S.T.E.M., at one time, was simply an acronym for Science, Technology, Engineering, and Mathematics. It had a simple National goal of bringing attention to a group of occupations that were not being filled by students coming through the American education system. As attention increased and probing questions required more detail, the acronym grew into a word. STEM fields, STEM occupations, and STEM majors were not so easily defined and the need to identify the requirements for a strong STEM Education at a National level became increasingly difficult. As we articulate below what STEM Education should accomplish, there is one thing that is clear. There are common threads that tie the S, the T, the E, and the M together. Threads based on common skills, knowledge, and language. Threads, as we will see in our Programs of Study, that also connect STEM to many other subjects and real world experiences. There is a lot of work ahead in the development of a robust STEM program in the Brandywine School District, but identifying and strengthening the common threads will be a critical component. This is why it is illustrated in the graphic on the front of this report – to illustrate that the whole of STEM is greater than the sum of its parts.

Throughout this overview, there will be references to what is called the STEM pipeline. It helps to provide a visual analogy to illustrate the expectations of a STEM education. Figure 1 for example shows that the purpose of the pipeline is to use the education system to provide students with the knowledge and skills necessary to become employable in an increasingly technological environment that is connected to a globalized economy.

Figure 1 – The STEM Pipeline

Figure 2 shows that as we try to peer into this pipeline, things become a little more intricate. On the right hand side, we see pipes within pipes, representing the specialization employers will be looking for in filling a variety of jobs. On the left side, where students enter the pipeline, we don’t see this specialization. This is very important for two reasons; one is that many of the jobs that will be available to the students entering the pipeline now have yet to been created, the other is that the interests and talents of entering students have yet to be developed. At some point however, career decisions need to be made and careful consideration should be given to the transferability of skills and knowledge between careers.
There are a number of STEM related careers that share a common mindset and core education. These are our engineers, our biologists, chemists, and physicists, our computer scientists, our mathematicians and our architects. This is illustrated in Figure 3 as the STEM Knowledge pipeline. There is a lot that we know and can forecast with this group using employment projections. The challenge is in making sure that there are enough in the pipeline who are adequately prepared and sufficiently inspired to persevere through a relatively academically rigorous journey.

There are two common concerns regarding the STEM Knowledge pipeline. One is that we don’t have enough students who are interested in those areas of study. The other is that they don’t have an adequate amount of preparation. These concerns tend to get skewed when looking at racial and gender differences. Ultimately, many students find themselves in the STEM Knowledge pipeline only to discover that they were either under-prepared, can’t identify with a peer-group, or were misinformed about what the field entailed. This is often referred to as the leaky pipeline as illustrated in Figure 4 since these students ultimately do not end up in the STEM careers.
Part of the leakiness is natural as many students in post-secondary education often change their career outlooks. Unfortunately for STEM Knowledge areas, students seldom “leak in”, especially without significant preparation. Figure 5 illustrates the need for students to be given ample opportunities to get back on track in the K12 system if they want to keep STEM Knowledge careers a realistically and viable option. This is especially true in mathematics where on-track means Algebra I in 8th grade and Calculus in 12th.

Many students who leak from the STEM Knowledge pipeline find themselves, thankfully, in the STEM Skills pipeline (Figure 6). This pipeline represents approximately 70-80% of the job force and entails the millions of men and women who rely on a wide range of STEM related skills every day to solve problems that are both planned and spontaneous. These commonly include critical thinking skills and math skills, but also include scientific, programming, and troubleshooting skills as well. Many of these skills are introduced in the elementary years and then emphasized in secondary education often through project based experiences and long-term assignments. They are also emphasized in career-focused
courses such as Business Education, Family & Consumer Sciences, and Technology Education. Students entering this pipeline still need to have a strong foundation in mathematics and science education.

Figure 6 – The STEM Skills Pipeline

We know that the increased pace of technological innovation has presented a host of problems that require a matched increase in innovative solutions. Most of us assume that these innovations will stem from the professionals in STEM Knowledge pipeline (Figure 7). However, history has shown us that many of our best innovators have come through the STEM Skills and, as shown below, the STEM Experiences pipeline. STEM experiences guarantee that all future employees (current students) are proficient users of technology, are knowledgeable of environmental impacts of everyday decisions and have an understanding of the role of STEM in solving global problems such as hunger and human right violations. But it also ensures that students have access to an education that is rich with a wide range of learning experiences that include the humanities, cultural studies and especially art and music. Experiences where creativity is nurtured and challenged.

Figure 7 – The STEM Experiences Pipeline
Math and Science education has been an integral component to the educational experience for multiple generations with English Language Arts and Social Studies making up the core subject areas. This leads to one of the more common questions surrounding STEM education: what is engineering education? In a nutshell, engineering education applies appropriate technologies to concepts such as constraints, modeling, systems and trade-offs and skills such as drawing and experimenting. Though many of these aspects are more relevant to select areas in the STEM Knowledge and STEM Skills pipelines, there are two engineering related experiences that can have a profound impact on learning for all students and are appropriate for a wide range of age groups and interests. One is the ability to clearly define problems and the other is the ability to solve problems systematically through what is referred to as the Engineering Design Cycle. Figure 8 shows the Engineering Design Cycle in its most basic form. Once a student can imaging the problem and a possible solution, they articulate the potential solution (design), create a prototype of the solution (make), and then evaluate the solution (test). If the solution does not solve the problem or creates a different problem, the students will need to go around the cycle again. Repeating the cycle is a critical experience because it supports stick-to-itiveness, risk taking and the value of mistakes as learning opportunities.

Figure 8 – The Engineering Design Cycle

A necessary part of strengthening the STEM pipeline is the establishment of feedback opportunities. As shown in Figure 9, this can come in the form of business partnerships where professional scientists and engineers spend time working with middle and high school students on long term projects. Though these professionals have a lot of knowledge and experiences to share, the moments can be most profound when they can simply model their habits of mind, their approaches to experimentation and problem solving and a positive attitude towards learning something new around projects selected by the students.

Another important feedback partnership comes from high school students, confident and prepared to enter the post-secondary pipelines, spending time with elementary aged students. Again, there is an opportunity to share knowledge and experience, but the biggest impact comes from the sharing of experiments, selected and perfected by the high school students, and carefully delivered to promote lots of questions, discussions, and sustained interest.
Finally, as we come to the realization that a STEM education must resonate with the advancing changes in technology, we must also ensure that we do not unintentionally establish a digital divide between in-school technology and out-of-school technology. We know that any education is only as strong as the connections that can be made with the real world experiences of students. If our goal of STEM education is to produce innovative problem solvers, then we should encourage student to engage in problem solving in multiple venues and have the technology resources there to assist them. Einstein once said, “it’s not that I’m so smart, I just stay with problems longer”. Therefore it is important to think about the type software and hardware we can expose students to in school and ensure that it is prolific and easily accessible in many arenas including after school clubs, libraries and at home. Open source software and hardware is often free or at cost, improved upon by brilliant people from around the world, and is easily accessible. Blending Open Source resources with our instructional technology infrastructure must be a priority.

Figure 10 – Open Source Software and Hardware
In conclusion, thanks to the 2010 Race to the Top grant and the 2012 Referendum, the Brandywine School District has placed itself in a position to take significant action on the needs stated above and position itself as a leader in STEM Education. The district has established the following three goals to sustain these initiatives.

1. Expand the number of Brandywine School District students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in these fields.

2. Expand the STEM capable workforce to create, grow, and attract STEM related businesses to North Wilmington.

3. Increase STEM literacy for all Brandywine School District students including those who pursue non-STEM related careers, but need STEM skills.