Wayne School of Engineering: A Case Study of an Inclusive STEM-Focused High School in Goldsboro, North Carolina

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1. INTRODUCTION

Approximately one third of all children in the United States attend rural schools, where there is low population density, remoteness from large metropolitan areas, and often, lack of resources (Alliance for Excellent Education, 2010; Bryant, 2007). Although students who attended rural schools performed as well academically as their peers in non-rural schools (Fan & Chen, 1999), fewer students from rural areas complete college degrees. Data from 25 to 34-year-olds in the American Community Survey indicated that only 21% of people attending rural schools attained a bachelor's degree or higher, compared with 34% from non-rural schools (Rovansik et al., 2007). With one third of U.S. children potentially in a situation that results in less opportunity for college success, an examination of well-established rural schools could provide insights to support these students.

Rural schools face challenges that are often different than non-rural schools. Resource constraints are particularly acute in rural schools, and they struggle to offer advanced courses and extracurricular programs (National Center for Educational Statistics, 2009). These schools often find that creating and maintaining outside-of-school partnerships are difficult because of geographic location. Administrators are challenged to meet increased achievement expectations although already limited resources are declining (Williams & Nierengarten, 2011). Rural schools tend to serve large minority and socioeconomically disadvantaged populations (Lichter et al., 2003; National Center for Educational Statistics, 2009). Because of their small size and limited resources, teachers are often teaching multiple content areas (Brown & Swanson, 2003; Colangelo et al., 1999) and have little access to professional development opportunities (Barley & Beesley, 2007). Dropout rates tend to be higher than in non-rural schools (Rural School and Community Trust, 2010), and there is a documented gap between rural students' academic performance and what teachers believe these students could achieve (Hardre & Sullivan, 2009). In spite of major obstacles, rural schools offer advantages over non-rural schools in areas such as community support (Hardre, 2007; Howley, 2009; Woodrum, 2009), role modeling (Ballou & Podgursky, 1995); and programs tailored to local resources (Faircloth, 2009; Woodrum, 2009). Rural communities, being small in size, often have strong connections among families, schools, and religious institutions (Coleman, 1988; Crockett et al., 2000; Elder & Conger, 2000). Rural schools are more advantaged in local social resources, yet they face a variety of other obstacles in supporting quality educational experiences for all students.

There is a national awareness of the challenges faced by rural schools, and efforts to improve these conditions often leverage science, technology, engineering and mathematics (STEM) resources. STEM funding has been used to support facilities, administrative structure, curriculum design, teacher preparation, career awareness, and school support networks in an effort to provide opportunities to rural schools (NSF, 2013). The purpose of this paper is to present a descriptive case study of an inclusive rural STEM school that has successfully dealt with the challenges faced by rural schools and offers an innovative and productive learning environment, despite limited resources.

1.1. FRAMING THE STUDY

This case study of Wayne School of Engineering asks:
Is there evidence for each of the candidate critical components (explained further in the section "Exploring the Design and Implementation of WSE") found in the design of WSE, the school that is the focus of the case study?
How are the critical components implemented at WSE? Do other components emerge from the data collected on-site that are critical to the school's character and success?
What are the contextual affordances and constraints that influence WSE's design, implementation and student outcomes?
How do WSE student STEM outcomes compare with those of the school district and state (e.g., STEM achievement measures, graduation rates, college acceptance rates)?

1.2. SELECTION OF WAYNE SCHOOL OF ENGINEERING

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 began 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.

The school selected for this case study was the Wayne School of Engineering (WSE) located in Goldsboro, North Carolina. WSE was selected because the state of North Carolina has a large inclusive STEM high school initiative, and it was one of the first schools involved in the New Schools Project funded by the Bill and Melinda Gates Foundation. It met our study criteria of serving a diverse population in terms of ethnicity and socioeconomic status as well as having a STEM-focused curriculum. WSE is now one of four laboratory schools that showcase successful practices to visitors wanting to build their own inclusive STEM school.

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. Our request was unusual only in that the proposed work was more extensive and systematic than typical of shorter visits or those oriented towards teacher professional development.

2. THE WSE CASE

2.1. CONTEXT AND OVERVIEW

2.1.1. School district and locale.

The site of this research study was Wayne School of Engineering (WSE), an open enrollment public high school in a countywide rural school district in eastern North Carolina. WSE is located in the central attendance zone of the Wayne County Public School District (WCPS) inside the city limits of Goldsboro, the county seat. Wayne County, NC had a population of about 125,000 in 2011, with approximately 37,000 residing in its only city, the county seat, Goldsboro. Goldsboro was formerly an important rail junction. It still has an industrial base but industries are now located away from the city of Goldsboro. Besides the county and city governments and hospital, the U.S. Air Force was also a major employer in Wayne County. The base was located near Goldsboro and about 15% of WSE's students were from Air Force families in 2012 when we visited the school.

At the time of our site visit in September 2012, WSE, serving 325 students in grades 9 through 13, was co-located on the large campus of a comprehensive high school, Goldsboro High School (GHS). The two schools shared a parking lot but had separate entrances; connections between the buildings were closed off to create two stand-alone schools. There was no cross-over of students or teachers for academics; however, WSE students and staff participated on GHS sports teams as members of the team or coaches. WSE was located next to a public library and public park, both of which were available for use by the school. WSE students were transported by school district busses between their homes, schools, and the nearby community college. According to an Associate Superintendent of WCPSD, the state was providing additional bus transportation to transport students across the district, noting that "some of them live as far away as 35 miles."

In the 2011-2012 school year, WCPSD served approximately 20,000 K-12 students including approximately 5,500 high school students. The student demographics for the district were: 41% White, 35% African American, 17% Hispanic, and 6% two or more races, with 66% of students classified as economically disadvantaged (eligible for free or reduced price lunch). During the same school year, WSE had 325 students enrolled with the following demographics: 47% White, 31% African American, 7% Hispanic, and 15% two or more races, with 44% classified as economically disadvantaged. This was markedly different than the adjoining comprehensive high school, GHS, which served a predominately African American population (99% of students), with 86% of students classified as economically disadvantaged.

2.1.2. School history and design.

WSE started in 2007 with a ninth grade class of 74 students. The staff consisted of the principal, a counselor, and four teachers. WSE added one grade per year and graduated its first senior class in 2012. In the fall of 2012, WSE expanded. High school students were eligible to stay for an additional year of community college courses, at no cost to the student. WSE also began a middle school with a sixth grade class of about 70 students, with plans to add seventh and eighth grades in 2013 and 2014, respectively.

WSE came about as an innovative approach to improving high school educational opportunities in the central attendance zone (Goldsboro), following a court order listing Goldsboro HS as one of the 10 lowest performing high schools in the state that must be reformed. Goldsboro HS was reformed using the America's Choice model; and one campus building was designated as a facility for a new STEM-focused high school with an engineering theme, based on the NC STEM high school project known as the New Schools Project. WSE's first principal, Gary Hales, was at the time an assistant principal at GHS, and worked with the district's director for high school education to write a successful application for a planning grant for innovative high schools. Grant funding for designing and preparing to open this new high school included funding from the Gates Foundation and the state of North Carolina's New Schools Project. An educational consultant from Eastern Carolina University (ECU) was engaged to assist in these efforts and to provide professional development for teachers during the start-up period, focused on the use of project-based learning and inquiry learning. However, no grant funding was designated for school facilities or operations. At the time of this study, ECU was still involved with WSE through the Project Heart program, providing opportunities for WSE students to tutor students in WCPSD schools and earn college scholarships and opportunities to earn money in college by tutoring. In addition, WSE had recently been able to take advantage of a Department of Defense activity grant, written to acquire technology. This grant included money to purchase iPad carts and to equip a digital media room and a STEM lab. More details about WSE's administrative structure and partnerships are provided in those sections of the case study.

As part of the NC New Schools Project, WSE was one of North Carolina's STEM high schools that received a one year planning grant associated with that program. The original purpose of the North Carolina New Schools Project was to create a system of networked STEM schools that were also linked with government, business, and higher education institutions in the state to improve STEM education. Some of the services provided through the New Schools Project include teacher externships, STEM experts who assist teachers in co-designing authentic projects, work-based learning activities, and coaching on career awareness and preparation. The overarching goal was to support schools and teachers so that "schools can provide the tools and space for exploration and invention …that foster a culture of inquiry among students and teachers" (North Carolina New Schools Project website, 2013). More details about the New Schools Project are provided in sections of the case study related to WSE's teaching staff, instructional strategies, partnerships, and supports for students underrepresented in STEM fields.

At the time of our visit, Wayne School of Engineering (WSE) had implemented a curriculum structure in which students take two mathematics and two science courses each semester, through the use of a block schedule. The intent was to accelerate students into early college coursework as soon as they were personally ready. With only 300 to 350 high school students, WSE can and did monitor individual student readiness and also monitored their success in college coursework, bringing them back to the high school campus to work in the Virtual Lab if they exhibited problems succeeding in the college courses at the nearby community college. The block schedule at WSE also allowed students to retake high school courses in a timely manner if necessary. Through blending high school courses, engineering courses taught by community college instructors at the high school, and college coursework taken online or at the community college, WSE was able to offer their students the opportunity to graduate in five years with an associate's degree in science or arts, or graduate in four years with college credits in science or

arts that would be accepted through articulation agreements with a number of North Carolina public colleges and universities.

Vitally important to WSE's design and successful outcomes was a partnership with the Wayne Community College (WCC), located a mile away from WSE, with bus transportation provided for students from WSE and another WCPSD high school geared towards 1st generation college-going students. Engineering department instructors from WCC teach grade-level appropriate AutoCAD and other elective courses after WSE students take an introductory engineering course based on a high school engineering curriculum developed by the Boston Museum of Science. Students who do well in these courses can take more advanced engineering courses taught by the same instructors at WCC such as Computer Aided Manufacturing and AutoCAD III. WSE's curriculum, including options for a fifth year, is detailed in the case study sections on the STEM curriculum and early college level coursework.

Community service and internships were also an important element of graduation requirements at WSE at the time of our study. Local entities partnered with WSE included the Community Gardens, medical practitioners, industrial businesses, and the city government. These partnerships and the associated informal learning taking place through community service and internships are discussed in the case study sections on partnerships and informal learning.

2.1.3. Admissions.

Admission to WSE was by interview and lottery, with all of the eighth graders in the school district eligible to apply. WSE was using a county-wide application and lottery process to fill middle school level seats as well (i.e., sixth grade seats beginning in 2012). This will change in 2015 when WSE completes its expansion to a grade 6-12 school. Then the admissions process will be predominantly for entering sixth graders.

The demographic composition of WSE compared to its district and the State is shown in Table 1 for the year prior to our visit.

Table 1.
2011-2012 Demographics Comparing WSE, District, and State

	WSE	Wayne County Public Schools	North Carolina
Students Served	325	19,315	1,475,200
Grade Levels	9-12	K-12	K-12
American Indian (%)	0.0	0.2	1.4
Asian (%)	0.6	1.0	2.5
Hispanic (%)	6.8	17.0	13.3
Black (%)	30.8	34.5	26.3
White (%)	47.4	41.3	52.7
Two or More Races (%)	14.5	5.8	3.7
Pacific Islander (%)	0.0	0.1	0.1
Male (%)	52.9	51.5	51.2
Female (%)	47.1	48.5	48.8
Free/Reduced Lunch (%)	44.4	66.3	56.0

Source: "Grade, Race, Sex 2011-2012" and "Free & Reduced Meals Application Data 2011-2012" from Public Schools of North Carolina Financial & Business Services website (retrieved from http://www.ncpublicschools.org)

2.2. EXPLORING THE DESIGN AND IMPLEMENTATION OF WSE

This study explores design, implementation, and outcome dimensions of WSE focusing on ten candidate critical components defined in Table 2. Additionally, the study was designed to capture themes that emerged from the data.

Table 2
Definitions of 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.
2. ***Reform Instructional Strategies and Project-Based Learning***. STEM classes emphasize active, immersive, and authentic instructional practices/strategies informed by research. Opportunities for project-based learning and student production. Performance-based assessment practices that have an authentic fit with STEM disciplines.
3. ***Integrated, Innovative Technology Use***. Technology connects students with information systems, models, databases, STEM research; teachers; mentors; social networking resources for STEM ideas, during and outside the school day.
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." Include 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.
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.
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.
7. ***Well-Prepared STEM Teaching Staff***. Teachers are qualified and have advanced STEM content knowledge and/or practical experience in STEM careers.
8. ***Inclusive STEM Mission***. The school's stated goals are to prepare students for STEM, with emphasis on recruiting students from underrepresented groups.
9. ***Administrative Structure***. The administrative structure varies (school-within-a-school, charter school, magnet school, etc.). Affected by the school's age and provenance, i.e., whether the school was converted from another model or was created "from scratch" as a STEM school. Funding structure varies.
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. Altered, improved opportunity structures, i.e., students are positioned for STEM college majors, careers, and jobs.

Source: Lynch, S. J., Behrend, T., Peters-Burton, E., and Means, B. M. (2012). *Multiple instrumental case studies of inclusive STEM-focused high schools: Opportunity structures for preparation and inspiration (OSPrI).* Paper presented at the annual meeting of AERA, Vancouver, BC. Retrieved August 10, 2013, from the AERA Online Paper Repository.

Before visiting the school, its design and outcomes were investigated using publicly available data and documents found on the school and district websites. Two online questionnaires provided additional design information before the visit. One was a school description questionnaire completed by a school administrator, either the principal or a designee; the other was a survey completed by teachers. We conducted phone interviews with the administrator to follow up on questionnaire responses. To understand implementation, the OSPrI study team, comprised of six researchers whose expertise spanned science, mathematics, technology, and engineering, visited the school for three to four days. In teams of two, they collected data using observation instruments and focus group and interview protocols. Data was then analyzed in the context of the school to answer our research questions. The reader is referred to the Research Framework document co-located with the case studies on the OSPrI website

(ospri.research.gwu.edu) for details of the research design, including conceptual framework, critical components, and methods. A list of data collection activities conducted during the site visit is shown in Table 3.

Table 3.
Data Collection Activities during site visit at WSE.

Observations	
STEM	Non-STEM
Honors Integrated mathematics III	Honors Freshman Composition
Honors Advanced functions & modeling	Honors English IV
Honors Pre-calculus	
Honors Engineering the Future	
Honors Drafting	
Honors Design Process 2	
Honors Computer Aided Manufacturing	
Honors Earth Science	
Honors Biology	
Honors Physics	
Honors Chemistry	
Focus Groups	
Teachers	Students/Parents
Teachers of Engineering	Parents (across grade levels)
Teachers of Mathematics	9th graders
Teachers of Science	11th graders
Teachers on Use of Technology	Engineering & use of technology
Teachers on Informal learning	Informal learning
Interviews	
School Personnel	Non-School Personnel
Principal	Community Gardens
Special education teacher	ECU Project Heart
Community college teachers	ECU professional development
Technology specialist	Alumni
Other Activities	
During School Day	After School
School tour & student video presentation	
Teacher professional development	Robotics club
Researcher activities	
Team Debriefs	

In the following subsections of the case study, the ten critical components are discussed in terms of their design and implementation. This is followed by similar sections on themes that emerged in our analysis, then discussion of STEM outcomes.

2.2.1. STEM-Focused Curriculum

2.2.1.1. *Definition*.

The definition for a STEM-Focused Curriculum is listed in Table 2.

2.2.1.2. *Design*.

WSE was designed to offer students an honors curriculum with a concentration in science, technology, engineering, and mathematics. As described in the 2012 Student Handbook, this STEM focus was intended to help students "make sense of the world" and also provide them with skills and habits of mind necessary to be successful in the 21st century. By graduation, students at WSE completed a minimum of four science courses, four mathematics courses, four English courses, four social studies courses, two foreign language courses, and a selection of elective courses in STEM areas. Graduation requirements also included 15 hours of early college coursework and an internship to be completed before graduation. Table 4 outlines the typical sequence of courses in the STEM subject areas offered at WSE.

Table 4.

Typical Sequence of Courses in STEM Fields at WSE

Content area	Course sequence				
SCIENCE	Honors Earth and Environmental Science	Honors Biology	Honors Chemistry	Honors Physics	
TECHNOLOGY	Technology Lab				
ENGINEERING	Honors Engineering the Future	Honors Applications of Science	Drafting Engineering I (by WCC instructor)	Honors Drafting Engineering II (by WCC instructor)	Honors Drafting Engineering III (by WCC instructor)
MATHEMATICS	Honors Integrated Mathematics I	Honors Integrated Mathematics II	Honors Integrated Mathematics III	Honors Advanced Functions and/or Pre-Calculus	Honors Intro to Derivatives and AP Calculus

Note. After the Technology Lab course, technology instruction at WSE is conducted through an immersion of technology in all classes, as opposed to standalone courses.

Nearly every course at the school was designed to be an honors-level course, with no courses offered below the honors level aside from the Drafting Engineering I course. All incoming 9th graders took honors Engineering the Future and honors Applications of Science courses that were designed and created by the school. They also took a technology lab course. In addition to these core courses, students were required to complete honors level courses in Earth and Environmental Science, Biology, Chemistry, Physics, and Engineering Drafting (i.e., AutoCAD), as shown in Table 4. All WSE students took honors Integrated Mathematics, with some starting at level 1 and some at level 2. Once they completed honors Integrated Mathematics 3, they were

required to take one additional advanced mathematics course and had the option to take AP Calculus and Intro to Derivatives and other classes that focused on robotics, biomechanics, and solids modeling.

Classes at WSE were designed as intense and concentrated semester-long courses in order to parallel the schedule at WCC. Students could complete two mathematics, engineering, or science courses in one year. Advanced STEM coursework was offered through the partnership with WCC, as detailed in the section on Early College. As students completed the sequence at WSE outlined in Table 4, they could enroll in college-level courses at WCC. Most students were expected to take introductory courses in mathematics, science, and engineering at WSE, and then if recommended by the principal, they were to have access to advanced offerings at WCC. For example, mathematics courses met for 80 minutes each day and concluded in one semester. A student starting at level 2 of the integrated mathematics series could complete all courses required for graduation in two years, then take mathematics courses for credit at WCC. Additionally, engineering department instructors from WCC taught grade-level appropriate AutoCAD courses. This allowed the students to form mentoring relationships with WCC engineering instructors that would carry forward and support their transition to taking advanced engineering courses with the instructors at WCC if they did well in their core engineering courses and chose to focus on it at the college level. WSE students could also take calculus at WCC, either after or in lieu of the AP Calculus course at WSE. Students could choose to remain at WSE for a 5th year and earn an Associate's degree from WCC, as discussed in the section on Early College.

In addition to courses at WSE and WCC, students had access to the state's distance-learning program (North Carolina Virtual High School). This greatly expanded course offerings for students desiring the opportunity to take additional coursework ranging from foreign language or other electives to additional mathematics courses. The school had two distance-learning labs and students could request permission to take these classes online at home.

2.2.1.3. *Implementation*.
In this section, each STEM content area's implementation is discussed followed by a discussion of interdisciplinary integration.

2.2.1.3.1. *Science.* Within science courses, rigor was maintained through multiple strategies, the most pervasive being small group environments with short projects. During the science teacher focus group, teachers described how they planned together to maintain fidelity with the state standards and to implement pedagogy that holds students accountable for quality work. One teacher stated that:

We really grade what they learned, not just what they turned in. We all go above and beyond the course of study, adding more detail when needed, and we make the students think a lot. We are more about quality than quantity. It might not be much like the traditional setting with a pacing guide; we are more concerned about how students learn the material.

Evidence of the rigor offered in science classes was demonstrated by WSE students' pass rates on the state assessment. Biology was the only tested science subject, and in the two semesters

prior to the site visit, the teachers explained that their students had a 93% and 95% pass rate. The teachers attributed this success to the students' ability to solve problems, not just memorize material.

Another strategy that was common at WSE was addressing the state standards by working on projects that were relevant in to the STEM field. The focus on real-world STEM curriculum at WSE increased interest in these fields, according to students and parents. One parent commented, "WSE prepares [my daughter] better than if we was in a traditional high school. Taking these fun classes, she wouldn't be earning college credits." Another parent commented, "One of my children is a writer and WSE made STEM more palatable for her, and my son wants to be an engineer." A student similarly commented:

I'm taking a level design course and an artificial intelligence programming course. The level design course we are in the process of using Unreal Tournament 3 (Unreal editor). It's what you would be using if you enter the field that I want to go into.

2.2.1.3.2. *Technology*. WSE did not have a separate technology class but it offered electives through the North Carolina Virtual High School. Students also had access to technology classes through the partnership WSE established at Wayne Community College. The partnership is further described in the section on Early College Coursework.

2.2.1.3.3. *Engineering*. As an engineering-themed high school, WSE offered introductory level engineering courses and the opportunity to continue with college level engineering coursework, earning dual credit, as described in the section on Early College. The introductory course, Engineering the Future, is taught by WSE teachers. Drafting courses (AutoCAD I, II, and III; Hydraulics) are taught at WSE or both WSE and WCC by instructional staff from the WCC Mechanical Engineering department for dual enrollment credit. Thus, students who elect to take advanced engineering college level courses at WCC have had the opportunity to form a mentoring relationship with WCC faculty before the transition to the WCC campus.

Additionally, the engineering design process is incorporated into most, if not all, courses taught at WSE. Principal Gary Hales explained:

We also take the engineering design principles… no one should just be satisfied doing something one time and turning it in. It's always tinkering with it and making it better. That's kind of what we want to teach our kids….A lot of times they'll do something, turn it in, get a grade and be happy with it. We want them to look beyond that.

An engineering teacher further described how the engineering design process was infused in other courses:

There is not just one shot—you have to keep redesigning. That includes English. They learn as they make mistakes: "I've done this wrong, haven't I?" When they make a mistake in drafting, I tell them, "I want you to note where you make a mistake and press on; do it over and over again until you get it right."

2.2.1.3.4. ***Mathematics.*** As in many other high schools, students entering ninth grade varied in their levels of proficiency in mathematics, so WSE had to focus on its mathematics curriculum. As a mathematics teacher described, "The students come in with a range of abilities. We spend a lot of time remediating them and catching them up to where they should be. We don't track here, so we struggle with the differentiation piece." Another mathematics teacher suggested that expansion of WSE to be a grade 6-12 school would alleviate this situation:

It's my first year at this school, teaching Integrated Math 1 and 2. [Some] students have learned the material already; others haven't at all. I introduced slope concept and students varied in understanding. WSE Middle School should make the high school more effective as they will all be coming in at the same point. They will have core material they need in the high school.

WSE was in the process of rolling out a grade 6 to 8 middle school, beginning with grade 6 the year of our visit, 2012. All of the administrators, teachers, parents, and students who were interviewed felt that this addition would increase the rigor in the WSE high school curriculum. Indeed, because of the partnership at WCC, there was a great deal of flexibility in the levels of mathematics that students could take. A mathematics teacher explained, "Some students need five … courses to get them ready for calculus, whereas other students only take two courses here at WSE before they are ready." The combination of offerings from face-to-face high school courses, online college courses, and face-to-face college courses provided flexibility and choice to students who had different levels of mathematics proficiency. The only Advanced Placement course offered at WSE was Calculus, with 16 students enrolled in Spring 2012, approximately 10% of all juniors and seniors.

2.2.1.3.5. ***Interdisciplinary integration.*** Teachers at WSE considered the school's curriculum as preparation for college coursework, and they worked to provide a learning environment that had a high cognitive demand. Accordingly, interdisciplinary units that involved projects were common at WSE. Typically students would encounter three to four interdisciplinary units per year. Teachers worked together to develop ideas to reinforce each other's curriculum. For example, the teachers of World History and Applications of Science collaborated on a Roman Culture unit. The Applications of Science teacher taught about the design of arches and other structures of Roman heritage, and the World History teacher had students role-play as if they were different levels of Roman society. The World History teacher told the students that writing the final paper was like solving a problem and approached it as a design problem. In focus groups, the teachers stated that "cross disciplinary work at WSE constantly moves forward and is nurtured." Although there were few formal resources to help teachers integrate the curriculum across disciplines, the teachers did not view this limitation as a barrier. A physics teacher stated:

Having less has made us better [at designing interdisciplinary projects]. The new [resources] that we get, we use fully, but we don't use it as a crutch. Having less make us keep working to keep the habits of mind of engineering pervasive throughout the curriculum.

2.2.1.3.6. ***Advanced STEM offerings.*** As noted earlier, the partnership with Wayne Community College expanded the curricular offerings available to students during their high school career. Because they were at WCC taking those advanced courses, most of the juniors and seniors at WSE only came to campus for one period a day, and they took courses online or at WCC for the

remainder of the day, resulting in very individualized learning experiences for students. The pass rate for all WSE students taking college courses (freshmen to seniors) was 94.5%. The principal personally approved the students who applied to take college courses, saying:

Students have to prove they're ready here before we allow them to go over there and take those courses. We look at their report cards and I sign everyone's report card and I put a little note on them 'good job' or 'you need to improve this grade' and so I see what they're doing and we give the ones we feel are ready a release form.

The partnership with WCC has been successful, with plans for future growth. One professor from Wayne Community College came to WSE's campus to teach introductory engineering. After this course, students went to the college campus to take the more advanced engineering classes. The professor said that when students arrive on campus for advanced courses, "We already have a relationship with them [the students], we already know them." The college faculty found the WSE students to be well prepared for this advanced college study, saying for example, "I've been really pleased with how well they have adjusted to the other students, and how well the other students have accepted them." In some cases, the WSE students outperformed the traditional community college students. A college professor stated:

They are very good independent workers, regardless of what of technical knowledge they come with. They take initiative, get started, and [don't] wait for me to hand it to them on a silver platter. And when they did ask questions they were very specific and focused questions – I could tell they've already thought and exhausted their minds.

The college wanted to continue to expand its offerings at WSE. Mechanical engineering was the focus of the engineering courses, and the department at the college wanted to offer other types of engineering courses to WSE students, such as industrial systems technology, electronics engineering, sustainability technology, and operations management, once space and logistics issues are addressed. Another future goal was to build hybrid courses for the WSE students led by WCC faculty.

2.2.1.4. *Summary.*

The curriculum at WSE is certainly STEM-focused, with particular emphasis on engineering design woven through both STEM and the humanities. Most students at WSE take college credit before they graduate, which is confirmation of the rigor of both the introductory courses taken by freshman and sophomores at WSE, which prepare juniors and seniors to be successful at the college level, further evidenced by the high pass rate of WSE students at WCC (95% pass). Early college opportunities were a hallmark of the curriculum at WSE. Teachers saw the 9^{th} and 10^{th} grade courses as preparation for college, and students who were ready to take courses through WCC were encouraged to do so as early as possible. Teachers and the principal acted as advisors in making sure students did not take part in classes for which they were not yet ready. The partnership with WCC was extremely strong, especially in the STEM fields, which fostered an interest in STEM among the students. These various course offerings and WSE's strong overall curriculum contributed to strong outcomes that WSE demonstrated.

2.2.2. Reform Instructional Strategies and Project-Based Learning

2.2.2.1. *Definition*. Table 2 provides a definition for this critical component.

2.2.2.2. *Design.*
WSE strove for an inquiry-based instructional model for all of its courses, resulting in student-centered learning centered on the state's learning standards. For WSE's staff, "STEM" was not just about the mathematics and science content being taught in the courses. Rather, as the principal, Mr. Gary Hales described, "it's a culture of a more application-based, relevant coursework, cross-curricular connections, not siloed." Notably, however, while models such as project-based learning were favored at WSE, Principal Hales stressed that "we need to be purposeful in what we are doing, we don't want to do fluffy projects."

Accordingly, these instructional models were adopted with the specific expectation that teachers collaborated in cross-curricular lessons that spanned across both STEM and non-STEM courses, and they built relationships that supported student learning in a substantive way. Teachers at WSE focused particularly on relevant issues (e.g., current events and recent social issues) from which course work aligned with the North Carolina learning standards were derived. The express goal of including these relevant issues was to engage students in active learning opportunities through this curricular design. Principal Hales described this design as follows:

We don't want a school where the teachers are just necessarily the givers of information. We want the students being inquisitive and questioning and discussing and that is what I tell folks when I am hiring them—is it's easy to create a lesson plan where you are the center of attention, but then I want you to create a lesson plan where the students are doing the work. You are not the center of attention. You are more of a coach on the sideline, and you can assist them, but you are not doing it for them or just spoon feeding them information to memorize.

Additionally, WSE intended for all students to focus on learning 21st century skills. The skills that were identified explicitly to the students in the WSE Student Handbook included: Information and Communication Technology Literacy, Critical Thinking/ Problem Solving, Communication, Collaboration, Global Awareness, Citizenship, and Self-Management. The Student Handbook also articulated that students would experience these skills in their classroom assignments and would be assessed on these skills. The Student Handbook pointed out that language literacy is a key to success in all academic areas, and WSE designed instruction that incorporated this literacy into all classes and activities.

2.2.2.3. *Implementation*.

2.2.2.3.1. *Classroom instructional practices.* Project-based learning was valued at WSE because the teachers and students felt that it opened up opportunities for learning that other teaching methods did not. They stated that the students who wanted to do well took the projects as far as they can. For example, one student who was interested in racing RC cars began bringing the car parts to school, looking for a way to connect what he was doing outside of school with what he was currently learning in engineering class. One teacher talked about how different the environment was at WSE: "When I first came here, I thought we [the teachers] were going to be

doing most of the talking. The learning environment at this school – now I am really a facilitator." The math that was taught was part of the real world.

You'll see conversations/arguments going on because students disagree about answers. They can talk about it. I could never go back to a traditional school. I couldn't go back to teaching that way. I think you see better results this way. There is just something about it that is real and complete. I am educating whole children and note pieces of children and I want them to be in school.

Project-based learning was done in small groups at WSE, which contributed to a sense of collegiality. Teachers purposefully mixed up the groups so that they were homogenous when appropriate and heterogeneous when appropriate. Teachers also reported that they felt the groups working together benefitted the students who had IEPs and special needs.

Here students always do hands on and use manipulatives which helps students with disabilities. The group work shows a positive change in social interaction for student s with Asperger's. He came out of his shell and began to make friends and he was doing so much better here. He was more willing to help himself. The school culture is a really big piece of it. It is just relaxed.

Teachers embraced project-based learning as effective, but not all of the teaching at WSE involved this pedagogy based on teacher preference. Some of the classes were still taught using traditional methods, but often teachers required students to work in groups, which shifted learning to a more student-centered environment.

Teachers had the goal of teaching high rigor, and planned to increase rigor while staying within reach of the students. One teacher claimed that they "are really grading what they learned, not just what they turned in." Teachers added more detail to the traditional curricular objectives and asked students to work outside of class independently. The same teacher added, "We are more about quality than quantity. We are more concerned about how the students learn the material." Teachers did not feel beholden to the pacing guide and were more concerned with getting students to work collaboratively and on topics that were relevant to the real world. Teachers tried to teach in a non-traditional way, but there were still some strongholds of traditional schooling such as multiple-choice tests given as a response to state-wide high-stakes testing. Notably, however, WSE had special exemptions from the District to not give district-mandated benchmarks. As the principal explained:

District has 9-week benchmarks, but we don't do that. We were trying to do something different. Everything to me should be a benchmark. I shouldn't have to take a day of instruction to give a multiple-choice test to see where they're at. Exit tickets give that data. You need to use that… That's why the joy of school is gone. I want to keep the joy in. I don't have a problem with assessments if they were more performance based. My kids can do. They are articulate and can talk to you. That is not the measuring stick though. It is a multiple-choice test, that in the long run, the students aren't held accountable. The teachers are. There's too many issues. I don't believe in a system I'm giving to someone else how they do is a mark on me, because I know. I wish they'd just trust professionals again.

Teachers embraced cooperative group learning, writing to learn, literacy, and learning to communicate. Some of the classes looked traditional, such as in chemistry, but when the students worked in groups, a new dynamic emerged. Students learned the material in their own group, and they immediately went to other groups to help their classmates. Group work helped with differentiation. WSE was not 100% project based learning, but the school was working in that direction. The math teachers were working especially hard to use project-based learning in their content. The teachers were limited by the lack of laboratory facilities, but worked to solve the problem by encouraging students to take college classes early. More information about college coursework can be found in the section "Early College-Level Coursework."

2.2.2.3.2. ***Class Vignette of Sophomore Chemistry.*** The following vignette of a chemistry class is provided as an example of a typical day in a classroom of WSE. The learning objectives for this class were to describe why the knowledge of compounds are important in daily life and to accurately apply nomenclature rules to write chemical formulas from English names of compounds and to write names from formulas. As the class began, the teacher explained what the students would be doing for the warm-up, and it was called "Pass the mole." She passed around a stuffed mole and the student who was holding it had to answer the question, and you could not speak twice until everyone had spoken. The teacher asked the students to talk about why learning compounds was relevant to their lives. Students quickly passed the mole around and said, "We take compounds for granted, so we need to learn more about them." Many of the other students talked about factual knowledge regarding compounds, such as how they bond. Some students referred to their notes, and eventually everyone contributed to the opening activity. One student asked for the mole back so she could correct what she initially said. When they were finished, the teacher mentioned that the students didn't really go where she wanted them to, but she mentioned how impressed she was about their factual knowledge. The teacher then reviewed the nomenclature sheet that the students needed to complete for the day, and went over an example to model what the students were expected to do. The students were slightly overwhelmed by the goal for the day, but they indicated that they were going to persist. Students formed groups around small white boards and worked the problems from the sheet together.

When they were given some time to work out problems, the class transitioned into a game where the groups solved problems and were given points for correct answers. Some of the groups independently got model chemistry molecule building kits to help them visualize the elements and compounds. As the students worked on problems, the teacher visited the groups and asked students what the different colored balls represented in the kits. The teacher mentioned to Student A that they really understood the material and she should help the group to her right since she was an expert. One student gained the attention of the entire class and the groups stopped working. She says she had a question, "If there are three nitrogens, is it a nitride?" Another student clarified the answer and the teacher gave him a token reward in the form of a "buck". As the groups were presenting their work during the game, other groups challenged them and asked questions. The teacher was rarely moderating the game because the students were running it collectively. When a group was stymied on a question regarding a Lewis dot diagram, a student in another group went to the front electronic board and drew the diagram. Another student asked her a question and she answered generally, and then walked to the struggling student to work one-on-one with him. The struggling student said it "kind of" made sense, but could they do more. They both worked on an additional problem that was supplied by the

teacher. They continued to work until the end of the period when the teacher explained how the work they had done this day would be used in writing chemical equations the next time they met.

2.2.2.3.3. ***Interdisciplinary collaboration.*** WSE fostered continuity and coherence across courses and grades by holding curriculum advisory meetings once a week, professional learning communities that met every day, weekly lesson tuning, weekly whole group reflections, school wide rubrics, and cross curricular instruction (Administrator Survey). Professional learning communities consisted of grade level teachers or teachers with similar content areas who met to design new interdisciplinary curriculum and check up on lesson outcomes. Weekly lesson tuning and group reflections occurred across all faculty at WSE. In preparation for the lesson tuning, one teacher or a small group of teachers described their lesson and have student work to share. The other faculty, even outside of the discipline, made comments intended to improve student learning for that particular lesson. The teachers at WSE reported that they appreciated all members of the faculty contributing to the lesson critique because the diversity of skills of all teachers allowed for more creativity in lesson design.

The teachers worked together to design interdisciplinary units. Teachers valued the cross-disciplinary approach and tried to create opportunities to foster this approach, but also felt that it needed to be constantly moved forward and nurtured. Engineering seemed to be the catalyst for a great deal of interdisciplinary learning. While studying the Roman culture, the humanities teacher assigned students to behave in ways conducive to an assigned social class, while the engineering teacher taught about Roman arches and the role of engineering and design processes in solving problems related to building arches. When engineering teachers at WSE first got the freshmen students, they recognized that the freshmen did not have experience in physics or chemistry from middle school. Engineering for the Future, a freshman course, took the opportunity to bring in as much of the science content as possible, because the teachers at WSE felt that science and technology complemented each other, and this course helped to bridge the students to thinking like an engineer. Persistence was taught in the engineering courses through the redesign, and redesigning Engineering projects required effective communication, which in turn was taught through the English content.

2.2.2.3.4. ***Student perspectives.*** Students acknowledged that the coursework was harder in the classes at WSE than the nearby schools, but that it was worth it. They felt as if the hands on experience, extensive group work, and exposure to technology outweighed the extra hours that they had to devote to their schoolwork.

Students agreed that classes at WSE were very hands-on. An engineering student stated, “A ‘regular’ school may talk that a motor does X and Y. Here, they’ll bring in a motor, take it apart and explain what motors do” (Grade 9 focus group). Eleventh grade students in the focus group interviewed during the school visit represented a wide variety of future careers: aerospace engineering, family business in the funeral service area, and the military. Students felt that the classes prepared them for these careers in a general way due to the project-oriented and student-centered learning they had experienced. Students were quick to voice that they felt confident that they could figure things out because of their experiences in WSE. “I can do anything” (Grade 9 focus group). Taking the online classes required students to spend a great deal of out of class

time working on the classes. If students had trouble with online classes, they could email, message, or Skype teachers.

Engineering courses focused on the engineering design process, and this came through with student responses to the question, "What does engineering mean to you?" Freshmen took the Engineering of the Future course and they had one or two projects every week, including making decks and ramps, and manufacturing concrete. The students stated that they were using math in the communication of their work, including graphs.

Students worked in groups for projects. They felt this was a good support, because if "you get stuck, you can discuss it in your group" (Grade 11 focus group). Collaboration was a large part of how students felt successful at the school, and students often "paired up and helped each other" (Grade 11 focus group). Teachers at WSE stated that freshmen came into WSE only knowing how to work individually; it took them a whole year to learn how to work in groups. Students also saw how teachers worked collaboratively, which added to the culture of the school. As an engineering teacher stated:

The students are very aware that the faculty talk to each other. The whole idea that teachers work together is important as a model. Collaboration is important to be successful as a student at this school.

For example, a robotics class project required a group to program a robot to complete a task on a track, however the student piloting the robot was not able to see the track, so the teammates had to collaborate well for the task to be completed. Projects helped the students understand the content. The class had a "Roman Day" where they dressed up as the members of different assigned social class groups. They had to act and to react to each other in the manner of the social group. One freshman stated, "We really felt the differences between our social classes. I learned more from that than if I took notes from it. It is like different ways of learning here." Another freshman added to the characterization of learning at WSE:

Everyone is so joined together here. Everyone keeps talking about it [the content] and it sticks in your brain. Now we talk about what we learned instead of how bored we are. Here we are always on topic. If you get off topic, you always know that you need to be on topic so you can catch up.

Students felt comfortable using technologies such as CAD, CAM, and film editors, even though technology was not a stand-alone course at WSE. WSE was planning on adding videography as a course, which was being spearheaded by a partner who was a local media producer. The plan was to have a full-time teacher co-teach with the media producer to create real-world experiences for the students. Students articulated that teachers who used these technologies created environments where students took initiatives. One advanced student spoke of taking a level design course and an artificial intelligence programming course while in high school (presumably at the community college). The technologies that were accessed in WSE classes were directly the ones that would be used in the professional field. Students felt that the use of technology had changed the way they could gather information; it sped things up, and gave them

an orderly way to organize lots of information. English class in senior year used the learning management system called Edmodo. The teacher could post assignments, and students could chat, leave messages, and post useful links. Additional information on classroom technologies can be found in the section "Integrated, Innovative Technology Use."

2.2.2.3.5. ***Parent perspectives.*** Parents were pleased that WSE was located on the same campus at Goldsboro High School, primarily because it offered the opportunity for WSE students to play sports. In terms of academics, initially, parents were a little nervous about their children learning at WSE. The parents were surprised by the type of studying their children were doing at home for school. They were not taking notes for lecture and "spitting it out for a test." Instead students were using their computers to find resources to pursue projects. Parents noticed that their children were more responsible for their learning than other children who had attended the traditional school, and that the teachers knew students' personal strengths and weaknesses and balanced the tasks that they asked of the students. After the WSE students scored well on the state tests, the parents realized that this type of learning was valuable. The parents of the students who have graduated WSE and gone on to college reported they were doing fine and thriving.

2.2.2.3.6. ***Challenges***. When asked about challenges faced at WSE, teachers, students, and parents focused on two difficulties: freshmen came in not knowing how to work in groups, and the type of learning found at WSE did not match with the type of learning in college that required taking notes from rapid lecture. WSE attempted to overcome these difficulties by scaffolding instruction for freshmen so that they learned their role as a group member for projects. The teachers at WSE also took freshmen through learning progressions in how to find reliable resources and use time management for long-term projects. In terms of preparation for college, there was not much to be done regarding the fact that college was very much learning how to take notes from rapid lecture. However, a course of action taken by WSE included early college experiences so that students had the opportunity to come back to teachers at WSE to ask for help with their college courses. One teacher stated, "When they meet with me, then they find their feet" when referencing the teachers' ability to help students adjust to the different types of learning in college. Teachers and students regarded the learning that goes on at WSE as being the kind that supports life-long learning. Students viewed college lecture as being another problem they could tackle using the problem-based learning techniques they acquired at WSE.

2.2.2.4. ***Summary.***

Teachers at WSE worked continuously to reform the curriculum. Teachers met formally and informally to develop traditional curriculum into problem-based learning units, often scaffolding this leap by having students work in groups to build skills and knowledge. Although not 100% of the curriculum at WSE was project-based learning, teachers saw value in the reform and were approaching problem-based learning and integrated subject matter when possible. Teachers were also constantly working toward increased rigor so that students were successful in the college courses they took, which could be as early as their 10^{th} grade year. Students saw how working in groups helped them academically, and they saw the real world connections between what they were doing in class and STEM fields, especially in their use of technology. WSE scaffolded the freshmen to learn how to work in groups effectively, and students were proficient at implementing their role in a group by the end of their freshman year. WSE students may have

found difficulties when first transitioning to lecture courses in college, but because they felt empowered to seek help, they engaged their teachers in a timely manner and the teachers helped the students learn how to decipher information from lecture.

2.2.3. Integrated Innovative Technology Use

2.2.3.1. *Definition.*

A definition for this critical component around an integrated, innovative use of technology is provided in Table 2.

2.2.3.2. *Design.*

Technology represented an important facet of the design of WSE. Wayne County Public Schools (WCPS) developed a comprehensive technology plan that outlined the role technology was expected to play in student learning throughout the county, with a vision statement setting forth:

In Wayne County Public Schools, all students and staff will experience continuous academic and personal growth through the effective use of current and emerging technologies, thereby preparing them for life in the 21st Century.

Additionally, WCPS intended for every one of its schools' classrooms to be a "technology-based environment" defined by two primary goals for technology. The first was to make sure all WCPS students were able to use technologies to prepare themselves for future work. The second goal for technology use was that WCPS believed that effective and creative uses of technology would help its schools meet the needs of a wide variety of students. Thus, WCPS's design for technology use was to supplement traditional educational methods while preparing students to use technology after they graduate from high school.

2.2.3.2.1. ***WSE's use of technology***. In alignment with WCPS's technology vision statement, the WSE Student Handbook emphasized technology as an "integral part" of the educational curriculum at WSE, stating:

Wayne County Public Schools Board of Education recognizes that the use of technology resources offers students and staff assets that are vital in becoming productive, informed and future-ready citizens…. Wayne County Public Schools believes that the educational opportunities students receive from accessing the Internet, in the form of information resources and opportunities for communication and collaboration exceed any disadvantages.

Accordingly, the WSE Handbook highlighted the importance of responsible technology use, particularly around the non-school use of social networks, requiring students and parents or guardians to sign a detailed Technology/Internet Acceptable Use Agreement before gaining access to the school's network.

With these responsible use agreements in mind, WSE's Handbook outlined several intended uses for technology resources at the school. For example, according to the Handbook, every teacher maintained an updated website for their classes to help keep students informed about assignments, both in class and out of class, and to provide helpful links to websites and resources

which "extend the classroom beyond the school." Additionally, WSE provided several different types of laboratory facilities for its students, including three computer labs—two of which were equipped with desktop computers and one which was equipped with laptop computers, a drafting lab, and work stations with 25 computers.

WSE also takes part in the North Carolina Virtual Public School (NCVPS) initiative, an online school community that was designed to serve K-12 public school students throughout the state of North Carolina. According to the Handbook, this NCVPS initiative was intended to "provide courses for students who want access to learning opportunities in addition to the course currently offered at their school." These online courses could be taken at school, at home, or in other setting where an Internet connection was present, and the courses were offered free of charge to public school students. WSE thus provided two computer classrooms, staffed by aides where students could complete this NCVPS coursework.

2.2.3.2.2. ***District and community support for technology***. One issue that WSE contended with regarding its design around technology use and innovation was that its district struggled to provide technology resources at the pace that WSE ideally desired. A representative of the school noted that there was not a district-level plan for technology maintenance:

I don't know if we have issues with access points, updating, I sometimes wonder if they will come up with a true renovation plan. They deal with things on a day-to-day basis. The school does best they can with what they have. Teachers wear a lot of hats. They try to make it work with everything. Wish they all had brand new macs but this is the real world and we're in a very rural area.

However, Eastern Carolina University has partnered with WSE to provide iPads and other technology resources to the school, which is described in more detail in the Real-world STEM Partnerships and Administrative Structure critical component narratives.

2.2.3.3. Implementation. On the whole, technology use at WSE was resourceful, though not especially innovative or integrated. Teachers, students, and administration were creative in finding ways to accomplish their goals despite limited technology resources, but most people felt they could be more effective if these resources were more developed. In a statement that captures this dynamic, the principal stated, "Everything's out of warranty, so I'm the technology repair guy. My limited knowledge, I'll take it apart, fix the keyboard, put new keys on them. We just make do." Challenges with old and outdated technology created many problems for teachers, who had to be resourceful to solve them. One teacher noted in a survey:

Our computers are limited and the ones we have do not always work. When I do get to use them, I have to devise class with two separate lessons, objective, and products to allow the other half to work in partners to do the above.

An advanced drafting class experienced challenges with installing the drivers they needed to complete a lesson; students independently contacted technical support to resolve the issue and when technical support was not able to help them, the students were also resourceful in figuring out the source of the problem and fixing it, then teaching other students how to fix it. Thus,

resourcefulness and overcoming challenges was a primary feature of the way technology was used to support teaching and learning.

Despite the limited resources, WSE was ahead of its peer schools in the area. 10th grade students reported that they found the school's technology to be more advanced than peer schools:

Without the school we wouldn't have as much access [to technology]. Other schools have NCVPS. We have that too, but we also have access to online courses as well. Other schools don't have access to WCC. There are Laptops in every room, Promethean boards in most rooms. We've got Wi-Fi here, which other schools don't have. I've heard we may be getting iPads. Were a lot more open to technology in school.

Perhaps this need for resourcefulness drove the necessity for the policies in practice to be more flexible than stated in its technology plan. 10th graders reported:

I wouldn't be allowed a phone at other schools. We're allowed here if it's educational. We're allowed to use our phones in class. Kids with smartphones bring and use them. About 50% of the students have smartphones. If they don't have a smartphone then they have a laptop or iPod. About 80% have technology they bring from home.

As such, the technology use was more flexible and individualized than might have been suggested by the official policy. Observations of classrooms indicated that students used their own technology to supplement official resources. The principal noted:

Some think, oh STEM school, oh technology everywhere. That's not the case. We share a lot and try to make do. I pushed and I got the district to let us do a 'bring your own device' policy. That was official for both teachers and students. To me it makes sense. I've never been one to ask for forgiveness instead of permission. You can't teach kids in hypothetical situation on how to use Internet and all this stuff. What better way than let them use it?

Teachers varied widely in their use and comfort with technology. A few teachers used learning management systems such as Edmodo to host course materials, and others used personal web sites, but there was no school-level consistency. Teachers varied in their use of the Promethean boards as well, and many reported that they struggled with technical difficulties when using the board. The teacher survey results suggested that they felt their use of technology was somewhat hampered by lack of access to professional development and student access to technology at home. However, there was some disagreement as to the students' home Internet access. One teacher reported, "We're not comfortable requiring work at home with a computer. Some students don't have internet." But another disagreed, saying, "Less than 25% have that problem. 25% is pretty generous. Most have Internet. For students without access, you have to give them another option." Teachers also reported that they felt access to hardware and software in school was inadequate, but importantly, that the lack of resources had only a small/limited effect on their ability to provide instruction in STEM. Specifically, as shown in Table 5, teachers reported that their students used computers in the following ways during class time (in order of frequency):

Table 5.
Reported Frequency of Student Computer Use During Class Time

Number of Teachers Reporting Use	Description of Use
12	To organize and store information
12	To create visual displays of data/information (e.g., graphs, charts, maps)
12	To create visual presentations
11	To plan, draft, proofread, revise, and publish written text
11	To create graphics or visuals of non-data products (e.g., diagrams, pictures, figures)
10	To collect data and perform measurements
10	To communicate information as a result of investigations
8	To support individualized learning
7	To manipulate/analyze/interpret data
7	To perform calculations
7	For remediation for basic skills
6	To create models or simulations
6	To compensate for a disability or limitation

Often at WSE, students were independent learners of technology: A 10th grader reported: "They'll tell you to use a technology and ask you to learn it on your own. It helps you to take initiative." Another student confirmed:

[Technology has] changed the way that we learn. Takes less time to search things. We can get things done quickly and orderly. The work that we do comes out a lot better than if we didn't have the technology. Teachers are more open to you communicating with them after school. Ms. Smith [pseudonym for a teacher] *gives you her phone number if you have questions at night. Teachers have email and respond if you have questions.*

At other times teachers stepped in to teach students how to evaluate valid resources:

I have 2 or 3 students attached to the Internet. And are built in the information world and think they know everything. They think everything on the Internet is true even though it's not. It's our job to teach not what is true, but how to handle that.

Additionally, teachers increased student productivity through the use of technology:

Sometimes there are those kids that need technology. If you give them an iPad, they'll go to town on it. I can get them involved. If you're doing group work, the one student who doesn't contribute can be the man on the technology.

2.2.3.4. *Summary.*
At a district level, the use of the technology was a struggle for Wayne County Public Schools due to the rural context. However, WSE was extremely resourceful given limited means to

technology. Resourcefulness and overcoming challenges are unexpected features of the way technology is used to support teaching and learning. The physical laboratory facilities at WSE were also limited, and similar to the computer technology, teachers at WSE still found ways to make learning student-centered. At a district level, the use of the technology is a struggle due to the rural context. Nonetheless, members of the WSE community, teachers, administrators and students alike, work together to share their expertise to create the most effective learning environment possible. The teachers at WSE report that the lack of technological resources does not hamper the educational experiences because they work collaboratively to remedy the gaps left by limited technology.

2.2.4. Blended Formal / Informal Learning Beyond the Typical School Day / Week / Year

2.2.4.1. *Definition.*

A definition for this critical component around blended formal and informal learning is listed in Table 2.

2.2.4.2. *Design*.

WSE set forth clear intentions for informal learning opportunities to play a key role for student learning. As part of its mission statement, WSE listed a set of educational beliefs espoused at the school, and one of the beliefs stated: "Education includes opportunities and experiences beyond the classroom." This focus on informal learning manifested itself in the school's culture for learning through community service and its program offerings.

Students were required to complete a grade-level project for every year that they attended WSE. Grade-level projects were primarily conducted outside of school time and were intended to promote meaningful academic engagement beyond the school day. These grade-level projects were meant to be expanded upon across all four years of attendance at WSE. Additionally, the projects offered students an opportunity to engage with real world organizations and investigate issues about which students were passionate. Each grade-level project was meant to teach the students a different set of skills and enable students to view issues at many different levels of thought. The grade level projects also helped emphasize the value that WSE placed on being contributing members of the community.

WSE's Student Handbook listed several clubs and internal organizations that were available for students to participate in. Aside from several non-STEM-related clubs, such as the Drama Club, the student government organization called the Titan Youth Council, and the Art Club, there were two clubs that were involved in STEM-related activities. The Agricultural Research Club was "for students interested in making a difference in their communities, [focusing on] community volunteerism with an emphasis on local food sustainability." In addition, the Titan Technology Club was for "service minded students… interested in recycling computer equipment for community use and donation." According to the Handbook, students did not have to be proficient in technology in order to participate in the club.

2.2.4.3. *Implementation*.

At WSE, formal/informal learning primarily occurred in two opportunity structures for students to blend in school and out of school experiences: (a) grade level projects, and (b) extra-curricular clubs.

2.2.4.3.1. ***Grade-level projects.*** Students are required to complete a grade-level project for every year that they attend WSE. Grade-level projects are primarily conducted outside of school time which promotes meaningful academic engagement beyond the school day. These grade-level projects are meant to be expanded upon across all four years of attendance at WSE. The projects offer students an opportunity to engage with real world organizations and investigate issues about which students are passionate. Each grade-level project is meant to teach the students a different set of skills, and enable students to view issues at many different levels of thought. Students use the four projects to determine what they may or may not want to study in their higher education pursuits.

The freshman-year project was focused on scholarly research. This project allowed students to research a subject matter of interest to them (STEM or humanities) and then required students to apply it to one of the core curriculum courses. This project was designed to give students necessary researching and writing skills that they could apply to courses they take in the future.

The sophomore-year project was focused on providing the students with an opportunity to engage in community service activities. Students were required to volunteer for 20 hours of community service during the school months. Most students volunteered at either Project Heart (a program in which students tutor other students at WSE, neighboring Goldsboro High School, or other high schools in nearby counties) or at a nearby community garden (where students learn about gardening techniques and food sustainability issues). Additional volunteer opportunities existed based on student resourcefulness. Students also presented their work to nearby community leaders as a way to open the school to its neighbors. At the end of the sophomore-year project, WSE students wrote a paper on social issues that helped them to reflect on their community service experiences.

The junior-year project expanded upon the sophomore year project and asked students to take their community service experience and begin to think globally. Juniors were required to volunteer for 40 hours of community service during the school months. Most students chose to continue volunteering with the organization that they volunteered at during their sophomore year, however they were also free to pick a new organization in which they were interested. At the end of the junior-year project, students were required to complete a research paper on the global issues they discovered in community service. This paper was designed for students to apply the skills they learned in their first-year project and integrate their reflections from their sophomore-year projects.

Finally, the senior-year project was focused on cultivating WSE students' career interests and providing them with real-world work experience. The stated goals of the senior project included: "Develop good work habits," "Experience personal growth," "Strengthen communication skills," and "Gain an awareness of the community's vast resources and the world of work." Seniors were expected to intern at a nearby organization for 60 hours during the school months. WSE students interned at technology companies, medical offices, hospitals, and nearby schools. Seniors were

expected to find the internships themselves; however they could receive some assistance from their guidance counselors or other adults. The senior-year project culminated in a paper in which the students research a potential career and include details about their own experiences.

2.2.4.3.2. ***Extra-curricular clubs*****.** Students at WSE had access to several clubs that include Agricultural Research Club, Art Club, Christian Fellowship Church Club, Drama Club, Titan Technology Club, Titan Youth Council, Wayne School of Engineering Ambassadors, and a FIRST Robotics club, which was a collaborative effort between WSE and the neighboring comprehensive high school, Goldsboro High School. The extra-curricular clubs provided students with additional informal learning activities. Students could join the clubs and acquire additional hands on experience at various STEM-related activities. For example, the robotics club taught its members how to build a robot, including design, electrical work, programming, and manipulating the robot. The first year that the Robotics club existed, the graphic design teacher was the lead sponsor and there were roughly 20 student members. According to the first-year sponsor, "We couldn't even get the robot out of the box," indicating that they needed some assistance with the engineering and physical building aspects of the club. The sponsor invited a parent who was a professional engineer to help with the club, and it launched the club into successfully participating in their first competition. The club increased in membership and during the site visit, the team was reorganizing the leadership responsibilities among the students in response to the large number of current members, roughly 50 students. The facilities for this club have also increased, and the team uses a building shed on the school grounds, but separate from the school building to assemble the robots for competition. Some students who spoke to the researchers during the site visit stated that they used these clubs as a way to get additional help in courses in which they were struggling, such as math. These students stated that during the club meetings, the sponsor, who are faculty and community members, assist students with their formal STEM class studies.

2.2.4.4. ***Summary***.

WSE supported blended informal and formal learning opportunities through its yearly grade-level projects, community service programs, and commitment to extracurricular opportunities. Besides opportunities to participate in a wide range of athletic teams with the co-located comprehensive high school, there were a number of clubs formed by students with a common interest. For example, we observed the first organizational meeting for an Engineering club. Students were selecting their officers, brainstorming what activities, including fund raising they wanted to do that year, and forming committees for these various efforts. The required four years of research, volunteering, and real-world work experience helped to build a cultural standard focused on helping the environment on multiple levels. The grade-level projects also gave students individualized opportunities to build the types of skills that they used in their future academic and professional lives.

2.2.5. Real-World STEM Partnerships

2.2.5.1. ***Definition*****.**

Table 2 provides a definition for this critical component, which focuses on partnerships in which industry or college representatives interact with students.

2.2.5.2. *Design*.

As stated in their Student Handbook, WSE believed that "partnerships with local businesses are extremely important to the success of [their] students." The school viewed these partnerships as elements that added relevance to their instruction and curriculum, which in turn led to a higher motivation for the students to succeed. Accordingly, WSE encouraged their students and teachers alike to interact with local businesses and stakeholders, with the ultimate goal of helping to guide students into a future career choice.

With this in mind, WSE established several partnerships with local businesses and colleges to provide WSE students with additional learning opportunities. Major partners included WCC for early college-level coursework, ECU for tutoring opportunities through the Project Heart program, and the Community Gardens where many students performed community service. The partnership with WCC is discussed in more detail in the section on Early College. ECU was administering the Project Heart tutoring program in the state of North Carolina and WSE was one of the schools participating. A coordinator interacted with students who participated in this program to earn college tuition scholarship money by tutoring at public schools in the district and also continue to earn money tutoring in college. Business partners primarily helped the school develop informal learning practices, typically by providing internship opportunities for WSE students. As described in their Student Handbook, internships were required for all WSE students to complete during the summer leading into and/or during the student's senior year. Not only were students required to complete a mandatory number of internship hours for the graduation requirement, but they also had to "complete a product for the host organization, complete research in the area of the internship, and write reflections about the experience." Local business and community stakeholders that partnered with WSE included the Community Gardens, the local hospital and medical practitioners, industrial businesses, the city government, the nearby Wayne Community College (WCC), and Eastern Carolina University (ECU).

2.2.5.3. *Implementation*.

WSE's real-world STEM partnerships have helped to improve the school's informal learning and early college activities. Many teachers and parents expressed a belief that WSE's partnerships with STEM-oriented organizations led students to embrace the STEM fields, even though they may have indicated an early interest in non-STEM activities. Some students were offered jobs after their initial internship experiences. Furthermore, these partnerships even helped students who may have had poor internship experiences, as they had a more detailed vision as to what they did not want to do in college or other future experiences.

WSE's efforts to establish local partners were embraced by the community. Several external community members indicated that the Wayne County community has rallied around helping WSE. Given that WSE is in a rural community, there were not many science, engineering or technology businesses in the surrounding community that could offer internship opportunities that were more STEM-oriented. Additionally some organizations, concerned with insurance issues when dealing with young interns, could not offer internships. However, several of these organizations were willing to give a presentation at the school or offer their facilities for tours. Because of the lack of STEM-related internships, contacts and social capital, WSE turned to community service and tutoring as the main sources of internship content. Although the internships provided students with character building and general organization and

communication skills, few of the internships offered specific building of STEM skills for students. Principal Gary Hales believed that as WSE's reputation amongst the business community gained more visibility, the school would find an easier time developing partnerships with businesses and local government offices.

Parents of students at WSE wanted to see the school develop an outreach program for internships. They perceived that the guidance counselor was overworked and needed more assistance to provide a diversity of potential internships. Additionally, Goldsboro was a fairly small area and internships that were nearby could be hard to come by. Consequently, some internships were located in distant counties, which created transportation problems for students who wished to intern at these alternative locations. Many students ended up interning at places that are easier to reach, even if they were less interested in the field.

2.2.5.4. *Summary*.

WSE faced several problems leveraging its partnerships with businesses to develop internship programs, primarily due to its location. However the school learned to deal with these problems by partnering with universities and was increasing opportunities for students with each subsequent year. The WSE internship program relied on the surrounding community, which responded positively, and has been successful in providing students with real-world experiences related to community service and tutoring that help inform their life choices.

2.2.6. Early College-Level Coursework

2.2.6.1. *Definition*.

Table 2 provides a definition for this critical component.

2.2.6.2. *Design*.

WSE's graduation requirements included 15 hours of college coursework. Their partnership with Wayne Community College (WCC) was at the core of the early college opportunities for their students, although courses were also available through Lenoir Community College. WSE did not offer many electives, so students took these college-level courses for their high school electives. Tuition fees and textbook fees for these electives were paid for by the state as long as the student was enrolled at WSE. As stated in WSE's Student Handbook in describing their post-secondary partnerships:

We also feel at Wayne School of Engineering that post secondary educational partners are extremely beneficial to our students. While enrolled in WSE, it is our goal that each student will complete at least 15 hours of college course work to meet graduation requirements. This can be done if a student takes one class per semester, including summer sessions. All tuition fees and textbook fees are paid for as long as the student is enrolled at WSE.

There were different WCC programs that WSE students could follow depending on their career interests and preparatory coursework completed: college transfer in the arts, college transfer in the sciences, associate of arts degree, associate of science degree, and associate of applied science. WSE was resourceful in dealing with a lack of space and resources at the school by partnering with WCC to tap into their course offerings as an extension of WSE. As noted earlier,

such curriculum planning was quite personalized for their students. Principal Hales described the goal for these early college experiences:

I want them to finish two years of college if they can before the end. That is our goal for every one of them. Some don't do it. Some get 15 hours of college work, and I would be happy with that. It's whatever they can do is where I want to push them.

Accordingly, at WCC, advanced STEM and non-STEM courses were offered to WSE students that they could attend either face-to-face or online. The college-level STEM courses at WCC were available to those students who took the basic courses in science successfully at WSE. Additionally, if WSE students wanted to pursue engineering, they could enroll in a "2+2" program, in which they graduated with a 2-year associate's degree and then transferred to East Carolina or UNC Charlotte under an admissions arrangement between WCC and these colleges. Under this program, WSE students first took engineering classes taught by a core group of WCC engineering teachers at the high school, and students could then take additional engineering courses through WCC. During the academic year of the school visit for this study, WCC was teaching two such courses at the high school each semester: AutoCAD Drafting and Computer Aided Manufacturing. Additionally, three of the high school courses offered at WSE were associated with articulated credits by WCC. Students who took those courses had the opportunity to earn credit from WCC upon completion.

2.2.6.3. ***Implementation.***

Student course scheduling was personalized at WSE, with college courses prioritized. Students who were taking college courses first obtained the college schedule, and then the WSE scheduling counselor fit the high school classes around the college courses. If the high school level courses did not fit, then students had the opportunity to take the courses online. WSE students generally began college coursework before their senior year, with some as early as 10^{th} grade. WSE students checked in and out of the high school during the day when they went to the college campus, only 2.4 miles from WSE. Some seniors were therefore at the high school for only one class and then took the rest of their personalized curriculum at the college campus or online.

The WSE administration allowed students to enroll in courses at the community college depending on student performance. The Principal personally reviewed each student's report card and made the decision about student readiness for college coursework at WCC

They have to prove they're ready here before we allow them to go over there and take those courses so we look at their report cards, I sign everyone's report card when they're coming out. I look at them and put a little note on there, 'good job' or 'you need to improve this grade' and so I see what they're doing and we give the ones we feel are ready a release form.

Every Friday they [advisors] *do progress reports. So they are always checking on the grades. College kids, we can't check on their grades. They are college kids. But, we have allowed if it goes to the grade report at the end, we might make a decision on them then. But high school kids, we log in, check on their grades, and send home a progress report every Friday. Even the ones not here, we are checking on their grades, and we pull them back if we need to. They know they*

have to maintain, we send a letter home with the parents. Your kid has done well in these classes, we feel they have the opportunity to do this, they can report to school second period, that is, if you allow it. If not, they can come in and sit in the lab, but we try to eliminate babysitting as much as possible.

WSE monitored students' grades on college coursework and "pulled them back" into high school courses and supervised online coursework as described by a school administrator: "Some students aren't ready for the community college scene, so we have to keep them here on our campus to take electives." These students were then given the opportunity to "prove themselves" in the following semester at the high school level.

About 10% of WSE students pursued a five-year associate's degree in engineering and a significant number of others took the courses offered at the high school taught by WCC engineering teachers for dual credit. In addition to engineering, some students took lab-based science classes at WCC, although rarely biology, since it was a state requirement that was associated with a high-stakes exam. WSE recommended that their students take introductory biology, chemistry, and physics at the high school before taking a college level course.

After WSE students completed Integrated Mathematics I/II/III, they had the option to take a college-level mathematics course to satisfy their fourth mathematics requirement. AP Calculus was also an option offered at the high school with the possibility of getting college credit depending on their exam score and the college policy for award of college credit. Some students took all the mathematics courses offered by WSE, and then also took additional mathematics courses at WCC. According to a WSE administrator, most WSE students satisfied their graduation mathematics requirements by the second semester of their sophomore year, because students could take a full mathematics course each semester.

Parents and students both noted the college coursework focus at WSE during the onsite focus groups. For some, this was a major draw: the opportunity to earn college credits that would be transferable to a degree program. Most, if not all, of the other students graduated high school with college credits that ranged from fully transferable to East Carolina University, North Carolina State University, or another North Carolina public university, to dual credit electives that were not applicable to a college degree program. Students could choose to remain at WSE for a 5th year and earn an Associates of Arts or an Associates of Science degree from WCC, and in such cases, the state of North Carolina paid for their books and courses. Thus, the Associates degree was essentially free to students. Those students who chose to do so could begin taking college courses as a freshman and build to taking almost a full day of college courses as juniors and seniors (though only a few take the option of earning an Associates due to student choice, perhaps because college seems so appealing to students, and WCC is perceived more as a high school opportunity). The Principal of WSE predicts that as more students become aware of the financial benefits of this option, there will be more "5th year" seniors who graduate with an Associate's of Arts or Science.

2.2.6.4. *Summary*.

WSE has organized their course offerings strategically by partnering with WCC, and this partnership encourages students to take responsibility for their learning through independent

scheduling. Giving students opportunities to take college courses was a priority for WSE, as evidenced by the requirement of WSE students to take 15 credits in college to fulfill graduation requirements. WSE had limited resources and space to offer many different courses, and in response to these limitations, WSE organized opportunities for students to take college offerings, which opened up a variety of different subjects that would not be taught at a traditional school and increased the rigor of the courses. Because of the variety of classes offered at WCC and the flexibility of WSE scheduling, students' coursework became individualized and built skills that were directly marketable outside of high school (for example, the CAD courses). Taking college courses early with effective support also set up students to have high self-efficacy in their ability to pass college coursework. Students in the focus groups who saw themselves as successfully taking college courses were more willing to continue their work in a 4-year college setting.

2.2.7. Well-Prepared STEM Teaching Staff

2.2.7.1. *Definition.*

A definition for this critical component is listed in Table 2.

2.2.7.2. *Design.*

When describing the qualities he looked for when hiring teachers for his staff, Principal Hales emphasized one particular concept: a willingness to differentiate instruction. Overall, WSE embraced a philosophy of taking in all students who came through their doors and offering the same high level of instruction to each. Principal Hales acknowledged that it was challenging to find teachers who possessed the skills to provide truly differentiated instruction that would foster growth for all students, low achieving and high achieving alike. As a result, by design, WSE hired teachers who had pedagogically open minds, the ability to challenge their preconceived notions about standard teaching practices, and were willing to work toward alignment with WSE's philosophy. The goal that Principal Hales had for all of his teachers was to increase academic rigor for all students to enable them to consistently be at or above standard.

Perhaps because of the reform-minded philosophy at the school, Principal Hales reported that few veteran teachers applied to teach at the school, resulting in the hiring of a staff that, on average, had fewer years of teaching experience. WSE structured numerous professional development and staff collaboration opportunities into its daily and weekly schedules for its teaching staff to counter-balance this effect. For example, one morning each week was dedicated to staff meetings, also called the *tuning process*. As described by an administrator, the staff did "a tuning piece every week, we [did] a reflection piece every week, we [did] a piece on assessment and then we're out on staff development on Thursdays [where] they're sharing what they're doing in their classrooms." The school also aimed to foster staff collaboration through grade level planning sessions and other subject-specific efforts.

WSE was one of North Carolina's STEM high schools and received ongoing support associated with the North Carolina New Schools Project. Some of the benefits provided to teachers through the this project included teacher externships, the support of STEM experts who assisted teachers in co-designing authentic projects, work-based learning activities, and coaching on career awareness and preparation. The overarching goal was to support schools and teachers so that

"schools can provide the tools and space for exploration and invention …that foster a culture of inquiry among students and teachers" (North Carolina New Schools Project, 2013).

2.2.7.3. ***Implementation***.
WSE's hiring process influenced the sense of community experienced at the school. Principal Hales expected all teachers to "buy into" the vision and to have the ability to create a sense of community in their classes and across the school. Consequently, teachers who believed in the mission committed to the school, and teachers who did not fit in with the culture at WSE tended to leave. The culture had been strengthened over time this way, with teachers who were excited by the school's model being motivated to apply and ultimately stay for the long haul. One teacher commented, "I think the staff here has had trouble because you will work harder here than you will anywhere else - this is not a paycheck school. People who sometimes come here don't stay because you have to work hard." As a result of both the common vision among the staff, and the challenging nature of the job, teachers who stayed and invested professionally in the school felt a strong sense of identity as a WSE teacher.

I could never go back to a traditional school - I couldn't go back to teaching that way - I think you see better results this way - there is just something about it that is real and complete - I am educating whole children and not pieces of children and I want them to be in school

Surveys data collected prior to our site-visit indicated that teachers came to know of and ultimately work at WSE through a variety of means including (a) being recruited by the administration, (b) being contacted by friends at the school, (c) applying based on a job advertisement, and (d) specifically seeking out the school based on its reputation. WSE's teachers came to WSE from variety of backgrounds, and with an array of professional and educational experience. As a result, the faculty were encouraged to take advantage of their prior knowledge and experience by teaching what to their strengths, and to bring in real-world experiences and knowledge whenever possible. One teacher noted:

I am a lateral entry teacher seeking a license in drafting. This is the beginning of my second year. For several years, I wanted to become a science teacher since I have a biology degree. I did not expect to be teaching drafting instead of science, but it is what I had been doing for 15 years prior. I love being in the classroom and relating business concepts through visualization to my students. I feel blessed to be a lateral entry teacher in such a rich learning environment. Our faculty constantly collaborates to be the best for our students.

Of the group of teachers responding to the Teacher Survey (N=16), most were between 25-39 years old (80%), White (84%) and female (75%). Teachers had an average of 8.3 years of teaching experience, and 2.9 years of experience at WSE. While all teachers had at least a Bachelor's degree, several teachers had graduate degrees and additional research experience as well.

2.2.7.3.1. ***Training and professional development.*** Many of the teachers at WSE were trained at universities within close geographical proximity (e.g., East Carolina University [ECU], Mount Olive College, UNC-Chapel Hill) although some moved to the area because of their STEM career experience, particular for the engineering courses. Teachers frequently observed their

peers teaching, formally or informally, as part of their own professional development (PD; 80% within the most recent year), and collaborated with teachers from other schools (30%; 20% within the past year). ECU also offered professional development opportunities for teachers to learn additional skills, such as how to use AutoCAD and how to teach robotics classes. Teachers of STEM subjects indicated that they frequently collaborated with STEM and non-STEM teachers for the purposes of identifying ways to integrate content from diverse disciplines. Most (85%) of WSE STEM teachers indicated that they had attended a workshop on STEM teaching within the past 3 years with one-third attending within the current school year. Of the WSE faculty who taught STEM courses, 28% had attended a national or state STEM teacher association meeting within the past 3 years,, 42% reported taking a college course on STEM content within the past 3 years, and 42% had taken a college course on STEM teaching in that time period.

In terms of the effectiveness of their PD, teachers reported that they were most likely to change their teaching practices based on PD that covered engineering principles; inquiry-based teaching strategy; project-based learning; and STEM integration. PD that covered the use of technology for assessment, instruction, or communication was also useful, although this type of PD was reported as more likely to confirm that the teachers were already doing a successful job than to inspire them to change practices.

Overall, teachers were confident in their abilities to perform their job duties (see Table 6). When asked to rate their confidence in performing several activities, they felt most confident in recognizing and responding to student diversity, helping students take responsibility for their own learning, and managing a class of students engaged in hands-on/project-based work. The only areas that teachers felt relatively less confident were in using strategies to specifically encourage participation of females and minorities in STEM, and in involving parents in the STEM education of their student. When asked about what factors the teachers felt contributed to their effectiveness in classroom instruction, they felt that the importance that the school places on STEM and the state and district curriculum frameworks contributed most significantly. Teachers felt that testing policies and practices, and the system of managing instructional resources at the district or school level contributed the least. Teachers felt that they had adequate time to prepare and plan lessons, to work with other teachers, and to pursue professional development.

Table 6

Teacher Self-efficacy

Question - I am confident in my ability to:	Scale 1-5*
Recognize and respond to student diversity	4.60
Help students take responsibility for their own learning	4.53
Manage a class of students engaged in hands-on/project-based work	4.33
Lead a class of students using investigative strategies	4.07
Encourage students' interest in S/T/E/M	4.07
Use strategies that specifically encourage participation of females and minorities in S/T/E/M	3.80
Involve parents in the S/T/E/M education of their students	3.53

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

2.2.7.3.2. *Other support.* Principal Hales was a near constant presence throughout WSE's building, especially in individual classrooms, particularly using frequent class walkthroughs to monitor teaching and to see how students were learning. He explained:

Go into the classroom and in 7 minutes, you can [see] *what you are looking for. Then you reflect on whether they are doing project-based learning. New Schools Network has basically the same type of walkthrough. This is part of the schools' outcome data in that system - another way to measure the outcomes…. The hardest challenge is for traditional thinking teachers* [and] *principals to see the way we learn here. Building the school from the ground up was key in getting the right teachers.*

With this knowledge of in-house teacher performance in mind, WSE developed several methods of collaboration and planning to support its teachers' efforts. Teachers generally felt that they had a considerable amount of time available for collaboration and that their collaborative time had a strong and positive impact on their STEM instruction (see Table 7 and Table 8 for more information). Teachers were encouraged to be collaborative, and their planning time allowed for sharing of ideas and resources. For example, each week a "lesson tuning" session was held, at which WSE's teachers were split into small groups. In each small group, a teacher was selected to share something (e.g. a recent class project) with the group. A teacher explained:

We do a tuning piece every week, we do a reflection piece every week, we do a piece on assessment, and then we're out on staff development on Thursdays. [Teachers are] *sharing what they're doing in their classrooms, they're not being exposed to something new, they're actually sharing something that they've done and want to share with others.*

Table 7
Time for Collaboration

Question – Rate your access to the following resources:	Scale 1-3*
Time available for teachers to plan and prepare lessons	2.85
Time available for teachers to work with other teachers	2.92
Time available for teacher professional development	2.85

*1=no access, 2=limited access, 3=adequate access

Table 8
Value of Collaboration

Question – Rate the effect of your access to the following on your STEM instruction	Scale 1-5*
Time available for teachers to plan and prepare lessons	4.58
Time available for teachers to work with other teachers	4.75
Time available for teacher professional development	4.17

*1 = inhibits effective instruction, 2 = somewhat inhibits effective instruction, 3 = neutral or mixed, 4 = somewhat facilitates effective instruction, 5 = encourages or enables effective instruction

2.2.7.4. *Summary.*

WSE's hiring process was well aligned with the goals and mission of the school and the selection of a philosophically coherent faculty, along with the provision of designated time in the daily schedule, enabled and encouraged its teachers to collaborate effectively and to work toward common goals. Teachers at WSE had a strong sense of mission, and valued the school's STEM orientation. Supported by the system of formally scheduled tuning sessions, teachers worked collaboratively and evaluated each other's practices to facilitate ongoing continued improvement. STEM and non-STEM teachers collaborated seamlessly to produce humanities education that integrated STEM. Many of the teachers took advantage of the professional development offered through North Carolina New Schools and elsewhere, and were likely to change their practices because of these experiences. The teachers at WSE were confident that they were effective in teaching students, and felt they had adequate time to prepare lessons, to work with other teachers, and to improve their practices.

2.2.8. Inclusive STEM Mission

2.2.8.1. *Definition*.

A definition for this critical component is listed in Table 2.

2.2.8.2. Design.

2.2.8.2.1. ***Mission statements***. WSE published separate Mission, Vision, and Belief statements that emphasized their goals of preparing their students for life and careers after high school. While these three statements did not explicitly highlight a focus on teaching STEM, WSE's required coursework demonstrated their commitment to teaching STEM fields, particularly engineering.

WSE's Mission statement was set forth on its website and Student Handbook:

Wayne School of Engineering will provide a caring, supportive environment with rigorous inquiry based academics, focusing on real-world applications to produce citizens ready to achieve success in the 21st century.

During an interview, Principal Hales explained their Mission statement in terms of relationship, rigor, and relevance:

The first part of [the mission statement] is the relationship aspect of the school. I think that is the most important aspect to me. If you got that piece, then it makes the others a little easier. Students want to know you care about them and you have their best interest at heart. But, it's pretty self-explanatory. We want real world based academics more than just the test score. We want students to enjoy what they are doing, see a point to what they are doing, and when those things are connected, the rigor, you can be more rigorous with students and they will accept more of a challenge, if you have the relationship and the relevancy part down.

WSE's Vision statement expressed a similar notion of citizenship and college preparedness:

Wayne School of Engineering students will possess the necessary character traits and academic skills to achieve responsible citizenship, college readiness, and success in the 21st century.

WSE also has a Beliefs statement that anchors the instructional preparations for their students:

We Believe:

- *All students will achieve academically without tracking.*
- *College preparedness is for all students.*
- *Communication through collaboration is vital.*
- *Relevant subject matter breeds global habits of mind.*
- *Education includes opportunities and experiences beyond the classroom.*
- *A nurturing environment enhances the educational experience.*

These beliefs contained inclusive language and expanded on the Mission statement themes of rigor (college preparedness), relationships (collaboration, nurturing environment) and relevance (relevant subject matter, experiences beyond the classroom).

WSE's mission to prepare all of its students for college and beyond was also evident through its fast-track approach to mathematics and science credit accumulation during the first two years of high school, followed by a personalized curriculum planning process to ensure that all students met the 15 hours of college credit requirements for graduation. The Student Handbook described this goal and the means through which they intended to include all students regardless of their own available resources:

We also feel at Wayne School of Engineering that post secondary educational partners are extremely beneficial to our students. While enrolled in WSE, it is our goal that each student will complete at least 15 hours of college course work to meet graduation requirements. This can be done if a student takes one class per semester, including summer sessions. All tuition fees and textbook fees are paid for as long as the student is enrolled at WSE.

2.2.8.2.2. ***Student admissions and lottery description.*** The admissions process at WSE was intentionally designed to be inclusive. As described by Principal Hales, WSE wanted to stay as true as possible to their goal of giving all students a chance to succeed. They wanted to prove that they could "take those lower achieving [students] in middle school and move them to where they need to be." As such, Principal Hales described his student population as being "very close to the same population of any high school," with a mix of students who had discipline issues in 8th grade, students who were high achievers, and those who were in summer school.

As part of their recruitment and application process, early in the school year, teachers visited all of the Wayne County middle schools to present information about WSE and distribute recruitment materials. Eighth grade students from any attendance zone in the county school district could then apply to enroll in WSE by accessing the application form on the WSE website; the application was available each January. The application process required students to complete a handwritten application and to submit two recommendation forms from staff members at their current middle school and a copy of the student's discipline profile and attendance record. Additionally, students with individualized education programs (IEPs) were required to include a copy of it in the application packet.

Until 2011, the WSE admissions committee interviewed all potential students, but the applicant pool became too large. The interview was meant to be informative, with every student applicant interviewed, and it was designed to determine whether or not the applicant was interested in attending WSE and committed to completing the level of STEM work that WSE required of its students. After the interview, students who wished to remain in the pool were then selected by lottery. After 2011, WSE bypassed the interview step, and applicants went straight into the lottery. In 2007, WSE's first year, there were 84 applications, and all were admitted. There were 105 applications in their second year, with all admitted again. The number of applicants increased each succeeding year, and by 2011, WSE had approximately 200 applications for 100 slots, resulting in half of the applicants being admitted by the lottery.

2.2.8.3. *Implementation*.

***2.2.8.3.1. Inclusive environment*.** The statistics in the context section of this case showed that WSE was inclusive and diverse, and reflected the diversity of the Wayne County School District. Parents said that they were attracted to the school because of its smaller class sizes and its STEM focus. All students at WSE were asked to do more and perform at an honors level, and no one was left out of the academic rigor. Parents and students remarked about improvements in students' time management and focus as a result of being engaged with the increased rigor. When asked about the inclusive nature of the school, an 11th grader in a focus group provided some insights:

The school culture is very diverse. There are no bullies; everyone is different…in other schools people follow the cool crowd. Here we're all unique. Here you don't pick on people; we're supportive of other students. We're really close, almost like a family. We even have a doorbell. We're all weird in our own ways, we really connect. Always hugs and smiles. The staff wants us to be friends, and to feel safe at school and wants us to fit in (with lots of groups). No drama, don't bring it in. We need to work with others when at a job, and need to get used to working with others. Here we do a lot of group work and they pair you up with people; that's how we come to be friends. Here you can be friends with people in other grades – that doesn't happen at other schools.

This inclusiveness was furthered by the emphasis on personalization, a major focus of the school's mission. Incoming students were varied in what they have learned and were able to do. They came from middle schools throughout the large rural district, and between 15 and 20% of students were from military families and had attended schools throughout the U.S. and in other countries. WSE worked to personalize each student's academic program and took into account students' prior academic experiences. The curriculum specialist explained:

It's built into everything we do, very personalized. Every kid that goes here is not going to college. However, we try to give options and opportunities. If they want to take college classes, they have to prove themselves, and once they do, we try to do all we can do to push them in that direction…they start taking college classes as early as freshmen, and some of our juniors and seniors, we don't even see. They clock in and out…so this is a lot of freedom.

The nurturing environment was a function of the school's small size and the close relationships among the students, teachers, principal, and school staff. Ninth graders described incidents of caring attention from their teachers and peers, while eleventh graders talked about knowing all the freshmen. Students reported that they felt free to seek help from any teacher, not just a specific teacher of a course they was taking. This was facilitated by the small size of the school and positive relationships among all members of the school community.

The WSE staff estimated that about 10 of the 350 students had some type of special needs and had Individualized Education Plans (IEPs). There was a part-time special education teacher who reported that several WSE students were appropriately transitioned out of special education altogether when they enrolled at WSE. Students with disabilities were able to garner more attention in this small school setting than in a traditional school, and the teachers expected special education students to perform at the same level as the other students with accommodations. An administrator explained, "Teachers design lessons so kids fit well in every group. Students can be successful in every group and they come to see themselves as a successful learner." In addition, the administrator indicated that "the dynamics of the school help" students with disabilities, since it is a small, tightly knit group socially.

2.2.8.3.2. STEM Focus. The STEM focus of WSE's mission was apparent in the coursework required for graduation and the STEM college level coursework at the nearby community college available at no cost for WSE students, Wayne Community College (WCC). The engineering teacher at WCC was a former teacher at WSE, and was a key stakeholder in designing the smooth transition of the WSE students from high school expectations to college expectations. The collaboration between the community college and WSE led to a robust implementation in the engineering content area. This robust implementation was grounded in a symbiotic relationship between WSE and WCC: opportunities for WSE learners to experience community college, and expansion of the pipeline of students from WSE into community college programs, particularly engineering.

As part of WSE's personalized curriculum planning process, students were assessed for their readiness for college-level content and their ability to be self-directed learners. Some students were mature enough to take on the challenges of college science, mathematics, and engineering classes after completing the core high school science, mathematics and engineering coursework. Other students needed transitional support, even for non-STEM college courses, and were scheduled into an online learning center staffed by teachers and tutors. More autonomous learners could take online courses at home. The principal reported the success rate for WSE students who successfully passed WCC courses at 95%.

2.2.8.4. Summary.

WSE's overall mission focused on college preparation that included supporting all students in a rigorous STEM-focused learning environment. WSE articulated this mission in terms of relationship, rigor, and relevance. Students, their parents and teachers, and school staff commented on aspects of a close-knit community of learning which supported students in taking on the challenging honors level curriculum. The small size of the school itself (i.e., 325 students), small classes, and emphasis on group work were cited by students and parents as well as leading to a community where students and teachers fostered positive relationships and where

students felt free to seek academic help from their peers and any teacher in a particular content area, not just their current teacher. WSE implemented their rigorous academic goals through honors-level instruction during the early years of attendance, which led to college-level coursework at the community college. The relevance aspect demonstrated that WSE valued learning that was pertinent to real-world situations, and extended opportunities to learn informally in the community in addition as project based learning opportunities in the classroom. Personalization of each student's curriculum, particularly for the college coursework component, allowed students to choose courses that were of interest, and therefore relevant, to them personally.

2.2.9. Administrative Structure

2.2.9.1. *Definition.*

The definition for this critical component is provided in Table 2.

2.2.9.2. *Design.*

The current principal of WSE, Gary Hales, was involved in the planning, design, and opening of the school in 2007, as part of an effort to improve educational opportunities for students in WCPS's central attendance zone. As described in the Context section of this case study, Principal Hales, at the time an assistant principal at the comprehensive high school, Goldsboro High School (GHS), worked with the district's director for high school education to write a successful application for a planning grant to develop innovative high schools. The administrative structure of WSE is typical of a public school where the Principal is the academic leader, supported by assistant principals, teachers, and counselors.

At the time of the site visit, WSE was situated in two buildings adjacent to the entrance of GHS. One building housed WSE's high school and the other housed the new middle school. WSE and GHS were thus physically connected and shared a library, parking lot, and nearby public space that included athletic facilities. WSE was also located next to a public library and public park, both of which were available for use by the school. The only common student program between GHS and WSE was athletics. Neither students nor teachers from WSE participate in classes at GHS, although Project Heart (a tutoring program) was populated by both WSE students and GHS students. As Gary Hales said, "I had to make a decision really early on that we are going to be autonomous when we built this school." He felt that crossing over would dilute the school culture that was fostered and was concerned about the lack of flexibility with each student's learning needs. Principal Hales remarked that with a crossing over of programs, you get excuses such as "We can't do that because our kids need to go next door to take 'so and so.'" Instead, Principal Hales wanted to create a school with a separate culture, classes, and activities.

The success and design of the school drew some attention, and they consequently served as one of four learning labs for the state of North Carolina. The Assistant Superintendent stated:

We actively sought out different partners. With the response the team got from the community and meeting with the Board of Education, we were chosen as a learning lab and we are one of four in the state. We are very excited and we have had a lot of visits from across the state.

After building up grades 9-12 over the first four years, WSE had just begun a co-located middle school with a sixth grade cohort in September 2012. As Principal Hales described:

I got 150 [applications] in one month from the time I got approval [for the middle school]. I got 150 that quick from people that wanted their kids here. So it speaks volumes that they want an educational change for their kids, which I am happy about. It didn't take long. It was a quick turnaround.

The middle school program also focused on STEM, and provided an introduction to inquiry-based learning. School leaders felt that beginning the WSE mission in middle school would provide two additional years of experience to build skills to learn effectively in the unique learning environment at WSE.

2.2.9.3. *Implementation.*

The central personnel at the school included the principal, the curriculum specialist, and the counselor. Teachers, parents, and students reported that these three people were vital to the positive learning environment created at the school. The principal, Gary Hales, was a near constant presence in the school, and took time to observe the students and teachers. WSE teachers claimed that these impromptu observations were not meant to be evaluative, but rather simply for Mr. Hales to get a sense of the current activities at the school. The teachers and students at WSE repeatedly claimed that Mr. Hales and the administration have created a "family" oriented environment. As Principal Hales described:

It is a fine balance that we want to maintain because people love Goldsboro High School. I think this [WSE] has been a nice addition. We have added a lot of athletic teams they did not have. Our kids play athletics together with the host high school. We make up the soccer team, swim team, and a lot of our kids may not even get the opportunity to play if they just stayed at their traditional schools, but they can come here and play and take part. I think last year I had 321 kids, 128 were in athletics, so that's quite a number that are getting involved in those extracurricular activities.

The curriculum specialist supported the teachers by facilitating the professional development activities throughout the school. She also operated as the spokesperson for the school and took care of the communication between WSE and various partners. The counselor seemed to have a broad presence at the school, being mentioned by teachers, students and staff as an energetic, problem solving force in the school. One 11th grade student described her as "the school mom or president," which was indicative of the close relationships that were fostered at WSE. He said, "she will help fix your schedule, she'll take care of you." He said she's "always on our case about college," and added that she was "much more than just a usual school counselor" because of the personalized help and encouragement she provided.

The school was run by this small and energetic staff. Students, parents, and community members all commented on the extent to which the staff was cooperative, flexible, and responsive. Regarding his role with the student volunteer program, a community partner said:

This is not a one man show here … If I'm busy they can go to a teacher, or the secretary has even called places for them to do volunteer work. We're all in this together; it's a whole staff commitment.

Also commenting on the commitment of the lean staff a parent said, "I wish they had one more leadership position - the leadership at the school is going to work themselves to death."

WSE's ability to give individualized attention to each student relied on the efforts of the teaching staff as well. This close-knit group met every Monday for a professional development activity supporting teachers in developing student-centered curricular materials, particularly refining lesson plans and rubrics. Teachers were grouped in mixed content groups where they could provide interdisciplinary support for each other. Twice a week teachers met with their respective departments to work on assessment and action plans. Teachers also communicated individual student needs to the Principal thus supporting the school's ability to personalize student curricula. For example Mr. Hales explained:

I got a kid in the ninth grade that has already taken geometry. And we have in integrated math III and he's bored and so I told her, to go ahead and give him the exam, give him credit, and put him in pre-calc, so let's move him. So here is a ninth grader that is going to take pre-calculus second semester.

WSE offered only one Advanced Placement course, and Mr. Hales again explained:

The only reason I did that was to give my kids a calculus option that couldn't get it the college. But I don't need AP. My kids are getting college credit. So AP, it doesn't pay me for them to go through this course and hopefully get college credit. I can send them down there to take English, or a Math.

Because of the close relationship with WCC, WSE could maintain the flexible and individualized instruction at a college level without having to spend the resources to create an unbending AP system at WSE. As a stand-alone school, WSE could match its school schedule to the community college's and adjust school hours so that students could choose from a variety of classes offered at both schools.

2.2.9.4. *Summary*.

The success of this specialized school in the center of Goldsboro, NC came from having all the design parts aligned - a small school, run by a communicative and present leader, supported by the district and community. Students felt challenged and supported in their learning, including extensive access to courses at the nearby community college. The staff was small in number, yet managed to create a school environment that was highly organized and responsive to individual student interests and learning needs. Situated within a tense and controversial history, WSE managed to grow in student numbers, expand grade levels, and develop community support.

2.2.10. Supports for Under-Represented Students

2.2.10.1. *Definition*.

Table 2 provides a definition for this critical component.

2.2.10.2. *Design.*
The principal of WSE discussed the design principles behind the founding of the school:

As a part of the North Carolina New Schools project, all schools work on redefining professionalism, readiness for college, and reaching under-represented students, rather than focusing on students who can succeed by reading a book in a closet and come out and pass any test that you give them.

The principal wrote the initial grant as part of a small schools movement; he believed that once you get too big, students are lost. An Assistant Superintendent described how she helped conceived the school:

As curriculum and instruction leader, I get to go to a lot of training. It's basically from the 1970s, you learn by doing. Teachers have always been taught "hands-on." I went with the New Schools Project, I heard about schools that had personalized education, where teachers were facilitators. Teachers did a bit of tutoring, but the majority of their week was in the workplace. I knew in my heart that is how children learn. I came back and told my school district and they said "What? You want to do what?" Then you send (colleagues) to the seminars so they can learn. People come to think: we do need to do this. You plant a seed and it will grow.

Small schools allow personalization, a major theme of WSE. Each student is known as an individual, and the student's classes and activities are planned around that knowledge and the maturing student's evolving abilities, interests and needs. Consequently, access to the school's resources in advanced coursework depends on the student's progress. This requires that all of the educators at WSE know their students well and work together to garner supports and resources allowing them to be flexible in helping students to find opportunities in this rural, dispersed and generally non-affluent community. Because resources are not plentiful, support for students comes first and the school's bureaucracy is of lesser importance.

Although the principal saw the student population as reflecting "the luck of the draw," students self-selected to attend WSE because of its reputation for rigor in the school district. The goal was to treat each student like an honors student in their first years, and then move them to college level work in their last two years. All of the classes were supposed to be taught at the honors level at WSE. The principal elaborated:

*I remember honor rolls in other schools…the same kids earning honors all the time. It didn't encourage anyone (*new*) to go up there…the same kids were always rewarded in schools, the ones that followed the rules and conformed. Here, it's not about being valedictorian or salutatorian. We ask kids, who wants to speak at graduation? I thought our girl last year* [who made a video about the school mission] *gave the best speech. She went up there, no notes, and nailed it.*

Supports for students in general took the form of tutoring when needed, college advising, helping students gain access to courses at the community college or to other opportunities for leadership

and growth in the community, and a school culture that has been built to be supportive, nurturing, and tolerant. WSE believed that "college preparedness is for all students" and put together several systems in its design to support that belief. Most of the school's teachers stayed after school two days a week and provided tutoring for struggling students. Moreover, WSE had a strong partnership with the organization "Project Heart." Project Heart was a local organization where students could volunteer to tutor other students at WSE and other schools in Wayne County. This partnership was intended to provide community service as well as building self-efficacy of learning for the peer tutors.

2.2.10.3. ***Implementation.***

2.2.10.3.1. ***Special Supports*****.** Tutoring seemed to be a major aspect of the WSE support program. It was used to help students who needed extra support and provided an additional aspect of personalization. The staff saw this a part of their jobs and were willing to work with students who needed extra help staying after school or meet with students before school. When asked what happened if a student is in danger of failing a class, a WSE educator replied:

They (students) either come in for tutoring after school or they take it again - the relationship piece they can go to any of the teachers, they feel comfortable approaching any of the teachers, they have the comfort with going with any one - even the substitutes jump in and try to help the students.

What was remarkable was that there seemed to be little stigma attached to needing a tutor—rather it was regarded as natural. This was especially true for the mathematics program where there was a high frequency of students requiring extra help to succeed. One parent commented:

I don't know where it is coming from, but the kids are able to learn…my daughter has been tutored massively with her math teacher. It is an easy thing to get in the math program. The one on one tutoring has been fantastic. Teachers get here early and stay late and they help the students a lot. Many of these teachers are really good. It is a shorter school day than a traditional school [so they are able to help more].

In addition, students could tutor one another or work in groups for projects. The electronic communication system facilitated these collaborations.

2.2.10.3.2. ***Advising and Counseling***. In a school that relied strongly on using community resources to advance its STEM program for students under-represented in science, advising and counseling was crucial. Although the counselor was a key person in this process, the teachers also took on important roles in advising and counseling. A community activist described the roles of WSE teachers by saying:

Teachers privately help students from struggling families. These students are connected to their teachers, and vice versa. They care about each other's lives. They know their names, they know their families, who they are, where they are from, and what they want to do…At WSE, it doesn't matter how much money you have or how advantageous your life may be. You have the opportunity to succeed at WSE. You have the same resources. ...Everyone gets to use them.

There was a weekly advisory period for students assigned to one teacher for just this purpose. In the first years of the school, the advisory cut across grade levels, but currently the staff found it preferable to keep students in the same grade together so that they could tailor the discussions to student progress through WSE, and then outside the school to access community resources. Each advisory meeting consisted of one teacher and approximately 15 students, and the students were given individual attention to support each in being academically successful. College admissions advising was also an important focus for older students. The advisories also allowed time for character education, team building activities, a look at what was happening in the students' world, and how to improve the school. The site coordinator described how this occurs:

Once a month we have an assembly where we all pull everyone together and have a mini-celebration about grades, about discipline. We use that time to recognize if someone gets a scholarship, or if something good happens to one of our teachers… In everything that we do here, we're trying to get kids college ready. The freedoms and the opportunities that we give them from the time they walk in the door are getting them ready for college. We really push them academically…we're always trying to find internship opportunities; we've got kids in the dentist office, a kid that's written a book…We really encourage our teachers to think out of the box with these kids.

In addition, the guidance counselor at the school who was regarded as a "real guidance counselor" according to the students and "a wonderful instrument for our school" according to the teachers. She was lauded by students, parent and teachers alike for her work with students. One 11th grader described her work:

What if you need extra help? Go to the school counselor, she's like the school mom or president. She will help fix your schedule, will take care of you. She …gives you opportunities to shine in the school. She's very easy to talk to, about personal problems, school problems--gives great advice. She is much more than just a usual school counselor, always on our case about college, like if I get a B. For college, she asks you what you want to do, then helps you make a plan, gives feedback. The school customizes your schedule. The counselor will say, 'here's the best schools for what you want to study, and we'll get you there.' I said I wanted to play football, so she gave me a list of schools and requirements. Now I have a checklist.

2.2.10.3.3. *External Resources*. The school took advantage of resources within the community for educational opportunities, but it was clear that the individuals involved also offered emotional support and opportunities to develop students' leadership skills. For instance, Project Heart was a federally funded program that paid low-income high school students to tutor students at other schools. Most of the Project Heart volunteers taught younger students, but some were beginning to work with peers at the struggling comprehensive school on the same campus as WSE. The community organizer for Project Heart described the process:

The curriculum specialist wanted students engaged in community service. It is a game changer for students. Most of the students who come to Project Heart are at the top of their grades and class, and some of them have never known what it means to struggle and some know all too well. And some of them are so focused on having to take this class and that class, and they never have

the opportunity to pause and see that there's a world out there, and an impact that they can make. Through the community service projects that I've seen these kids plan and execute, it's amazing to watch them grow, the real leadership skills, not just the things they get in a classroom. What they actually see when they step outside that door.

2.2.10.4. *Summary*

When thinking about supports for under-represented students in STEM focused schools, it is easy to suppose that there are discrete programs or persons assigned the tasks. However, at WSE, the school was designed to support the kinds of students that it attracted to its STEM program and to focus on college readiness and college credit accumulation. The supports seemed woven into the fabric of the school and involved all of the students and staff. There was a constant search for enriching resources outside of this very economically pressed school. Some support programs, like a summer bridge program for incoming freshman, had to be cut due to a lack of financial support. One teacher pointed out that while she liked to hear the praise from the community and school district about how much WSE was able to do with so little, she would have liked the amount of financial support increased to reduce the burden and expand the opportunities for students at WSE.

2.3. EMERGENT THEME

2.3.1. *School-wide Norms - Support and Close Relationships*

The 10 previously identified critical components help to describe the ways in which WSE operates and has accomplished its many successes, however this case study was conducted in such a way to allow for identification of an additional emergent theme that supplements the 10 critical components and provide a fuller picture of WSE. While the 10 previously identified critical components are able to characterize a great deal of the ways in which the school functions, one emergent theme provides additional information about the ways that WSE fosters success, the school-wide norm of community. The sense that WSE fosters close relationships has been discussed in other critical components, but is such an outstanding characteristic of WSE, it merits a separate discussion here.

The mission drives the sense of community at WSE and the principal perceives the first part of the mission statement "WSE will provide a caring supportive environment" as "the most important aspect. If you got that piece, then it makes the others a little easier [to be successful at WSE]. Students want to know you care about them and you have their best interest at heart." Principal Hales believes that "we want to transfer that caring relationship of kids volunteering down to the community. So if we provide a caring for the environment here, they are out taking that same stance out in the community assisting others."

The nurturing environment and sense of community at WSE is generated by the school's small size and the close relationships of the students, teachers, and the principal. Parents also indicated that the small class size contributed to their and their children's choice to apply to WSE, as well as student success in the coursework. Students reported that they feel free to seek help from any teacher, not just their current instructors. There is a sense of identity at the school and the students and teachers seem proud of this identify as "the engineering school." Part of this identity is their reputation for rigor, but the increased expectations are not exclusive of a caring

environment. A member of the New Schools Project further explained the importance of the compassionate environment that also embraces work ethic and rigor at WSE.

I do know that teachers here privately help some kids who have struggling families. These students are connected to their teachers, and vice versa. They care about each other's lives. It's a completely different school than I'm used to. They know their names, they know their families, who they are, where they're from, what they want to do. I work with a lot of different schools all over NC, and I've never been in a school – one other – where teachers and students were as invested in each other and the learning process. That other school was a small country school, not a magnet school, regular public school. I think it's something about the community. I have that in all of the counties that I work in. The children who end up applying to be a part of Project Heart on some level or another have either been helped by someone or have been in a position where they've been taught that helping people is a good thing. And so they learn, and they see, and they want to do it too. They connect with this idea, and they start doing it. With different groups, organizations, church groups that have volunteering, there's an attitude of "I like helping people, I want to help people." And it's a positive thing.

A community partner describes the sense that students at this school see WSE as something more than a high school; the students see the school as an opportunity to progress.
This school has a "clientele" that is different – "they want to be there, they want something different, they want something that is outside the normal middle school box." So yes, they are self starters. "They are a completely different population of students from your typical middle school student." They come from all over the county, and are not different in profile, not elective academically, but academically they are more motivated.

The small school size facilitates an flexible and individualized atmosphere where there is a palatable sense that WSE is something more than a typical school, but it is the people that deliberately, but not superficially, build the community that helps students see that they can make a difference in the world. This identity seems to give the students agency and creates awareness that they are part of something special where they can work to make their future dreams a reality.

2.3. OUTCOMES

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). Having explored the design and implementation components in the above sections, the study now examines the student outcomes produced at WSE. To capture this student outcome information for WSE, OSPrI compiled data on near-term outcomes such as demographics, attendance rates, and assessment scores from state databases. The study also gathered information on longer-term outcomes such as high school graduation rates.

2.3.1. Inclusive Demographics: Who is WSE serving?

The application process was designed to foster an inclusive student body, requiring students to submit recommendation forms, a discipline profile, and an attendance profile, and then selecting

students via a lottery system. Table 9 displays the demographic data from 2011-2012 for WSE, the neighboring comprehensive Goldsboro High School, Wayne County Public Schools, and the state of North Carolina. The racial diversity of WSE's student body did roughly reflect that of the county, with over 50% of WSE's students identifying as Hispanic, Black, or Two or More Races. However, the Free or Reduced Price Lunch (FRPL) population was notably lower at WSE than at Wayne County Public Schools overall, with 44% of WSE's students in 2011-2012 qualifying for FRPL status compared to over 66% in the county.

It is also worth noting the stark differences in student demographics between WSE and Goldsboro High School. Despite the close proximity of the two schools, Goldsboro High School's student body was predominantly African American, with over 90% identifying as Black for 2011-2012. By contrast, slightly more than 30% of WSE's student body was African American, although the school did serve higher percentages of students of Hispanic and Two or More Race descent. As with the county, though, WSE's FRPL population was much lower than that of Goldsboro High School, particularly in 2011-2012 where Goldsboro's FRPL rate was 97%.

Table 9
2011-2012 Demographics Comparing WSE, Comprehensive High School, County, and State

	WSE	Goldsboro High School	Wayne County Public Schools	North Carolina
Students Served	325	540	19,315	1,475,200
Grade Levels	9-12	9-12	K-12	K-12
American Indian (%)	0.0	0.0	0.2	1.4
Asian (%)	0.6	0.0	1.0	2.5
Hispanic (%)	6.8	2.8	17.0	13.3
Black (%)	30.8	92.2	34.5	26.3
White (%)	47.4	0.9	41.3	52.7
Two or More Races (%)	14.5	4.1	5.8	3.7
Pacific Islander (%)	0.0	0.0	0.1	0.1
Male (%)	52.9	48.9	51.5	51.2
Female (%)	47.1	51.1	48.5	48.8
Free or Reduced Price Lunch (%)	44.4	96.9	66.3	56.0

Note: Data obtained from "Grade, Race, Sex 2011-2012" and "Free & Reduced Meals Application Data 2011-2012" from Public Schools of North Carolina Financial & Business Services website (retrieved from http://www.ncpublicschools.org/fbs/accounting/data/ and http://www.ncpublicschools.org/fbs/ resources/data/ on January 4, 2013).

2.3.2. 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). Table 10 shows the attendance rates, defined by North Carolina's education department as the "average percentage of students who attend school daily," for WSE, Goldsboro High School, the county, and the state for 2011-2012. WSE's attendance rates for 2011-12was significantly

higher than those for Goldsboro High School. For example, an average of 6 or 7 students out of 325 were absent each day at WSE, whereas an average of 37 or 38 students out of 540 were absent each day at Goldsboro High School. WSE also compared well with the county and state attendance rates, although it should be noted that the county and state numbers encompass all grades, not just the high school grades.

Table 10
2011-2012 Attendance Rates Comparing WSE, Comprehensive High School, County, and State

	WSE	Goldsboro High School	Wayne County Public Schools	North Carolina
Attendance Rate (%)	98	93	95	95

Note: Data obtained from "Education First NC School Report Cards" from North Carolina Education First website (retrieved from http://www.ncreportcards.org/src/ on October 31, 2012).

2.3.3. Assessment Scores: How are WSE Students Progressing and Achieving Academically?

The North Carolina State Board of Education developed the state's "ABCs of Public Education" school accountability program in the 1990s, with a focus on "strong **A**ccountability, teaching the **B**asics with an emphasis on high educational standards, and maximum local **C**ontrol" (Growth and Performance of North Carolina Public Schools, 2012"). This ABCs program was expanded in 2002 to incorporate the federal accountability requirements of the No Child Left Behind Act (NCLB). As part of the state's compliance with these requirements, North Carolina high school students take the North Carolina End-of-Course Tests (EOCs), which are used to assess the students' mastery of the material in those particular content areas. The state also uses these EOC results along with other outcome components to assess each school's growth and performance for accountability purposes.

In 2011-2012, high school students enrolled in the following courses were required to take the North Carolina EOC tests: Algebra I, English I, and Biology. In previous years, North Carolina students were also required to take EOCs in other subjects as part of the ABCs accountability program, including Chemistry, Physics, Geometry, Algebra II, Civics and Economics, Physical Science, and U.S. History, along with a Writing assessment that was administered in Grade 10. However, at various points between 2009 and 2011, these assessments were removed from the North Carolina testing program. The majority of the EOC tests were eliminated due to federal bills eliminating funding for state-administered tests not currently required by federal law or as a condition of federal grants. On the other hand, the Geometry EOC assessment was removed by the North Carolina State Board of Education for the 2010-2011 school year to facilitate a transition to a new mathematics curriculum, with new assessments for the new curriculum anticipated for the 2012-2013 school year. Additionally, the Grade 10 Writing assessment was removed with approval from the U.S. Department of Education because the English I EOC assessment was deemed sufficient to meet the NCLB requirements for high school reading and language arts.

For the EOC assessments that remain in the North Carolina testing program for high school students, Algebra I, English I, and Biology, all measures indicated that WSE students performed at a very high level. Student performance on the EOCs is reported in achievement levels ranging from I to IV. Level III is defined as "Students performing at this level consistently demonstrate mastery of this subject matter and skills and are well prepared for the next grade level or for a more advanced level in this subject area", and Level IV is defined as "Students performing at this level consistently perform in a superior manner clearly beyond that required to be proficient in this grade level or subject matter and are very well prepared for the next grade level or for a more advanced level in the subject area." Students are considered to be at or above grade level if they receive a score of Achievement Level III or IV on the EOC tests. Figure 1 shows the percentage of students achieving at or above grade level on the 2011-2012 EOC assessments for WSE, Goldsboro High School, the county, and the state. Higher percentages of WSE students passed the EOC assessments than at Goldsboro High School, county, or state in all subjects, with a notable difference in the Biology and English I assessments.

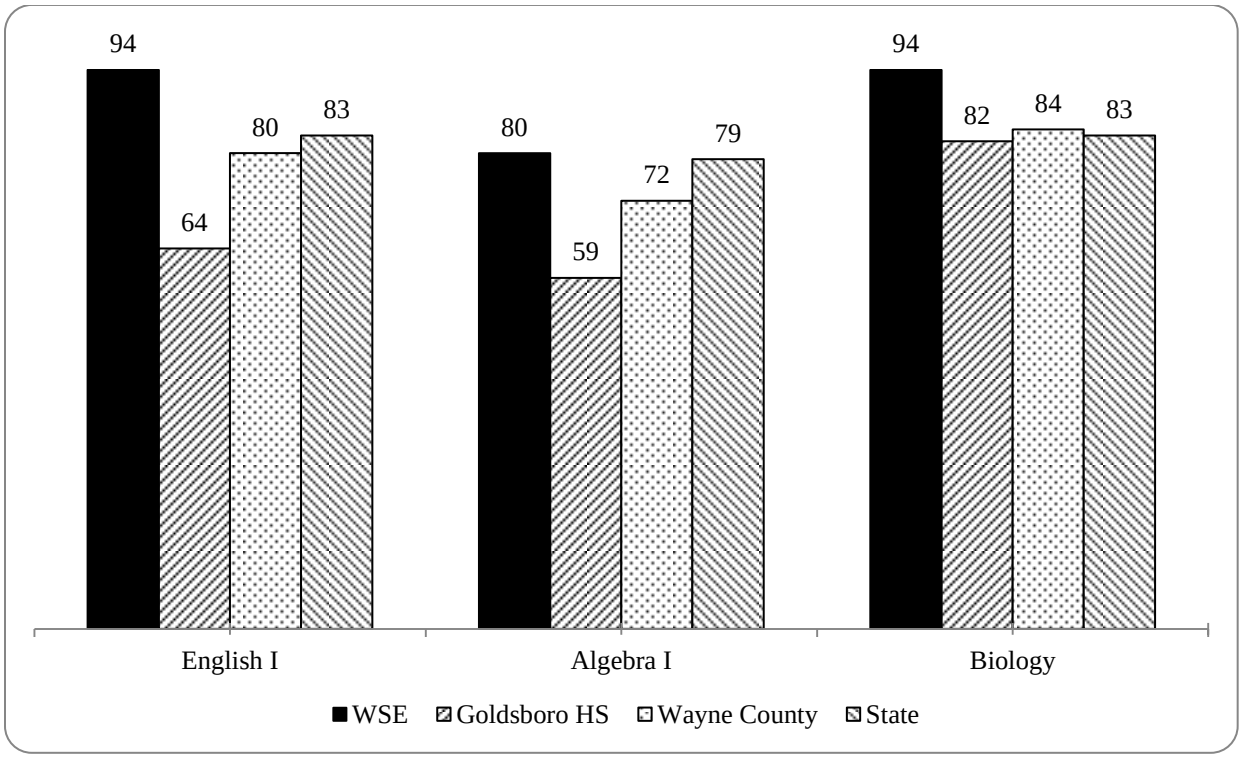


Figure 1
2011-2012 ABCs End-of-Course Test Results for WSE, Comprehensive High School, County, and State (Percent at or above grade level, for all grades tested)

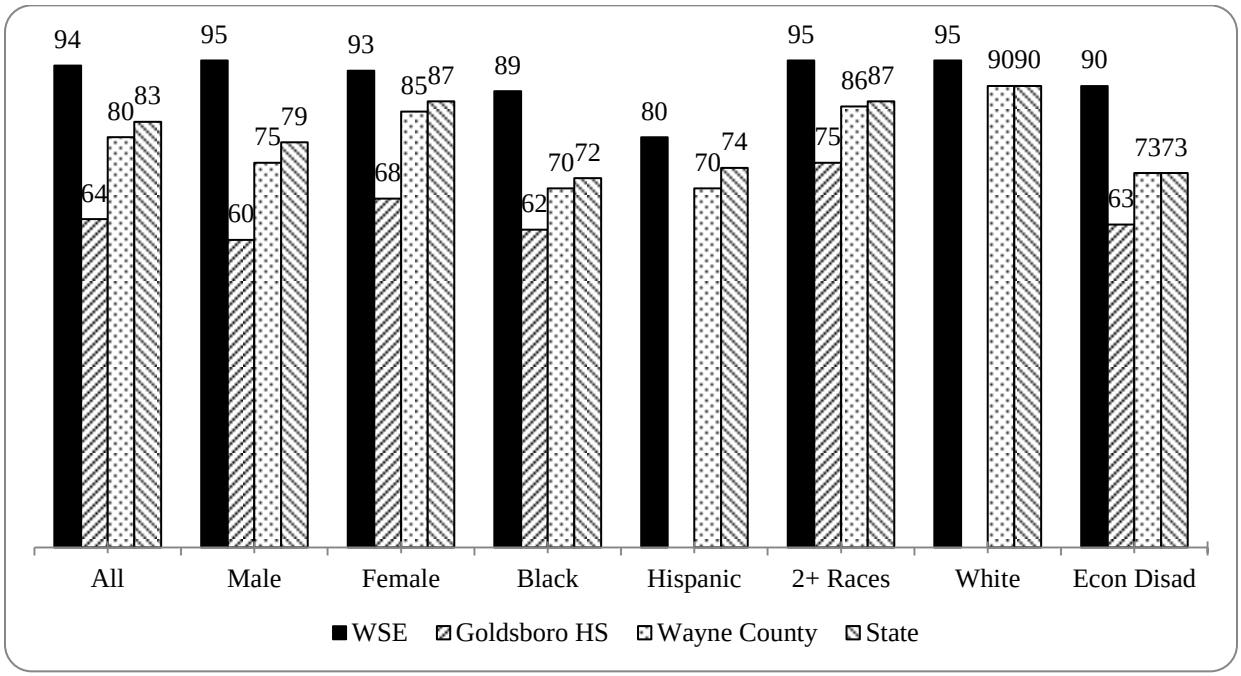
Note: Data obtained from "Education First NC School Report Cards" from North Carolina Education First website (retrieved from http://www.ncreportcards.org/src/ on October 31, 2012).

A more detailed look at how each student demographic subgroup performed on the EOC assessments confirms the positive outcomes for students at WSE. Figures 2, 3, and 4 show the

percentage of students achieving at or above grade level on English I, Algebra I, and Biology EOC assessments respectively for 2011-2012, disaggregated by gender, ethnicity, and economic condition. Omitted bars represent subgroups where that particular student population was too small for North Carolina Public Schools to report the value. Generally, across all three subjects, WSE outperformed the comprehensive high school, county, and state in each demographic subgroup, most notably with their economically disadvantaged students, Black students, and female students.

Figure 2

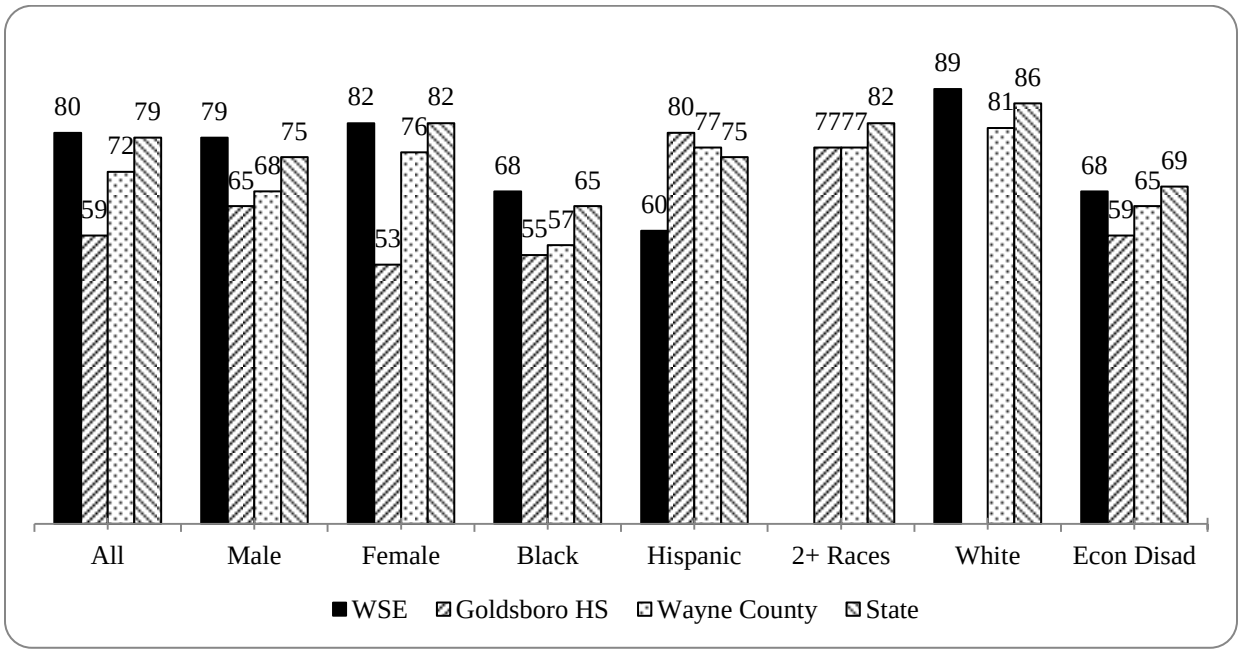
2011-2012 English I End-of-Course Test Results for WSE, Comprehensive High School, County, and State (Percent at or above grade level, for all grades tested, disaggregated by gender, ethnicity, and economic condition)



Note: Data obtained from "Reports of Disaggregated State, School System (LEA) and School Performance Data for 2010 - 2012" from North Carolina Public Schools Accountability Services Division website (retrieved from http://www.ncpublicschools.org/accountability/reporting/leaperformancearchive/ on January 4, 2013).

Figure 3

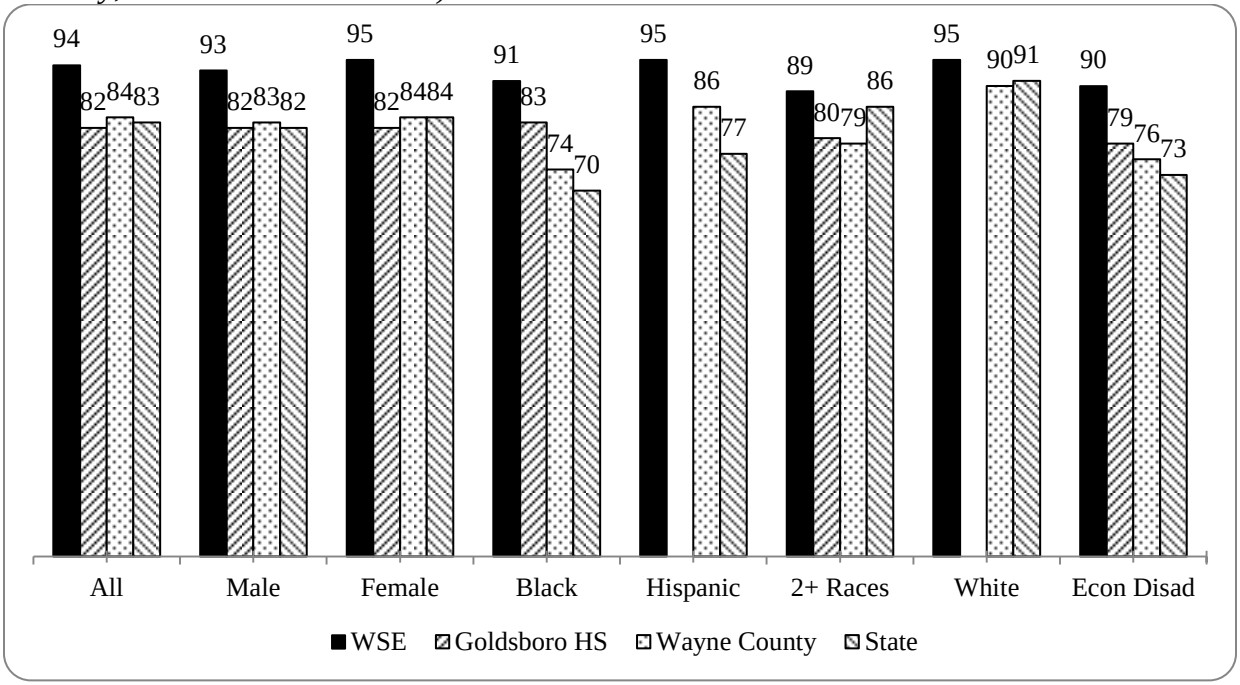
2011-2012 Algebra I End-of-Course Test Results for WSE, Comprehensive High School, County, and State (Percent at or above grade level, for all grades tested, disaggregated by gender, ethnicity, and economic condition)



Note: Data obtained from "Reports of Disaggregated State, School System (LEA) and School Performance Data for 2010 - 2012" from North Carolina Public Schools Accountability Services Division website (retrieved from http://www.ncpublicschools.org/accountability/reporting/leaperformancearchive/ on January 4, 2013).

Figure 4

2011-2012 Biology End-of-Course Test Results for WSE, Comprehensive High School, County, and State (Percent at or above grade level, for all grades tested, disaggregated by gender, ethnicity, and economic condition)



Note: Data obtained from "Reports of Disaggregated State, School System (LEA) and School Performance Data for 2010 - 2012" from North Carolina Public Schools Accountability Services Division website (retrieved from http://www.ncpublicschools.org/accountability/reporting/leaperformancearchive/ on January 4, 2013).

Some may argue that "academic excellence" requires more than achieving "at grade level" and being "well prepared for the next grade level," as Achievement Level III is defined by North Carolina Public Schools. Figure 5 addresses this concern by showing that a significant percentage of WSE students also achieved at the Level IV benchmark for all of the subjects tested in 2011-2012, performing at a "superior" level and proving "very well prepared" for more advanced work. Omitted bars again represent subgroups where that particular student population was too small for North Carolina Public Schools to report the value.

Generally, WSE compared favorably with Goldsboro High School, the county, and the state for each demographic subgroup, particularly with their economically disadvantaged students and Black students. However, it is notable that a lower percentage of female students attained Achievement Level IV at WSE than in the county and state overall; it appears that a larger proportion of female students at WSE achieved at grade level (Achievement Level III) than for their other subgroups.

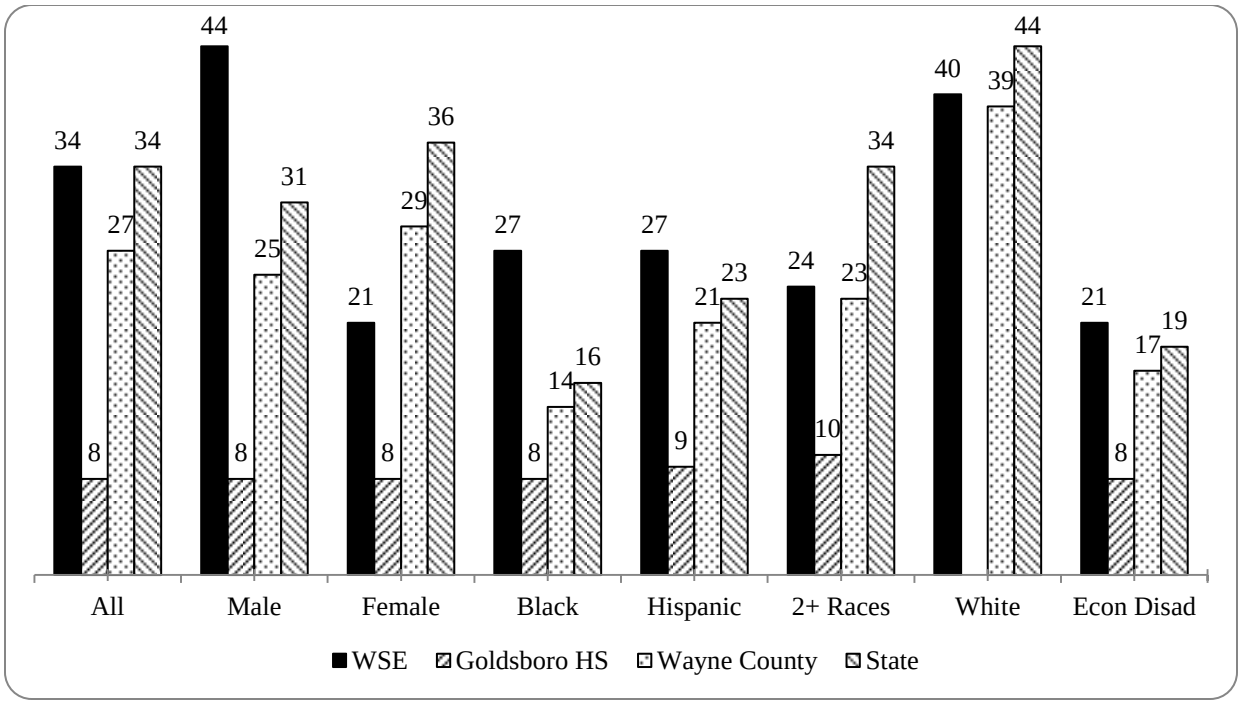


Figure 5

2011-2012 ABCs End-of-Course Test Results for WSE, Comprehensive High School, County, and State (Percent at Level IV "superior achievement," for all grades and subjects tested, disaggregated by gender, ethnicity, and economic condition)

Note: Data obtained from "Education First NC School Report Cards" from North Carolina Education First website (retrieved from http://www.ncreportcards.org/src/ on October 31, 2012).

2.3.4. High School Graduation: Longer-Term Outcomes.

Table 11 compares the high school cohort graduation rates for WSE, Goldsboro High School, the county, and the state. Overall, WSE graduated a higher percentage of its students than all three comparable groups, most notably for their economically disadvantaged students, of which they graduate over 95%. WSE also graduated over 95% of their Hispanic and Black students, compared to rates in the mid-70s for Goldsboro, Wayne County, and North Carolina.

Table 11
2011-2012 Cohort graduation rates for WSE, Comprehensive High School, County, and State

	WSE	Goldsboro High School	Wayne County Public Schools	North Carolina
All Students (%)	97.4	68.5	80.1	80.4
American Indian (%)	n/a	n/a	85.7	73.7
Asian (%)	n/a	n/a	81.8	87.5
Hispanic (%)	> 95	n/a	76.5	73.0
Black (%)	> 95	70.3	76.0	74.7
White (%)	90.6	20.0	84.0	84.7
Two or More Races (%)	92.9	n/a	81.9	80.6
Pacific Islander (%)	n/a	n/a	n/a	n/a
Economically Disadvantaged (%)	> 95	78.6	77.7	74.7

Note: Data obtained from "Education First NC School Report Cards" from North Carolina Education First website (retrieved from http://www.ncreportcards.org/src/ on October 31, 2012). WSE's cohort graduation rate was revised from 94.7% to 97.4% and accepted by North Carolina Public Schools because the state recognizes 5th year students as cohort graduates.

2.3.5. Summary.

The student demographics at WSE roughly reflected the racial and ethnic composition of the populations of Wayne County Public Schools and North Carolina overall, but it is evident that WSE served a significantly lower population of FRPL students than the neighboring comprehensive high school, the county, and the state. Whereas Goldsboro High School served a predominantly African American student body with FRPL rates over 90%, WSE's FRPL rates ranged between 40 and 50%. Nevertheless, an analysis of the disaggregated student outcomes on the North Carolina EOC assessments demonstrates that the economically disadvantaged, African American, Hispanic, and female students that did attend WSE – populations that have traditionally been under-represented in STEM fields – did very well academically. Higher percentages of students in each subgroup performed at or above grade level on the EOC assessments at WSE than at Goldsboro High School, the county, or the state, particularly in the Biology and English I assessments. WSE also compared favorably with the county and the state in terms of the percentages of students achieving at the "superior" Level IV benchmark, although WSE did lag behind with their female students. The cohort high school graduate rates were also significantly higher at WSE than at Goldsboro, the county, or the state, across all demographic subgroups, which is perhaps not surprising given their high attendance rates and student outcomes on the EOC assessments.

It is worth emphasizing, however, that this OSPrI study is not presenting these student outcome data as causal evidence that WSE'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.

2.4. DISCUSSION

Wayne School of Engineering can be characterized as a rural inclusive STEM school that provides a quality, personalized education by capitalizing on the available resources. Similar to other rural schools discussed in educational literature, WSE is composed of a tightly knit community of students, teachers, administrators, parents, and partners (Hardre, 2007; Howley, 2009; Woodrum, 2009). WSE is more than an institution of learning; WSE provides a sense of place that coalesces student pride. Students and parents are aware that WSE provides opportunities that are not found in the surrounding schools, and they sense that they are in a special, caring place that encourages students to persevere in the face of limited resources (Coleman, 1988; Crockett et al., 2000; Elder & Conger, 2000). The community of WSE works together to continue to improve their academic experience through grant writing, bringing in guest speakers, seeking out volunteer opportunities for all students (Faircloth, 2009; Woodrum, 2009), and perhaps most importantly, helping each other to learn, no matter if you are a student, teacher or administrator (Ballou & Podgursky, 1995).

WSE overcomes other barriers such as having a small modest physical facility and teachers who are teaching at capacity by matching their schedule to the local community college (NCES, 2009). In doing so, WSE is able to extend its course offerings to those of the community college, and in turn, upgrading the rigor of their high school classes for smooth student transition to college (Provasnik et al., 2007). Since the college provides a variety of classes (e.g., arts, humanities, and drafting) and vertical articulation of classes (offering advanced courses in biology, chemistry, earth science, mathematics, engineering and physics), students can use their junior and senior years at WSE to take coursework beyond the limits of traditional high schools and individualize their educational experiences (Williams & Nierengarten, 2011). Taking courses at the college level when still in high school not only increases the rigor, variety, and personalization of the instruction, it also builds student self-efficacy towards successful completion of college coursework (Provasnik et al.). The freshman and sophomore WSE courses are taught with students at the center and encourage a great deal of student responsibility for learning, sometimes using inquiry and problem-based learning. This results in a smooth transition to college-level courses.

Additionally, WSE builds in required extracurricular research projects that help students see the relevance of their in class learning, build 21st Century skills, and connect to partners outside of the school. The class-level projects serve many roles in extending academics at WSE and leveraging partnerships. First, the projects integrate traditional school learning in classrooms with applications in the world outside of school. Factual knowledge learned in the classroom is used in a meaningful way during the class-level projects. Students are expected to explore their community and find a place within that community in order to complete the project. This connects the school to the community and the community members to the school. The projects are also designed to build on prior knowledge. In this way, students see the reason for learning factual knowledge, and the process of completing each project provides opportunities to synthesize this knowledge. There is an expectation that the projects are done outside of class, which demonstrates to the students that learning is life-long and happens constantly. Lastly, the projects are intended to cohesively stretch across four years, demonstrating to students that learning is not accomplished instantaneously.

Wayne School of Engineering is an excellent example of a school that utilizes the community, both within and outside of the school, to accomplish the goal of higher expectations of academics. The students test scores on end of course exams (Biology, Algebra I, and English) are higher than surrounding schools, the district as a whole, and the state, even though many other schools in the state have more resources. Faced with limited budgetary, technological, and logistical resources, WSE administrators, teachers, and students work collectively to overcome these barriers and provide high quality education by finding ways to blur the lines of traditional secondary schools.

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