time spent in College Mondays or College Forward talking about college majors and possibilities and matching goals with possible careers, it was noteworthy that many of their choices seemed linked to person-to-person contacts. In a STEM-focused high school, it may be important to use get STEM professionals in the community into the school, or get the high school students working with professionals in a STEM setting in a community, to expand STEM horizons.

Texas Culture and Personalization. The student and teacher interviews at MNTH also revealed the presence of what teachers called the "Texas Culture." This seems to include a strong affinity for Texas and to stay close to home and family. One student talked about crossing borders to go to college as a significant challenge, and by this meant crossing the border out of Texas into nearby states like Arizona or Colorado, and only if she had relatives in the area. Students expressed the desire to be a day's drive from home when they chose a college, and many looked forward to living at home and going to college. One of the main themes of MNTH is that the people in the school are a family and that the school is "our house." Thus, the Texas cultural value of the importance of family is reflected and echoed by MNTH values. This mirroring of values may provide an important support for students, as the school culture reflects the values of the community.

Summary. Initially, it was expected that the supports for students under-represented in STEM education would consist of a list of activities and services. Indeed, MNTH's activities and services are duly described here. But perhaps more importantly, the mission of MNTH is to provide support services for its students, and the entire school and culture seems organized around that goal. Students, parents, teachers and staff all are committed to getting students ready for college and for college success. The vehicle is PBL and a supportive school culture that has built-in opportunity structures that seem likely to support MNTH graduates' success in college. These structures go far beyond academic learning of content.

3.2.9. Critical Component: Blended formal/informal learning opportunities

Definition. Blended formal/informal learning beyond the typical school day, week, or year: Learning opportunities are not bounded but ubiquitous. Learning spills into areas regarded as "informal STEM education" and includes apprenticeships, mentoring, social networking and doing STEM in locations off of the school site, in the community, museums and STEM centers, and business and industry (NRC, 2009; Rosenstock, 2008, PCAST, 2010). As a result, the relationship between students, teachers and knowledge changes (Elmore, 1996; Coburn, 2003), and hierarchies flatten, and "…substantially alter the traditional roles of learners, teachers, and instructional resources in the learning environment" (NSF-DRK12, 2010, p. 7).

Design. Informal learning opportunities are not implicit in the mission statement of MNTH, but some informal learning is required by the State of Texas as required community service. In addition, students and families considering MNTH are made aware of the opportunities and freedoms offered to MNTH students through informal learning. They are implicit to the school culture.

Implementation. At MNTH, formal/informal learning occurs as six opportunities for students to blend in school and out of school experiences: (a) senior project, (b) robotics club, (c) garden club, (d) required community service, and (e) social media. Students engaged in the formal/informal learning experiences gain technical knowledge, academic knowledge, 21st century skills, and knowledge about community responsibilities.

The senior project. The Senior Project is available to all seniors at MNTH, and the trimester set up of the school schedule gives seniors a half-day of classes. The intention is that

this unscheduled time in the afternoon is to be spent working on senior projects and internships. Because of transportation issues and the newness of the program, only 10 out of 70 students at MNTH are taking senior project during the observed year. The goal for MNTH was that everyone would have a senior project and an internship, but the logistical challenge is that almost 90% of the students ride the bus and the public transportation system does not link the Manor community to Austin where many projects might be mounted. The Senior Project can be an internship, but instead of activities such as job shadowing, the 10 seniors interviewed are accomplishing community service type projects such as sponsoring a 5K run for a college scholarship, designing and selling bracelets for a college scholarship for undocumented children, creating a documentary of the psychology of happiness, and creating a documentary to create an awareness of local public finance mishaps. All of the seniors have mentors who help them understand the professional skills and knowledge they need to organize a scholarship or to create a documentary. The seniors are not only responsible for developing their projects; they also find their own mentors and help maintain the relationship as the projects develop. Humanities teachers at the school monitor the senior projects, but do not create or sustain them for students.

The Robotics Club. The Robotics Club is a clear example of a blended formal/informal learning opportunity. During the inaugural year of the Robotics Club at MNTH two years ago, the First Robotics competition sent the official materials, but the club did not have the capacity to build the robots. However, Austin Dynamics, a local IT company, partnered with MNTH and sent engineers out to help the team with planning, design, and implementation of the robotics competition. Now that the MNTH Robotics Team is comfortable with the knowledge needed to compete in First Robotics, the engineers attend the team meetings less frequently and the Robotics Club is more independent. Often students join the Robotics Club to have the opportunity to meet engineers and to experience how engineers work. Attendance of team meetings ranges between 5 and 20 students throughout the year. The format of the Robotics Club has evolved over time. The club meetings were entirely out of school, but now students have an opportunity to extend their time with the engineering design in a robotics class offered by the school. The members of the Robotics Club do not have to be members of the class, but the club is moving toward raising the standards to be a full member of the club. This year, the adult leaders of the Robotics Club, the engineering teachers at MNTH and parents who are also engineers, initiated a new rule that everyone has to pass the MNTH fabrication course before the students can begin building at the materials facility. The Robotics Club is a prime example of how informal learning and formal learning can work together to extend the school day and to flatten learning relationships between students, community members, and teachers.

Community service. Community service is part of the school culture at MNTH. Students are expected to accumulate community 150 service hours before they graduate. Garden Club is one of the avenues to gain community service hours. The MNTH campus has a greenhouse where students work to grow vegetables. These vegetables are sold to the staff or donated to the school pantry.

Social networking. Another informal learning channel used at MNTH is social networking. An example of the ways the students and teachers use social media can be seen with the MNTH calculus Facebook page. The calculus students set up the Facebook page as a resource for homework help. However, the students started to invite other students who were not

enrolled in a calculus class and the social networking continued with a conversation around homework. Several of the students who graduated from MNTH continue to be in touch on this Facebook page as they face their college calculus work.

Internships. The community around MNTH is very aware of the noteworthy work that comes from the school, as evidenced by the conversations with members of the local Kiwanis Club. The area businesses actively keep track of applicants who come from MNTH for employment because they understand that the graduates of MNTH have the ability to communicate effectively, collaborate with co-workers, and to be productive. However, none of the high tech firms in the area of MNTH have the capacity for students to act as interns. As mentioned earlier, the public transportation system between MNTH and the high tech firms is not adequate. The principal of MNTH works around these barriers by inviting employees of the firms to sit as experts on panels that assess the PBL projects of the students. Although the community around Manor is geographically spread out, communication technology helps to build and sustain relationships between the school and the larger community.

Summary. Because of the development of student responsibility for learning as endemic to the MNTH culture, informal learning has a high potential to increase the capacity of students to learn STEM. MNTH is open and welcoming to the community and seeks opportunities for its students. However, the challenges of geographic size of the Manor ISD , the area from which MNTH draws, and the fact that these students are generally not from families that can provide them with cars for personal transportation, somewhat limits student participation in informal learning activities. However, the nearly ubiquitous use of social media links students informally to school, and the PBL environment gives them plenty to discuss. Through the PBL and occasional need for tutoring, there is an uninterrupted stream of communication as students learn from one another, their teachers, and access to the community.

3.2.10. Critical Component: Real-world STEM partnerships

Definition. Students connect to business, industry, and the world of work via mentorships, internships, or projects that occur within or outside the normal school day or year (Atkinson et al., 2007; Brody, 2006 in Subotnik et al., 2010; Kolicant & Pollock in Subotnik et al., 2010; Lee 2002; Stone III et al., 2006 in Means et al., 2008; Kaser, 2006 in Means et al., 2008; Means et al., 2008; Rosenstock, 2008). Industry partners support the school financially, or by providing expertise in the form of in-school activities or other events and relationships.

Design. *New Tech Network approach.* It is worth noting that even just initiating the process of becoming a part of the New Tech network of schools requires and reflects a commitment to developing connections with business and community partners for internship and other work-related opportunities. Schools that wish to implement the New Tech Network model agree to specific requirements designed to "ensure successful school implementation." One of the seven categories of requirements is "Partnerships", which includes (a) developing business community partnerships for financial support, internship opportunities, and participation in school projects, (b) developing community partnerships for financial support, community service opportunities, and participation in school projects, and (c) developing key partnerships with the local higher education organizations to provide college courses to high school students.

(Retrieved from "New Tech Network Conditions for Success", PDF available at http://www.newtechnetwork.org/ resources).

Internships and mentorships. In order to graduate from MNTH, students must complete a Capstone Project Senior Year Internship designed to connect the seniors to real-world projects. According to the MNTH Commitment Letter that parents and students must sign before the students are able to gain admission to the school, this senior internship is expected to be at least a "1 semester internship." The structure of the school schedule allows seniors to take half days of classes, with the afternoons left open to work on these senior projects and internships.

Implementation. There are a number of factors that make the implementation of real-world partnerships challenging. Many MNTH students rely on school buses for transportation, making travel to internship sites nearly impossible. The principal has attempted to work around these constraints by creating internships that take place on campus, including for example the school's Robotics Club. But, few students are able to obtain external internship placements, and only 10 out of 70 students at MNTH are taking senior project during the observed year. As a result, instead of completing internships, many seniors are doing community service or other projects, with mentors helping them understand and develop the professional skills and knowledge needed for future work-related opportunities.

MNTH's school leadership also expresses some difficulty in placing students in traditional internships due to industry hesitation. Specifically, engineering firms are not willing to place high school students in internship positions at their company because of the additional supervision and training they require. This is especially challenging given the close proximity of UT Austin, which provides a ready supply of college-age interns who are both more mature and better trained, compared to MNTH students. The school principal has said, *"*The high tech companies absolutely won't sponsor interns, they really don't have any opportunities at that level*."*

MNTH makes an effort to put alternative arrangements into place whenever possible. For example, the principal explained that engineers from Freescale Semiconductors come to the school to assist the students with Robotics Club:

> The first year we tried the competition we didn't even get it out of the box. They came and offered to come and help, we didn't need money but we needed their engineers to come out and help us figure it out. We developed a MOU with Freescale to help us. We did really well in the competition that year. The second year, we set up an arrangement that if the students were in engineering and participated in robotics with the Freescale engineers, Freescale would count that as an internship. It worked because they were satisfying their community outreach, and our students were getting internships; since our students don't have transportation to go places it was optimal. It worked out really well, 40 kids in First Robotics. We still have the arrangement but we are at a point where we don't need them for the robots anymore, we're self-sustainable. We've made it to semi-finals twice and won the entrepreneurship award twice.

The Robotics Club website also lists a number of sponsors from industry (see http://www.frc2789.com/#!sponsors).

Projects that connect to world of work. Industry representatives report that they see a high degree of fidelity between student projects and the world of work. According to one such representative, "We were very impressed [with MNTH]; they work the way that Samsung works."

Teachers also make an explicit effort to connect projects to their own experiences when possible, or they make other efforts to bring fidelity to the projects. MNTH partnered with a local nonprofit organization, Forefront Austin, to work with teachers to address problems facing Austin. Last spring MNTH sophomores did a project on immigration, and Forefront provided supporting resources, including a panel of immigrants whom students were able to interview. The students subsequently wrote papers that were posted on Forefront's website. Forefront is also working with seniors this year.

Other activities that expose students to world of work. Each year, MNTH holds a "Samsung Day," where students currently enrolled in engineering courses travel to the Samsung plant in Austin to learn about wafer production. They have the chance to interact with engineers and discuss aspects of the jobs, and complete hands-on activities (e.g., visiting the clean room and dressing.)

While business and industry partners were not involved in planning the school, MNTH has a great number of financial sponsors and donors who support the school in various ways. Some of the most critical partnerships include Samsung, Applied Materials, Dell, and Freescale Semiconductors. In addition, MNTH has partnerships with these and other companies to help increase the exposure the students get to their respective fields. For example, Apple Inc. provides professional development to MNTH teachers; Applied Materials, Inc. assists students with the Solar Car Races event, in addition to financial support such as providing funding for the solar-powered marquis in front of the school.

Educational partnerships that support the school. MNTH has taken advantage of its proximity to UT Austin to work closely with UTeach, a program from the university that recruits new STEM teachers from the UT Austin student body for an accelerated Master's and certification program. UTeach teachers come to MNTH for student teaching and participate in a number of development experiences that benefit both the teachers and students.

The Texas High School Project, now called Educate Texas, was also instrumental in supporting the school in the beginning. MNTH was started with a grant from Educate Texas as part of an initiative to develop schools dedicated to science, technology, engineering, and math in Texas. Educate Texas aims to pull together the resources of a variety of education stakeholders, use private funds to pilot breakthrough educational programs, and then use public funds to replicate the most successful programs. The goal is to ultimately have a "positive impact on the futures of low-income students, underserved students, and low-performing schools" in Texas and generate "scalable, sustainable improvements for Texas education." MNTH has a continuing relationship with Educate Texas as one of its TSTEM Academies.

The relationships between MNTH and business and industry partners also serve to strengthen the connections between students and the real working world. School leaders reach out to these partners to request participation in school events and activities. For example, working engineers are invited to serve as judges when students give engineering presentations. As the school principal says:

> Our partnerships are not about getting funds; I want experts to come sit on panels when kids do projects. They are still giving their time, and that's valuable, more so than if they just gave us money.

MNTH's principal has been unusually proactive in finding ways for the school to partner with business and industry representatives. The students also engage these partners eagerly when they have the opportunity. The principal explained how a partnership with Whole Foods came into being:

> Whole Foods is another partner. Bruce Silverman came to us. We had just done a GMO project when he visited to see what the kids were being fed. One of our kids came up and asked Bruce about his stance on GMOs. Bruce was so impressed with the conversation, the engagement, that he wanted to be involved. Now when we have events they give us water and recycle bins, and they gave the district 70 bikes at Xmas.

Summary. Despite a number of challenges associated with connecting the school to the world of work, MNTH has been successful in identifying opportunities to do so. Students are exposed to professionals in STEM, and in the community as a whole. They participate in internships whenever possible, and are encouraged to do so. Projects are grounded in real-world problems and ideas. The school has benefited from local organizations and businesses, including STEM businesses and universities.

3.3. EMERGENT THEMES

The OSPrI research project began with set of 10 critical components (See Table 3) that a review of the literature suggested would be found in ISHSs, and that would likely contribute to their success as productive, inclusive STEM high schools. These components would help build opportunity structures that, purposefully designed and implemented, would contribute to students' success in STEM. However, the OSPrI research team did not think that the list of 10 hypothesized critical components was likely to be exhaustive, nor was every component likely to be found to be "critical" in every school studied.

With this in mind, when we began coding the data gathered at MNTH, we also coded for concepts or themes that seemed important to understanding the workings of the school, but that were not necessarily included in the initial set of critical components. We organized these concepts into categories, and then examined each to ascertain whether it rose to the level of a new construct, not included among the original 10 Critical Components or whether it was really a variation or elaboration of a Critical Component. For example, coded observations of the presence of a "strong school leader" were judged to be part of Critical Component: Administrative Structure. After discussing each coded observation, some were judged to be anomalies that did not rise to the level of importance of an emergent theme. Other coded observations fell into groupings that seemed to be altogether new and unanticipated ideas, distinct from the original 10 Critical Components. These were seen as emergent themes.

There were three emergent themes that rose to this level: 21st Century Skills; School Culture; and Family and Our House. Each will be described below, and the case made for their occurrence and importance to schooling at MNTH.

3.3.1. Emergent Theme: 21st Century Skills.

The notion of 21st Century Skills grew out of a concern that all students be educated to be successful in a world altered by advances in technology and an increasingly globalized economy. Funded in the early 2000s through a grant from the U.S Department of Education, the Partnership for 21st Century Skills was established to bring together business, education, and community ultimately developing the *P21 Framework for 21st Century Learning*, to provide a model for the integration of 21st Century Skills into the K-12 curriculum. In addition to core subject content, this model directs focus onto what are called "the 4Cs," which include **c**ritical thinking and problem solving; **c**ommunication; **c**ollaboration; and **c**reativity and innovation. The New Tech High efforts embraced the notion of 21st Century Skills through an emphasis on project-based learning and the infusion of innovative technology use throughout the curriculum.

Design. According its website, "Manor ISD creates opportunities for all students, parents and staff to improve community involvement, support the commitment to 21st century learning, and increase the overall success of Manor ISD". In addition, MNTH's website had the following set of published goals or learning outcomes which are congruent with the literature on 21st Century Skills:

- Technology Literacy: The student selects and utilizes appropriate technology to effectively perform a variety of tasks.
- Global and Community Engagement: The student explores different perspectives on global, cultural and local issues and values, leading to action in his/her community.
- Work Ethic: The student demonstrates commitment to their team, personal responsibilities and tasks.
- Written Communication: The student effectively expresses and constructs ideas in writing clearly, concisely, and correctly to a variety of audiences.
- Oral Communication: The student speaks correctly, eloquently and effectively before a variety of audiences for multiple purposes.
- Critical Thinking: The student gathers, analyzes, and synthesizes information in a variety of contexts.
- Collaboration: The student actively and respectfully contributes to a team to solve problems while working towards a common goal.
- Numeracy: The student applies computation, measurement, estimation and data evaluation in various settings ("Manor New Tech HS Learning Outcomes)

Because MNTH was part of the New Tech High consortium, MNTH includes 21st Century Skills goals as developed by the consortium. These goals are explicitly stated in Table 6 (next page).

It appears that the means to achieve the lofty 21st Century Skills are embodied in other Critical Components. For example, the enactments of the Critical Components," Reformed Based Teaching" and "Technology" may be viewed either as subsets of the larger goal of attaining 21st Century Skills or they may be seen as the means of obtaining the 21st Century Skills. For instance, PBL as practiced at MNTH is an excellent vehicle for building Learning and Innovation Skills and Life and Career Skills. The technology program and infrastructure at MNTH creates the opportunity to realize Information Media and Technology Skills. Within STEM and non-STEM classes, the selection of problems that were the focus of the PBL units were often aimed toward Core Subjects of the 21st Century Themes.

Table 6
21st Century Skills

Core Subjects and 21st Century Themes	Life and Career Skills
• Global Awareness • Financial, Economic, Business and Entrepreneurial Literacy • Civic Literacy • Health Literacy • Environmental Literacy	• Flexibility and Adaptability • Initiative and Self-Direction • Social and Cross-Cultural Skills • Productivity and Accountability • Leadership and Responsibility
Learning and Innovation Skills	**Information, Media and Technology Skills**
• Creativity and Innovation • Critical Thinking and Problem Solving • Communication and Collaboration	• Information Literacy • Media Literacy • ICT (Information, Communications and Technology) Literacy

***Implementation*.** Throughout discussions of Critical Components in this paper, explicit references to 21st Century Skills can be found. For example, a poster in a 10th grade classroom lists Sophomore Norms: Be Prompt; Be Prepared; Be Productive; Be Polite; Be Positive". Beyond exhortations, 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?" When a student expressed confusion over the project's required format as film, another student replied, "It's kind of like a research paper in motion." Another student expressed how the school's environment affected her approach to learning, pointing out her ability to be reflective and self-regulating:

> Learning how to learn from textbooks—I wasn't successful at first. It was trial and error. At first I tried to read the whole thing. That didn't work so I learned how to pick out the important points and make an outline. The textbooks don't always explain it in the best way for me, so I hop onto the Internet to learn in a different way.

Teachers at MNTH embrace PBL, and directly link the work that they are doing as teachers of a PBL curriculum and instruction model to the development of 21st Century Skills, as can be seen in the discussion of Critical Component: Effective Teaching Staff. Moreover, the MNTH community links the development of 21st Century Skills with the school's other major goal: Getting students to attend and be successful in four-year colleges.

Students and staff both stress the importance in developing collaboration and public speaking/ communication skills at MNTH. As 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.

Another student noted immediate advantages to having 21st Century Skills:

> I didn't get a lot of job offers because I couldn't talk to (employers), but now I talk to them as an adult and have quite a few offers. I am a dancer and I teach a class. I had a job during the summer so I created a resume when I was in my digital media literacy class. It was easy for me. This school prepares you for careers.

Summary. The two main goals explicitly stated goals of MNTH are to advance in 21st Century Skills and attend and succeed in college. Clearly the two are related, and students and staff often referred to both goals. Students not only frequently discussed 21st Century Skills, they often showed 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.

3.3.2. Emergent Theme: School culture

Definition. In a review of the literature on school culture, Hinde (n.d.) notes that school culture has been described as being similar to the air we breathe; it can positively or negatively influence all aspects of a school. A positive school culture provides an encouraging and supportive place where students and staff like to be. Peterson and Deal (1998) note that positive school culture includes norms of collegiality, improvement and hard work, and where there is a shared sense of purpose. There are rituals and traditions that celebrate student accomplishment, teacher innovation and parental commitment. An informal network of storytellers and heroes provide a social web of information, support, and history, and a shared ethos of caring, concern, and commitment to helping students learn. In recent study that contrasts characteristics of effective high schools, Rutledge, Cohen-Vogel, and Osborne-Lampkin (2012) found that effective high schools take part in a strong culture of learning and professional behavior. There is a shared focus on high expectations for students and emphasis on students' academic needs among the all of staff. Students internalize these cultural values and take responsibility for their learning, working together toward clear learning goals. Further, effective cultures of learning are collaborative, with individuals across organizational levels working together to meet the school mission.

Design. There is an overlap between the "school culture" emergent theme and other Critical Components. However, this emergent theme is about the larger picture of the MNTH's unique culture, the driving and enabling force for the positive school climate and impressive student outcomes (see Outcome section to follow). MNTH's core values or pillars include respect, integrity, responsibility, perseverance and trust.

If one sign of a positive school climate is that it is a place that students like to be, then MNTH by design is such a place because "choice" is an inherent part of the admissions process. Students, with support from parents, must apply to attend MNTH. Their first experiences with the school require understanding the school and how its expectations are different from those of the nearby comprehensive high school, or other schools that they have attended. They must decide that they want to attend a STEM-focused, New Tech high school with other students who have made the same decision. They know that they will be required to do more work, learn in a different way, and commit to more STEM coursework. Different kinds of learning activities will be expected of them, due to the PBL instructional strategy that is the basis for teaching and learning at MNTH. There will be more need for self-regulated learning. These design features

help structure the positive school culture, but it is the administration, teachers, and staff that actualize and perpetuate it. It is worth noting that although MNTH is not a school that brimming with the latest bells and whistles and is far from an opulent country club type of school, the Manor ISD and MNTH administration are able to provide students and staff with sufficient resources to achieve its goals, which makes the lofty design principles realizable.

Implementation. At MNTH, it is not unusual to find students staying after school or coming early to work on projects. One teacher pointed out how this feeds the relationships that build, and students are happy to stay, "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." In a focus group, students point out that they have a voice in how they go about learning, given PBL environment. Teachers provide the resources for the projects, "…but if we need help we ask and she (the teacher) gives workshops and we are on our own." A student said:

> Last year (at the middle school), teachers were constantly on us about getting work done and here we can work at our own pace. It is hard but it teaches you responsibility. If I have a partner who can't do the work, I explain to them.

Students help one another, but if a group member slacks off, the group has the option of firing the student, who must then accomplish the assigned work without the assistance of the group. Teachers can ask students to evaluate the collaboration of others in their group, which students take very seriously. However, it is also possible for a teacher to step out of a classroom, and have students continue on their group unsupervised, using the ECHO system to guide their work.

PBL and access to technology help create the positive school culture, along with the relatively small size of the school. This results in a school with a flat hierarchical structure. The principal regularly cedes formal control to the Dean of Students, but if both are out of the building, any teacher may be asked to take over. This relaxed atmosphere is obvious in interactions between administration and teachers. Teachers are given ample opportunities for leadership, and are encouraged to innovate. Teachers are respected for their varied areas of expertise, as could be seen in observations of a Critical Friends professional development session in which the entire staff focused on improving a specific PBL assignment brought forward by one team of teachers. Students are respectful to teachers, and they also like them. Teachers acknowledge that students know more than they do about some things, especially apparent when using new technologies. Teachers and students engage in reciprocal teaching and learning. Students are allowed access to the Internet without the usual firewalls so prevalent in many schools, so the information available on the web is accessible to all; the teachers are not the only ones with power due to the universal access to information.

MNTH is remarkable for its celebration and acknowledgment of its unique culture through its use of social media, particularly YouTube. A favorite offering that gives the flavor of the school is called, MNTHS: Lip Dub 2012: Baba O'New Tech (see http://www.youtube.com/user/ManorNewTechHigh). This video is pure fun, but also acknowledges each student in the school, and took a great deal of technical knowledge and commitment of everyone in the school to produce.

Summary. MNTH has a positive school culture and is known as a place where students will work together to do challenging work through PBL. Where many schools celebrate athletic accomplishments, MNTH celebrates academic accomplishments, not only through competitions or out-of-school events, but in displaying the results of the projects that they work on in every class. The focus on projects makes the work done during school noteworthy and often worthy of celebration. Students seem proud of their school and its culture.

3.3.3. Emergent Theme: MNTH as a family: Our House

The third theme that ran through the data collected during the on-site visit at MNTH was that of "family" and that the school was "our house" and the sense that MNTH is a special place. This theme may include matters touching on school culture or other Critical Components, but focuses on sense of place, family, home, house, and community that is prevalent in the school among students, teachers and administration, and beyond to parents and others who know the school. The family theme was often literal, as students and parents directly spoke of members of immediate or extended family and kinship relationships and direct involvement of families in the school. At other times, family was used metaphorically to refer to the school community, and the larger sense of Texas culture, identity and place. The MNTH buildings were referred to as "our house" and connoted not only the structure, but the relationship of the house as a safe place for the family to live and work together, and where children can grow.

According to Rutledge et al. (2011), in effective schools, individuals report strong connections between the students and the school, as well as widely distributed meaningful relationships among students and adults at the school. Connections between students and adults are authentic, relevant, and responsive to students' needs and interests. Opportunities for connections among students and the school interact and build upon one another. There is an emphasis on personalization. By personalization, we mean something more than individualized or differentiated instruction or culturally responsive curriculum. Rather, personalization encompasses the entire student as she presents herself to the school community, and includes who she is, her family and background, her goals and aspirations, as well as the set of abilities and achievements for academic learning. It includes not only the academic, but the social and emotional. The academic self and positive relationships are contingent upon the organization.

Design. Although there are no explicit design elements that direct MNTH to become like a family to the students who attend, the major stated goal of MNTH was to get "first generation students (in their family) into college". In a sense, the nuclear family is the reference point for this goal, and the community of MNTH becomes the extended family that will help each student to achieve the goal. Although some students will very much need the support provided at MNTH to achieve this goal because their families may not be able to provide the specific knowledge for college admissions and attendance, families are not seen as a deficit, but rather than as critical to students' success. MNTH and the family work together. Another goal of MNTH was to build character, and students were held to a value system of caring and collaboration, rather than competition. In a PBL environment, it could not be otherwise. However, the MNTH and PBL environment also nurtured individual self-expression, personalization, and development of young adults as emerging valued full members of the Manor and Texas communities.

Implementation. Kinship Relationships at MNTH: A major initiative for MNTH for 2011 and beyond was to enhance its Parent Involvement Committee (PIC), a local organization created

by parents to benefit the campus. Parents regularly meet to find ways to help the school meet its needs for the students as well as to provide critical feedback for school improvement. The website states: "MNTH feels very fortunate to have a PIC as most high schools do not. We treasure our parents and community as they are our partners in education."

In addition, MNTH is active in involving parents by connecting them with the school's electronic communication system or ECHO system. Given that students come from considerable distances to attend the school and that the school is innovative, such communications systems are vital (see Fleming, 2012). The school makes a point of hiring parents when positions are available on the staff. Parents are also invited into the school to grade on performance assessment panels when their expertise fits the project. Other parents do laundry and keep the clothes in the clothes closet clean and presentable. These are the clothes that students wear for presentations or if they need more formal clothes for activities when they leave the school. One parent of a MNTH graduate commented on what MNTH offered her daughter:

> My daughter started in 10th grade when the school first opened. I have three sons who graduated from high school and they do very well. The difference I see is that my daughter grew up more mature (because of attending this school). She is more responsible and she can go and talk in public because of the presentations. They helped her a lot. She is confident. She is not scared of presenting.

Another parent noted one of the short-comings of the school, the lack of a big athletic program. Students at MNTH wanting to participate in an interscholastic sport could be on a team at the comprehensive school that is close by. But parents complained about lack of communication between coaches at that school and athletes at MNTH, and lack of coordination about transportation schedules. Still this family eventually came to grips with the advantages and disadvantages with the father saying:

> My son was going to the high school down the road and he was not happy about changing (to MNTH) because his concern was sports. It worked out OK, but it could have been better. He was new to the presentations and he is a structured person; you do the assignment and turn it in. There wasn't any free time to work on projects and that took a bit of adjustment. He did OK with it and grew in the same way as the school. One of the big reasons we came was the size of the school itself, not more than 100 per class. That was for me.

In an interview with 11th grade students, one girl expressed the importance of family and Texas culture in choosing a college. She seemed to be very bright, ambitious and independent, yet had doubts about leaving Texas and going to a school out of state. She talked about not wanting to cross borders, which turned out to be state borders rather than international ones. She said she might consider going to a university in a neighboring state bordering on Texas, but wanted to be within easy driving distance of her extended family, spread throughout the region.

The humanities teachers responsible for the college admissions program want to extend students' scope of college choices beyond that of Texas, and used examples of scenarios in which parents bribed their children to stay home and not go away to school, promising to buy them a car if they did. This scenario has a basis in reality at MNTH. It appears that there is a strong desire among some of these Texas families to maintain family bonds by keeping children

close to home; if no one in a family has had the experience of going away to college, this may be especially true. In contrast, in other parts of the USA, middle class parents often seek to get their children into the best college possible, no matter the distance.

In a focus group interview for 11th graders, when discussion turned to career choices about where they would go to college, nearly every student referred to some adult that they knew as the inspiration for their career goals, and often this was a family member. One girl was doing her community service as a tutor in an elementary school where her mother taught, and she perhaps wanted to be a teacher, also. Other students reported being inspired by their parents work, or significantly, by their parents' talents but missed opportunities due to lack of college or choices. Some students of this generation wanted to accomplish what their parents were unable to do.

It is worth mentioning that we did not hear anything about dysfunctional families and homes when we visited MNTH. Certainly some students must experience family stress and worse. We did not ask about this directly. However, it may also be true that families that help their children choose MNTH may be more involved in their children's lives and more stable. This is speculation, however.

Family and Our House as a dominant metaphor. "The culture, familial love, is significant. We are all in this together," says a teacher a MNTH. If a goal a MNTH was to involve nuclear and extended families in the culture of the school, and equally strong aspect of this theme was that the students and staff are one large extended family living in "our house". There were nearly no signs of vandalism or abuse of facilities at MNTH, and the student constructed murals (see Context Section) was a sign that students cared about the physical appearance of the school. Videos on YouTube also showed students pride in their school as "our house". One YouTube video on technology produced by a teacher is done with the background music "Our House" a song about an idyllic childhood memories (by Madness) (see http://www.youtube.com/watch?v=pF484ni VBNM). In the MNTH video, students explain both the school's goals and visions in the context of the MNTH notion of family feeling. This video provides an excellent summary of this theme in the words of students and staff.

The family feelings are nurtured by seniors orienting new freshman and explaining the new family they are entering, deliberately encouraging filial feelings in both directions. Graduates come back and present panels on how they are doing at college and giving tips to those still at MNTH. During weekly Circle Time meeting for all students in the school, the notion of our house came up again and again. If there is a serious infraction of MNTH rules, students can apologize to the entire school, and anyone in the school is entitled to question the sincerity of the miscreant. A student panel helps make decisions about rules and what happens to students if they are broken. However, this school gives the feeling of a safe and nurturing place where all students can be themselves, including self-described nerds and students who are different in ways that might attract bullying at more conventional schools. At MNTH, there is an atmosphere of not only acceptance, but of celebration of difference. A student in a focus group pointed out:

> Say something happens to you because you have been trained in this school and you have the basis of knowledge from computers and you leave with skills that are really helpful—communication and technology skills. This school is very welcoming. All you have to do

> is apply and if you don't think it's for you they will bring in others with open arms. This is a big family.

It is worth noting that these familial relationships are built in the context of learning guided by a close eye on the Texas State Standards, PBL activities based upon learning the standards, commitment to the development of 21st Century Skills, and students poised for success in college. A technology teacher notes:

> Some (students) use Google for information, go seek their own information. Then they call me and say, I just looked at this website and I don't understand. Enough of them seek help from each other, enough to notice, not as many as should, but that is what we want. One class sets up a Facebook page. I made me friend them, so they stop just posting answers and discuss the problem. They also feel comfortable going to any teacher on campus, especially teachers they have had in the past. Relationships really do come through that way.

Throughout our visit, we heard frequent comments about MNTH referred to as "our house" by students, teachers, staff and parents, as were mentions of filial support and family. This notion was a prominent emergent theme. The school community seemed to be perceived as an extended family, with graduates going out into the world and returning to the shelter of the school. The school was there to launch students successfully, but with support, into the wider community and world of work and college and beyond.

Summary. It is possible to have a nurturing school where students do not learn much because the program is not well developed, and it is possible to have a school that is high achieving, but cold. MNTH seems to be able to be supportive in a familial sense as it produces positive student outcomes. This is a safe and comfortable place for students and for families, especially first generation families. But as the Outcome section will show, it is also a school that achieves very well, and launches its students into the postsecondary world of college and careers.

3.4. EXAMINING STUDENT STEM OUTCOMES AT MNTH

Having explored the design and implementation components above, the study now examines the student outcomes produced at MNTH. There is overall agreement that 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). To capture this student outcome information for MNTH, OSPrI compiled data on near-term outcomes such as demographics, attendance rates, and assessment scores from state databases and MNTH's administrative team. The study also gathered information on longer-term outcomes such as graduation rates, college admission rates, and development of 21st century skills for postsecondary success.

3.4.1. Inclusive Demographics: Who is MNTH serving?

The non-selective, or open, admissions process at MNTH is described above in the Context section. Table 2 lays out the comparative demographics between MNTH, the nearby

comprehensive Manor High School that serves most of the students in the district, Manor ISD, and the state of Texas. As discussed in the implementation portion of the Inclusive STEM Mission component, while MNTH does not completely reflect the diversity of the school district, it remains a remarkably diverse school. Over 66% of its student body in the 2011-2012 school year is of Hispanic or African American descent, a percentage that exceeds the demographics of the state overall, and over half of its population is economically disadvantaged. One group that is under-represented at MNTH compared to the district and state is the English Language Learner population, likely because the school is not able to provide special services for ELL students due to its small size. However, some ELL students do attend MNTH and are supported individually by the teachers and the school's instructional coach.

3.4.2. Attendance Rates: Attendance as an Indicator of Student Engagement.

The important role that student attendance plays in promoting academic success is widely acknowledged and accepted (see, for example, Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). MNTH's principal also pays close attention to attendance rates as an indicator of how engaged his students are at the school. Because Manor ISD reports on attendance rates a year behind other academic year data, the most current information available covers the 2009-2010 school year. Table 7 shows comparative data for MNTH, the comprehensive Manor High School, Manor ISD, and Texas. MNTH's focus on student attendance is evident; their attendance rates are higher than those for the comprehensive Manor High School overall and across the board for each demographic subgroup. MNTH also compares well with the district and state attendance rates, although it should be noted that the district and state numbers encompass all grades, not just the high school grades.

Table 7

2009-2010 Attendance Rates (%) Comparing MNTH, Manor High School, District, and State

	MNTH	Manor High School	Manor ISD	Texas
All Students	96.2	90.3	95.2	95.4
African American	95.7	89.8	94.8	95.6
Hispanic	96.2	90.3	95.4	95.6
White	96.5	90.7	95.3	95.3
Low SES	95.9	90.7	95.2	95.2
Special Education	97.0	87.4	93.0	94.7
Limited English Proficient	96.1	91.6	96.4	96.3

Sources: City-Data.com; Manor ISD's 2010-11 Annual AEIS-AYP Report to the Board, presented February 27, 2012 (retrieved from http://www.manorisd.net).

3.4.3. Assessment Scores: How are MNTH Students Progressing and Achieving Academically?

Texas students take the Texas Assessment of Knowledge and Skills (TAKS) standardized tests as part of the state's compliance with the federal accountability requirements of the No Child Left Behind Act. Students in grades 3 to 11 take these end-of-year tests, used to assess their attainment of reading, writing, math, science, and social studies skills and knowledge. For the high school grades specifically, 9th graders take the English Language Arts (ELA) and

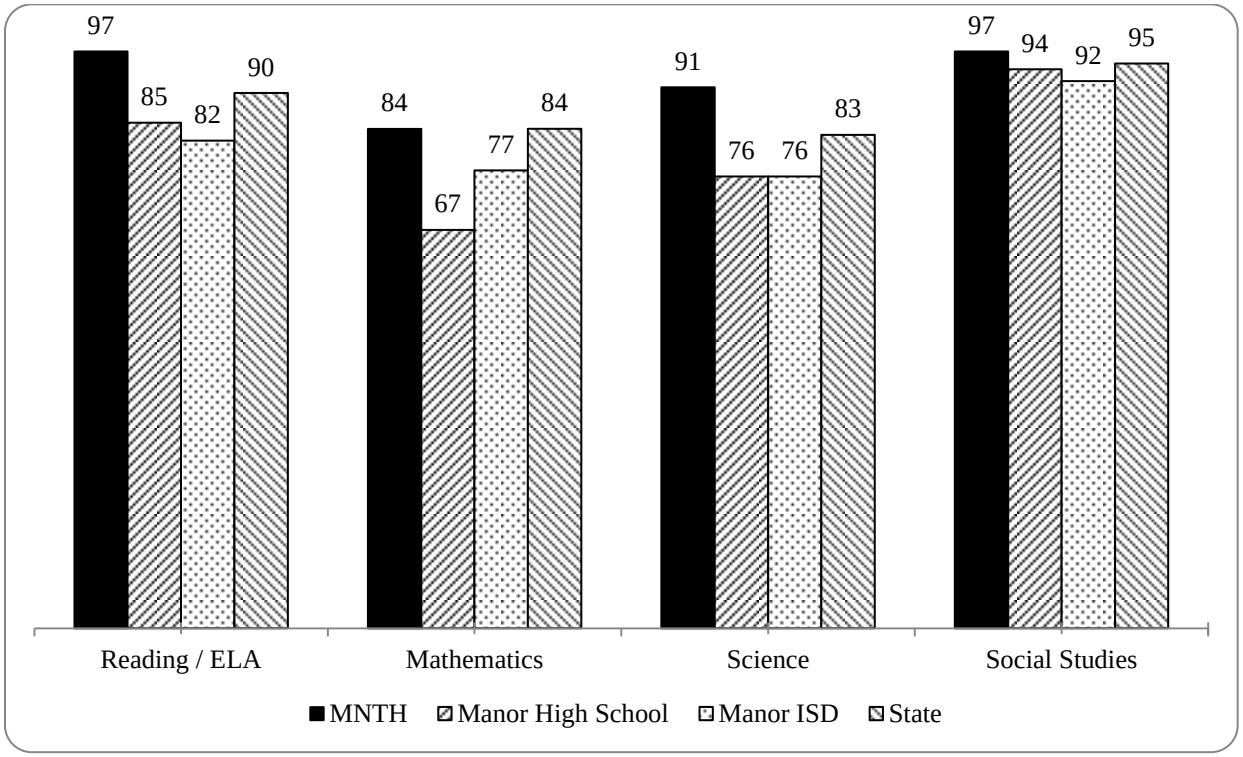
Mathematics assessments, and 10th and 11th graders take the ELA, Mathematics, Science, and Social Studies TAKS assessments.

By all measures, MNTH students are very successful on the TAKS assessments. Exhibit 1 shows the percentage of students "Meeting Standard" (an achievement level set as the student passing standard by the Texas State Board of Education) on the 2010-2011 TAKS assessments for all grades tested, comparing the data for MNTH, the comprehensive Manor High School, the district, and the state. Higher percentages of MNTH students pass the TAKS assessments than at Manor High School and Manor ISD in all subjects, with a notable advantage in the Mathematics and Science assessments. MNTH also compares quite favorably with the state of Texas overall, outscoring the state in every subject except for Mathematics, where they are even.

It should be noted, however, that these data for the district and state from 2010-2011 include their test scores for all grades that take the assessments, grades 3 to 11; the district and state databases do not provide sufficient disaggregated information on grade-specific outcomes to calculate these percentages for only the high school grades in the district or state. In other words, the figures for the district and state in Exhibit 1 include outcomes for students who are in the elementary and middle school grades and are not directly applicable comparison points for MNTH. As a result, the comparison of MNTH's results to those from Manor High School may provide the most relevant insights.

Exhibit 1

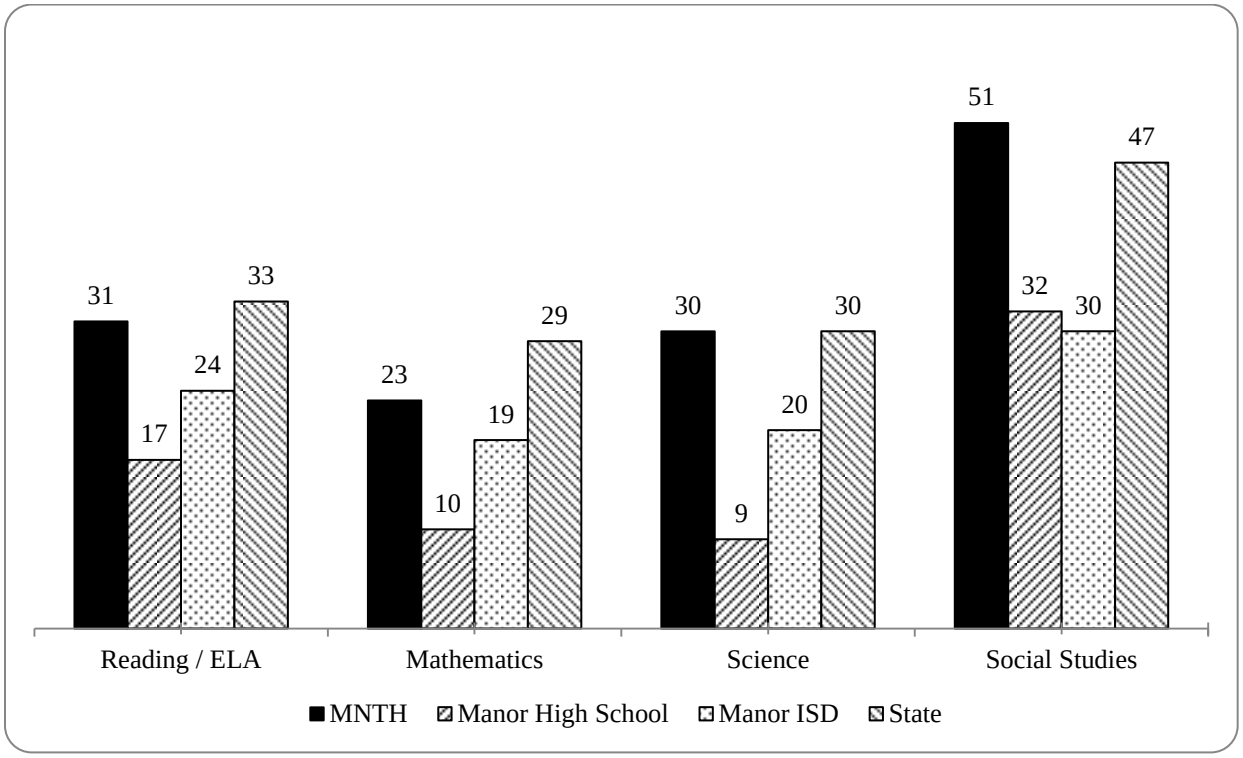
2010-11 TAKS Assessment Results for MNTH, Manor High School, District, and State (Percent Meeting Standard, for all grades tested)



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

For many, "academic excellence" often goes beyond merely passing or "meeting standard" in a standardized state test. Correspondingly, as Exhibit 2 shows, a significant percentage of MNTH students achieve the "Commended Performance" level on the 2010-2011 TAKS assessments, defined by the Texas State Board of Education as the highest performance level on the TAKS. In fact, higher percentages of students at MNTH achieve this Commended Performance level than at Manor High School or Manor ISD in all subjects, most notably in the Science assessment and the Social Studies assessment, where over half of their students achieve this highest level. MNTH also compares well with the state of Texas overall, although the school does lag slightly behind the state in the Mathematics assessment. Again, however, it should be noted that the district and state figures in Exhibit 2 include their test scores for all grades that take the assessments, grades 3 to 11, and thus include outcomes for students who are in elementary and middle school grades.

Exhibit 2
2010-11 TAKS Assessment Results for MNTH, Manor High School, District, and State (Percent Achieving Commended Performance, for all grades tested)



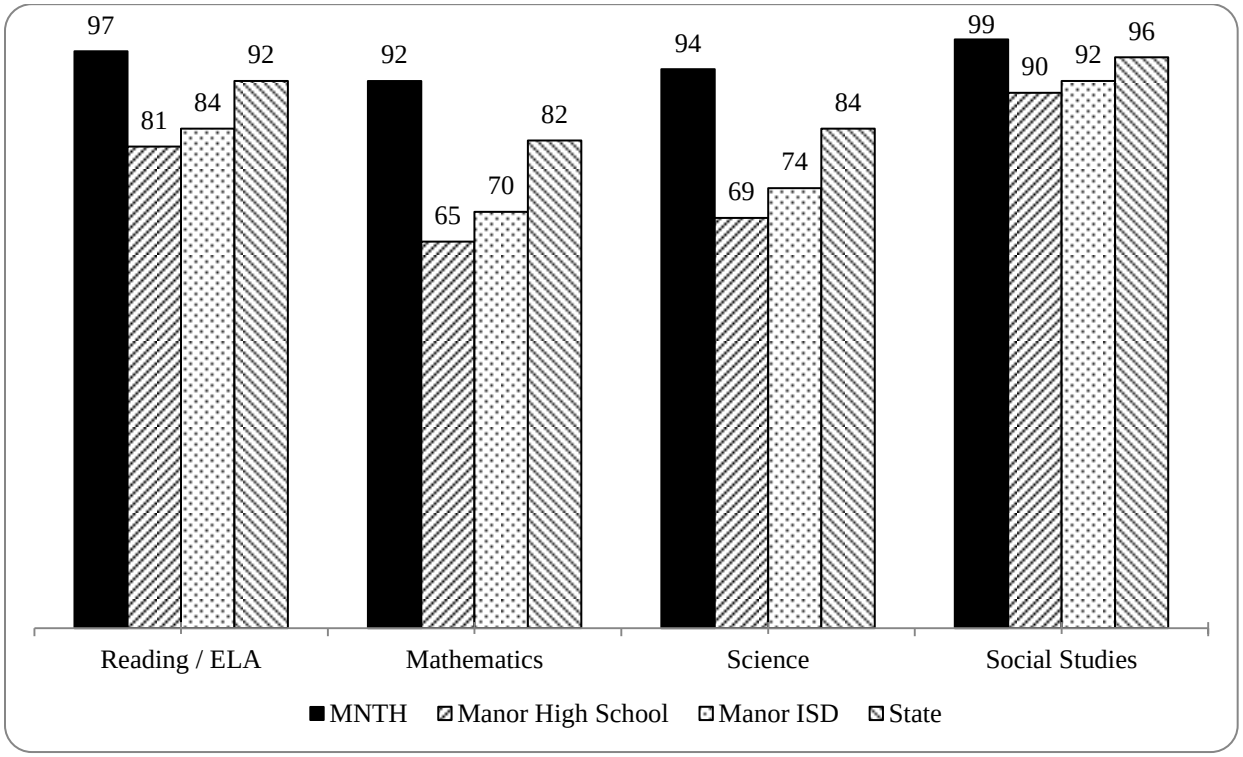
Source: Texas Education Agency Academic Excellence Indicator System Reports (retrieved from http://ritter.tea.state.tx.us/perfreport/aeis/).

The 2011-2012 TAKS assessment results display similarly positive trends for MNTH's testing outcomes. Exhibit 3 shows the percentage of students "Meeting Standard" on the 2011-2012 TAKS assessments for MNTH, the comprehensive Manor High School, the district, and the state. Exhibit 4 displays the corresponding percentage of students achieving the "Commended Performance" levels. It is notable that due to a change in reporting practices by the Texas Education Agency, the Academic Excellence Indicator System reports for 2011-2012 include

TAKS assessment scores for only the 10th and 11th grades for the schools, district, and state, allowing for a more precise comparison of outcomes across the four comparison groups. For these assessments, MNTH either outperformed or equaled the performance of Manor High School, the district, and the state in all subjects.

Exhibit 3

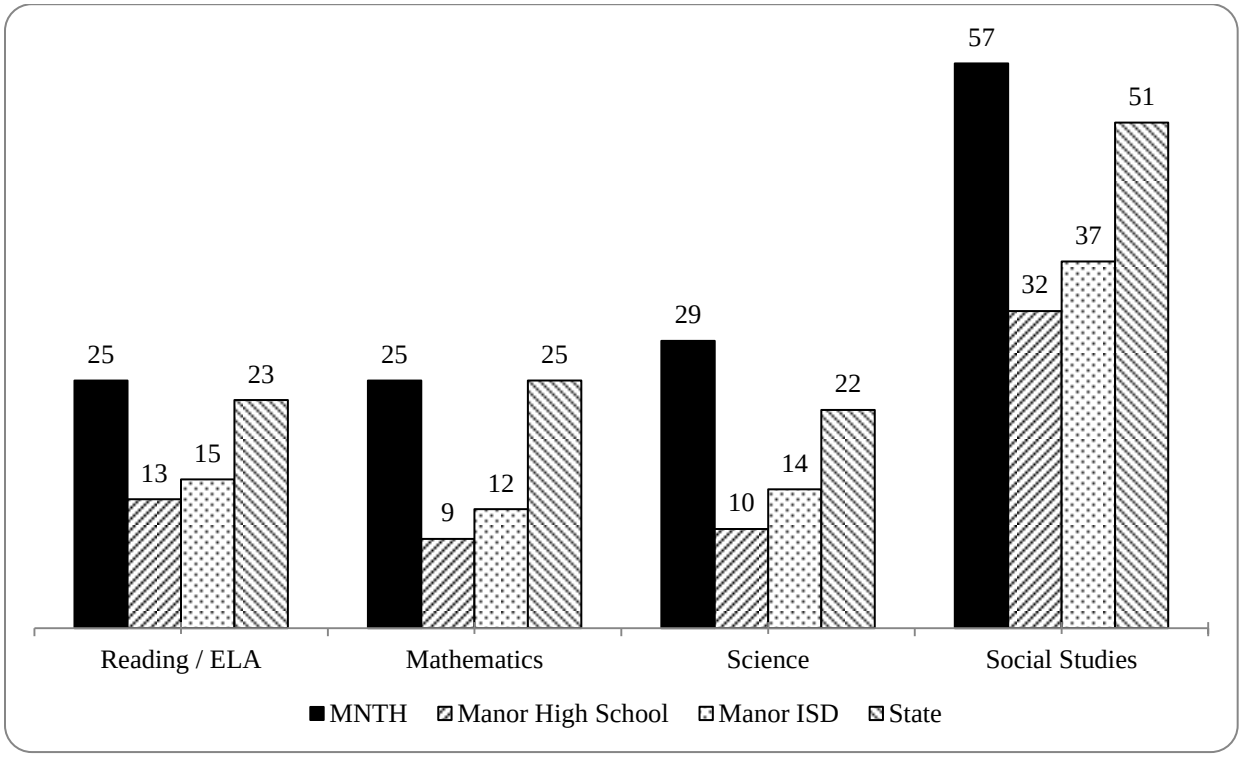
2011-12 TAKS Assessment Results for MNTH, Manor High School, District, and State (Percent Meeting Standard, for grades 10 and 11)



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

Exhibit 4

2011-12 TAKS Assessment Results for MNTH, Manor High School, District, and State (Percent Achieving Commended Performance, for grades 10 and 11)



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

A closer examination of the progression in academic achievement by student cohorts as they spend more time at MNTH and advance through the high school grades is also quite informative. Table 8 tracks the TAKS assessment scores for the Class of 2011 at MNTH as they advanced from grade to grade, displaying first their incoming scores on the 8th grade Texas assessments before they arrived at MNTH, then their scores on the 9th grade assessments in 2008, 10th grade assessments in 2009, and 11th grade assessments in 2010. For each year these students studied at MNTH, they improved their academic performance on these assessments (represented by the "(++)" notation in the table), except for the 11th grade ELA exam where they stayed even with the previous year's ELA results. Notably, the gains MNTH students made over time on the STEM-related Mathematics and Science assessments were particularly substantive, with a net gain of 25 percentage points in Mathematics (starting at 59% coming in and leaving at 84%) and 29 percentage points in Science (starting at 65% coming in and leaving at 94%).

Table 8
Cohort Progression on TAKS Scores for MNTH Class of 2011

	% Met Standard ELA	% Met Standard Mathematics	% Met Standard Science	% Met Standard Social Studies
8th Grade (2007)	77	59	65	90
9th Grade (2008)	88 (++)*	64 (++)	(Not administered)	(Not administered)
10th Grade (2009)	90 (++)	67 (++)	81 (++)	97 (++)
11th Grade (2010)	90 (even)	84 (++)	94 (++)	99 (++)

* (++) indicates an increase over the previous year.
Source: Information provided by Steven Zipkes, Principal at MNTH; Texas Education Agency Academic Excellence Indicator System Reports (retrieved from http://ritter.tea.state.tx.us/perfreport/aeis/).

Table 9 tracks similar data for the Class of 2012 at MNTH, displaying first their incoming scores on the 8th grade Texas assessments, then their scores on the 9th grade assessments in 2009, 10th grade assessments in 2010, and 11th grade assessments in 2011. The trend here is similar, with gains made in each year the students are enrolled at MNTH. Again, the improvements made in the Mathematics and Science assessments are notable, with a 32 percentage point increase in Mathematics (starting at 61% coming in and leaving at 93%) and 19 percentage point increase in Science (starting at 78% coming in and leaving at 97%). Indeed, over 90% of this cohort Met Standard for all four TAKS subjects in their 11th grade assessments. While one may expect students to show gains each year, these appear to be substantial increases over time, hitting the test ceilings in ELA and Social Studies in 10th grade, and showing the most impressive gains in Mathematics and Science.

Table 9
Cohort Progression on TAKS Scores for MNTH Class of 2012

	% Met Standard ELA	% Met Standard Mathematics	% Met Standard Science	% Met Standard Social Studies
8th Grade (2008)	80	61	78	90
9th Grade (2009)	94 (++)*	73 (++)	(Not administered)	(Not administered)
10th Grade (2010)	99 (++)	77 (++)	88 (++)	99 (++)
11th Grade (2011)	99 (even)	93 (++)	97 (++)	99 (even)

* (++) indicates an increase over the previous year.
Source: Information provided by Steven Zipkes, Principal at MNTH; Texas Education Agency Academic Excellence Indicator System Reports (retrieved from http://ritter.tea.state.tx.us/perfreport/aeis/).

The student academic outcomes reflected in these TAKS scores, both in comparison with Manor High School, the district, and the state, and as tracked by cohort, suggest that the school

succeeds in advancing student learning. Because MNTH students choose to attend the school, it could be argued that their self-selection for this school leads to an incoming student body that comes in with more advanced academic skills and knowledge than those who ultimately attend other schools in the district.

Tables 10 and 11 accordingly compare the 8th grade assessment scores for those students who were admitted to MNTH with the corresponding scores for 8th grade students in Manor ISD overall. Although the overall Manor ISD 8th grade data also includes those students who ultimately attended MNTH, making this an inexact comparison, it provides a rough indication of the similarity of students at MNTH versus the rest of the district. Students coming to MNTH do arrive with higher Science assessment scores than the overall population in the district, perhaps reflecting their interest in enrolling at a STEM high school to begin with, and this may be a factor in their success in the science assessments in later grades. However, it also appears that incoming MNTH students are equivalent to the rest of the 8th graders in the district with regards to their incoming Mathematics skills and even slightly behind their peers in ELA skills, as represented by their assessment scores.

Table 10

Comparison of 2007 8th Grade Assessment Scores for Future MNTH Students and District Overall

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

Source: Information provided by Steven Zipkes, Principal at MNTH; Texas Education Agency Academic Excellence Indicator System Reports (retrieved from http://ritter.tea.state.tx.us/perfreport/aeis/).

Table 11
Comparison of 2008 8th Grade Assessment Scores for Future MNTH Students and District Overall

	% Met Standard ELA	% Met Standard Mathematics	% Met Standard Science	% Met Standard Social Studies
8th Graders Enrolling at MNTH (2008)	80	61	78	90
8th Graders at Manor ISD Overall (2008)	87	59	45	82

Source: Information provided by Steven Zipkes, Principal at MNTH; Texas Education Agency Academic Excellence Indicator System Reports (retrieved from http://ritter.tea.state.tx.us/perfreport/aeis/).

When viewed comprehensively, the TAKS results presented in Tables 10 and 11 indicate that MNTH students both come to the school with lower incoming Mathematics scores and score lower on their Mathematics assessments in their 9th and 10th grades at MNTH compared to the results posted in the ELA, Social Studies, and Science tests. Considering the STEM-focused mission of the school, Zipkes and his staff noted this trend, and consequently the school focused heavily on improving its students' achievement in Mathematics. The data for 11th graders in both 2010 and 2011 shows a marked improvement for these scores, likely reflecting this increased attention from the school.

In a similar vein, MNTH students score very well on the ELA and Social Studies assessments, with 97% of its students overall and 99% of its 11th graders meeting Texas standards on both TAKS assessments in 2011. Additionally, 31% of its students overall in ELA and 51% of its students overall in Social Studies achieved the Commended Performance level in 2011. These are clearly non-STEM subjects, but the data suggest that the quality of education at MNTH in these subjects is quite high. This may be an indication that the infusion of STEM and PBL strategies throughout the school contributes to the overall academic performance of its students beyond the sciences and mathematics courses.

3.3.4. Post-Secondary Acceptance and Enrollment: Longer-Term Outcomes.

MNTH has been very successful with its focus on longer-term post-secondary outcomes. Table 12 displays post-secondary acceptance rate data presented by Principal Zipkes for the Classes of 2010 through 2012. Overall college acceptance rates for MNTH students are consistently high, with 100% of seniors in 2010 and 97% of seniors in both 2011 and 2012 described by MNTH as "College/University Bound."

Table 12
Post-secondary Acceptance Rates (%) for MNTH Classes of 2010 through 2012

	"College/University Bound"	Accepted into 4-year Universities	First-Generation College Goers
Class of 2010	100	84	62
Class of 2011	97	80	50
Class of 2012	97	62	65

Source: Zipkes PowerPoint presentation from July 2012.

The National Student Clearinghouse (NSC) data for MNTH also reflects high college enrollment rates for MNTH in 2010 and 2011. These percentages far surpass post-secondary enrollment rates for 18- to 24-year-olds in degree-granting institutions nationwide, according to data sets published by the National Center for Education Statistics (NCES) (2011). For example, in 2010, the most recent data published by the NCES, 41.2% of all students aged 18 to 24 were enrolled in either a 2-year or 4-year institution (NCES, 2011, Table 213). Table 13 presents a side-by-side comparison of MNTH enrollment rates with these nationwide percentages.

Table 13
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
MNTH, 2011	81.4	48.5	32.8
Nationwide Rates, 2010	41.2	28.2	12.9

Source: National Student Clearinghouse, provided by MNTH; NCES Digest of Education Statistics

Interestingly, there is a noticeable decline in the percentage of MNTH seniors accepted into 4-year universities, from 84% in 2010 and 80% in 2011 down to 62% in 2012. This trend, however, actually mirrors a nationwide increase in the enrollment rates for 2-year institutions, according to the National Student Clearinghouse Research Center (NSCRC) (2011). In addition, the proportion of MNTH seniors accepted into 4-year universities versus 2-year institutions still surpasses the national enrollment rate averages. In 2009, of the "traditional-age, first-time" students enrolled in post-secondary institutions nationwide, 55.5% were enrolled in 4-year institutions and 44.5% were in 2-year institutions; these rates were similar in 2010, with 57.1% enrolled in 4-year institutions and 42.9% enrolled in 2-year institutions nationwide (NSCRC, 2011, p. 14). MNTH's success with first-generation college attendees also remained consistently strong over the years.

In line with their successes in getting their students to post-secondary institutions, MNTH has received numerous accolades for its focus and success in teaching 21st Century Skills to its students. The Partnership for 21st Century Skills (www.p21.org), Edutopia (www.edutopia.org), and U.S. News & World Report have each profiled or recognized MNTH for its commitment and excellence in education. In addition, on March 3, 2010, the United States Secretary of Education

Arne Duncan highlighted MNTH in his speech to the Association of American Publishers on using technology to transform schools in the 21st century, citing the school for its success in teaching underserved youth through project-based learning and integration of technology (Duncan, 2010).

3.3.5. Summary

An analysis of the short-term and longer-term outcome data for MNTH indicates that their students are succeeding in high school and immediately beyond. It is worth emphasizing, however, that this OSPrI study is not presenting these student outcome data as causal evidence that MNTH's design and implementation have led directly to these positive student outcomes. These data do not allow such inferences, because the comparisons are at times statistically inexact, relying on existing data but without a carefully drawn sample for an experimental comparison group. Such a study would need to take into account such factors as differences in students' achievement or STEM interest prior to entering high school, among others. Such an effectiveness study is beyond OSPrI's scope. Instead, these comparisons merely mirror the rough comparisons and estimates that schools and districts often use in looking at trends and general indicators to judge a school's successes. In this case, all available indicators appear to point to the success of MNTH in preparing students for college and beyond.

4. CONCLUSIONS AND IMPLICATIONS

This MNTH case study was the first of a series of 12 cases on inclusive STEM high schools. MNTH proved to be a revealing example of a new school model. The school provides an instructional environment unlike any we had seen in public schools, building a community of students and teachers who were open to creating opportunity structures and taking advantage of them. The school's most salient features were:

1. A PBL learning/instructional environment for all classes, all of the time. This changed the dynamic of the classes, of human relationships, and of the ubiquitous role of technology in the school. We believe that this school is a good, albeit rare, example of a place where relationships between students, teachers and knowledge has been altered in a profound way. It is a learning community. The most consistent testimony to the power of PBL was students' abilities to explain their projects in a way that was informed, enthusiastic and confident. This instructional approach appeared to enhance student self-efficacy, 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 projects to move forward successfully. Because of this instructional environment, students did not learn *about* 21st Century Skills, rather students *adopted and infused* them into projects. Politically, it was advantageous to the school that student assessment results were consistently high, given this unusual learning environment.
2. Supports for students in under-represented groups. We anticipated that we would find a sound tutoring system in place, given the school's STEM demands, and connections to mentors. But we were struck by the finely honed program to get students ready for the college admissions process and the results; virtually every student was admitted to college with a fairly elaborated plan of what would be necessary to achieve college goals. If their goals changed, then left intact would be the 21st Century Skills that allowed students to find and seek support if needed, work in collaborative groups, and use

technology for STEM or for any subject or activity. There were opportunity structures that involved risks and personal time and commitment, but for every risk there were supports that students could rely upon.

3. School culture and MNTH as family/our house: It became apparent that by choosing to go the MNTH, this diverse group of students and their families were committing to a new type of STEM school that would require more from students than a typical comprehensive high school, but that would also provide returns--student attainment and confidence. This school seemed to provide a "rite-of-passage" for students who persevered. To be successful, students had to build collaborative relationships that deliberately expanded their worlds, particularly in STEM fields. This school became a strong, supportive and extended family for students and staff.
4. Leadership and Teaching Staff: The MNTH Principal, Steve Zipkes is a dynamic leader whose enthusiasm is contagious and who pulled together a dedicated and skilled teaching staff that can execute the MNTH vision and take it to high level of realization in the context of Texas STEM schools. The two critical components, Administrative Leadership and Qualified Teaching Staff seem inseparable when considering MNTH's substantial accomplishments as a positive and innovative STEM learning environment and as a healthy, inclusive school community.

Other candidate critical components that contributed to the accomplishments of MNTH include the intentionally strong focus on STEM coursework and the high number of graduation requirements in STEM (including engineering and technology). The courses were designed to provide students with a broad and deepening interdisciplinary understanding of STEM in personal, community and global contexts. The STEM concentration gave students advantages in obtaining college admission. Technology was seamless and ubiquitous, the glue that held the entire enterprise together in a school where students must commute long distances. MNTH remains true to its initial mission of being an inclusive STEM school, with substantial numbers of students who are first generation in their families to attend college, or who are from modest socioeconomic backgrounds. The school celebrates the fact that the MNTH student population mirrors that of the state of Texas. Perhaps because of the long distances that students must travel and the rich and extensive STEM program of studies required by MNTH, early college enrollment or extensive involvement of students in mentorships outside of school were not as visible as other critical components. However, MNTH provides opportunities for students under-represented in STEM by developing a supportive school program that took place on-site, often bringing the community into the school.

As MNTH follows students into college longitudinally through the services of the National Clearinghouse, the impact of this school on student attainment in STEM fields and in college success will become clearer. MNTH has deliberately build opportunity structures to enable students to access STEM-rich environments and the confidence to succeed in a complex and connected world.

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