

A.C.E.S Wild:

“Applied Concepts of Engineering and Science” Course Shakes Up Tradition

Fred Stillwell¹ and Jeff Rosen²

Abstract – New articles are released regularly that talk of the plight of K-12 education in retaining student interest in STEM concepts and that document the fears of STEM - based employers that they will not have a workforce ready to handle the challenges of the new Global Economy. East Cobb Middle School has offered a course that connects the grade-appropriate science and mathematics concepts through engineering principles. Now, ECMS, in collaboration with Georgia Tech, is proposing to the State Department of Education the creation of three new middle school courses, one at each grade level, called Applied Concepts of Engineering and Science (A.C.E.S.). Each year the course would have a specific focus area, but maintain the same primary function--to connect the science and math concepts through engineering - based activities. The A.C.E.S courses would be considered an additional academic class that is required for all students.

Keywords: k-12, middle school, STEM,

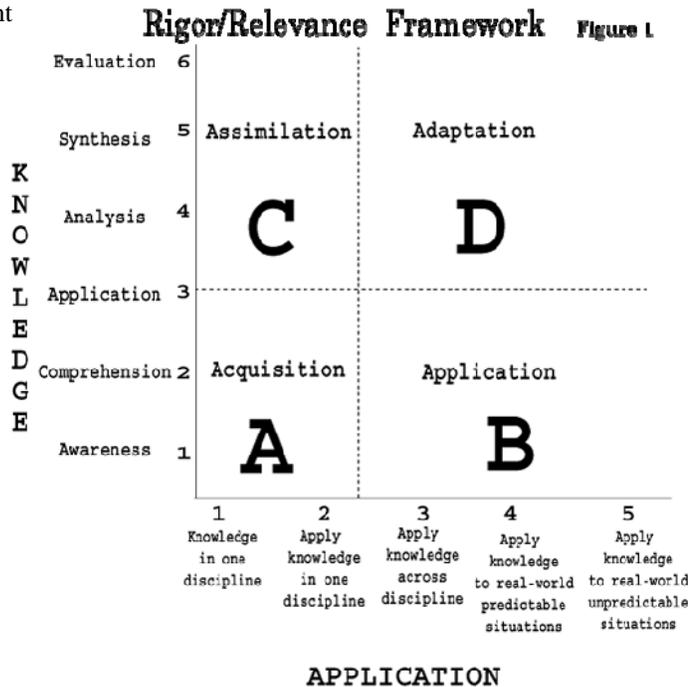
Introduction

As many states begin to develop Science, Technology, Engineering, and Mathematics (STEM) plans designed to address the rising global concern for a STEM capable workforce, the focus of many tends to be at the high school level. The Institute for Engineering and Technology reported that a Swedish study by Lindahl found that students lost interest in STEM, especially science, between the ages of 12 – 13[3], which correlates to 6th – 8th grade in the US. Global industry leaders are calling for a need to further develop the STEM workforce and produce more students who are capable of innovative and critical thought in STEM related fields. The results of a MathMovesU survey indicates that only 1/3 of students in grades 6 – 8 select the option that they “liked math a great deal” and that 45% of 8th graders find math to be “boring”[4]. Many of our political and business leaders are concerned with this issue; however most have suggested that we create incentives and policies that are targeted at secondary and post-secondary education. These concepts are valid in the effort to raise the production of STEM interest and degree students, but will not influence the fact that students, by the time they have reached those grades, have likely already lost their interest in STEM fields. The 2005 Nation’s Report Card on Science shows that 68% of 4th graders scored at or above the Basic achievement level, while only 59% of 8th graders achieved the Basic level or above [5]. This report also shows that a focus on STEM interest development at the 6th – 8th grade level is essential for the rejuvenation of the STEM student population in the U.S.

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Many of the current efforts to improve STEM education in the K-12 arena are focused on curriculum development and professional learning experiences of the design curriculum. In these models there tends to be a couple of items that are regularly overlooked, the need for teachers to strengthen their own content knowledge in STEM areas and the development of pedagogy that makes the content exciting and real to the student. The trend to introduce more project-based learning models raise the question about the watering down of the content; however with training on the concept of making content relevant to the student's life while maintaining a level of academic rigor should alleviate such concerns. Industry is asking for workers that are able to problem-solve as situations arise in the real-world environment. The idea of rigor and relevance has been studied to ascertain how the connection between one's levels of knowledge compares with the ability to apply that knowledge in a real situation. In Willard Daggett's Rigor/Relevance Framework [6] (figure 1) for learning in the new educational environment, the concerns of most industry leaders for a workforce capable of changing to meet the demands of society land firmly in the Assimilation (C) or Adaptation (D) quadrants. These workers are able to review the process and make the necessary modification as needed to maintain production and impact development of future products and processes. In the framework, which can be seen as a blending of Bloom's Taxonomy and applied knowledge experiences the two most advanced quadrants are labeled as Assimilation and Adaptation. This can be defined as one's ability to take in and incorporate one's own knowledge and make it suitable to the requirements of the process. In the development of content and pedagogical training for the teacher it is important to maintain awareness for the rigor of the material and the relevance of the discussion topics. For this to occur we must better equip students with the skill set to work in an every changing environment in the workplace and in education. With these principles in mind East Cobb Middle School, in Marietta, GA is working with the Center for Education Integrating Science, Mathematics, and Computing (CEISM) at Georgia Institute of Technology to create and acquire state approval for a three year STEM-based academic course called Applied Concepts in Engineering and Science (A.C.E.S).



Correlated themes between regular science offerings and A.C.E.S courses.

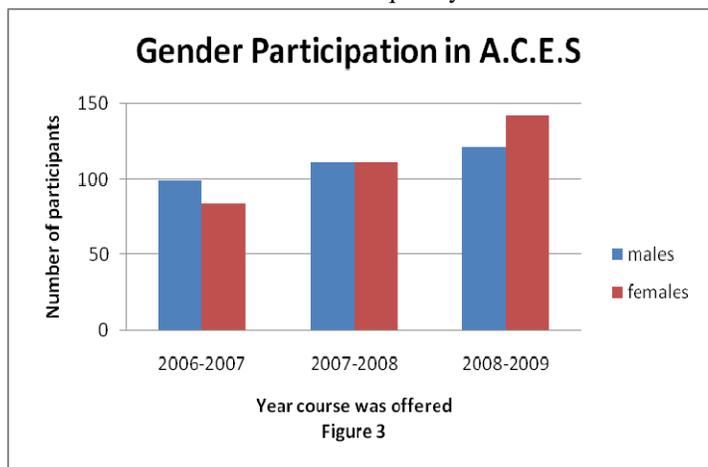
Figure 2

Grade Level	Regular Science Focus	A.C.E.S Focus
6 th	Earth Science	Exploration
7 th	Life Science	Bioengineering

What is the A.C.E.S program?

8 th	Physical Science	Shrinking Globe
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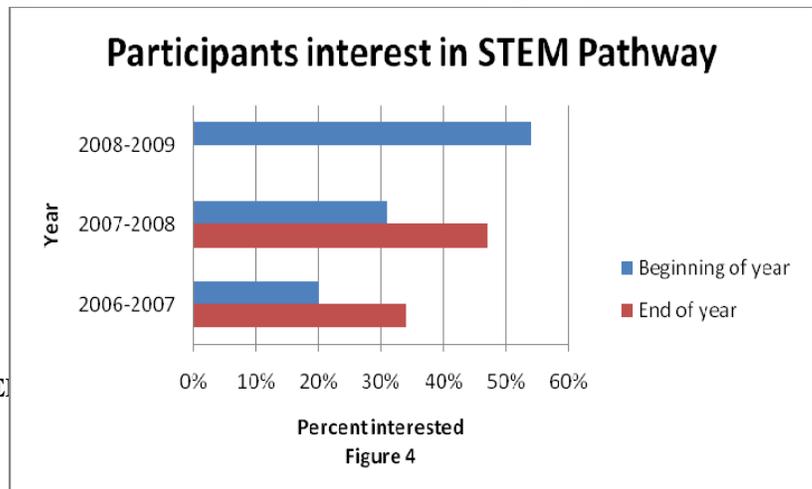
The A.C.E.S program is centered on the introduction of an additional academic course at the 6th – 8th levels in a given school. In the 6th and 7th grades, this course would be a required course for all students as part of the academic instruction, with the students maintaining their participation in the exploratory/connections classes such as technology, music, and physical education. At the 8th grade level, the course would not be mandatory, since students identified as reading deficient would need to take a required reading class, and some students may prefer to take a foreign language in preparation for high school. However for these students, the STEM content would be added to the exploratory/connections class, thereby ensuring that every student maintained exposure to STEM studies throughout the middle school years. Each of the three courses is focused on a complimentary topic to the science concept in the corresponding grade level science curriculum, as outlined in the table (Figure 2) to the right. The concept behind A.C.E.S is to combine the four traditional academics (math, science, language arts, and social studies) in an applied and integrated environment that complements the rigor of the traditional class with the relevance of real-world application. All of the courses are correlated to the appropriate grade level science standards and will allow for numerous connections to the math, language arts, and social studies standards. One main issue that has been raised and subsequently addressed is the loss of student participation in the Career, Technology, and Agricultural Education (CTAE) middle school courses; however by the approval of A.C.E.S as an additional academic offering, students will still take the same number of exploratory courses including the CTAE offerings. Of course the next question raised by most people is “Where in the school day do we find time to offer such a course?” This question will be addressed later in the paper. During this course students would learn in a completely project based learning environment that requires them to integrate all subject areas in a study of the history behind the project, and to apply the appropriate STEM content to obtain, analyze, synthesize, evaluate, and produce the project model. At the end, students will be required to present, in both written and oral form, the final project they produced. This additional academic offering will be premiered at ECMS in the eighth grade only during the 2009 school year, with support from the school system and school principal.



Impact on student interest in STEM.

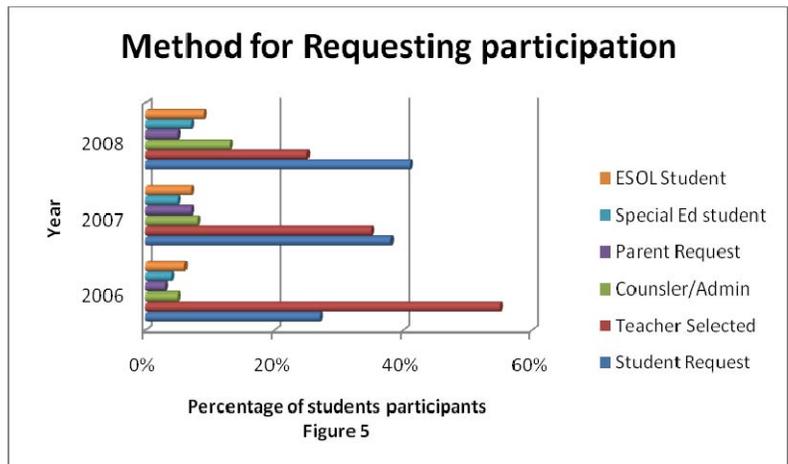
The concept of the A.C.E.S class has been piloted at East Cobb over the past three years and the numbers indicate a positive growth in student interest. In 2006-2007, a total of 183 students participated in the STEM class from grades 6 – 8, compared to 264 enrolled in 2008-2009. Of the current 8th grade participants, 91% participated during their 6th and 7th grade years as well. While these numbers are encouraging in general, the more interesting numbers occur in the gender participation (figure 3), where early in the program 54% of the participants were male compared to 54% female this year. Given national concerns about the need to attract a greater number of students from under-represented populations into STEM, the numbers during the first three years of this program support the idea that if we offer an interesting experience that is both rigorous and relevant to the student at an early age many of them respond with a sustained interest in STEM topics, especially the female participants.

The A.C.E.S. STEM class also appears to positively impact students’ interest in pursuing a STEM career. Over the three years, the numbers consistently (figure 4)



show that 15% more students express an interest in pursuing STEM after participating in the A.C.E.S course than at the beginning. The starting percentage increase can be attributed to the retention of students from the previous year which make the ending number more interesting, as nearly 50% of the participants are new to the program. The most interesting computation of this data is that of the new participants over 60% of them gain interest in STEM after their participation, which should be supported by the numbers that will be collected on this year's participants.

Students from diverse groups, including English for Speakers of Other Languages (ESOL) and Special Education programs (Special Ed) choose to participate in a class for a variety of reasons. For the A.C.E.S. STEM class, these reasons have changed over time, as shown in Figure 3. In 2006, over 50% of the student participants enrolled in the STEM program because their teachers recommended it, compared to 2008, when teacher recommendations only accounted for 25% of the participants. The 2008 data shows that the largest percentage of participants were those who chose to register for the class themselves. Based on these numbers, the teacher request remains high and occurs because teachers think this course would be good for the student. The students are selecting the course for the excitement and enjoyment of learning as indicated by the following quotes from current students in the course.



"STEM made me think about the objects that I am around everyday; for example, how a certain object is made and what materials are needed. STEM shows how the technology works in today's world." Ashley T.

"STEM lets you think outside of the box with hands-on activities. It is a fun, educational, and creative environment." Divya P.

"STEM has taught me that everybody has different skills and interests. STEM has changed my interest from animals to engineering." Bonnie P.

As we have found, one of the main reasons for the decline in student interest in STEM can be attributed to the loss of relevance in the student's perception of the learning, however from the data we collected from the students in A.C.E.S, this trend is reversible. There is no overnight solution; to implement such a program requires many levels of effort and vision.

What does it take to implement such a program?

With the current economic situation in most school districts, the biggest obstacle associated with the implementation of the program is the personnel costs to add the additional class. To implement the full program at all three grade levels, it would require the addition of approximately 10 new teachers who have a solid background in all STEM disciplines. This also requires a willingness to revisit the class schedule to accommodate the course with limited impact on the existing academic courses. This project is possible with some limited implementation levels as will be demonstrated in 2009-2010 at East Cobb where 8th graders will be offered the full A.C.E.S course and the 6th and 7th graders will have the option to take the course as an exploratory connections class. On the other hand, to fully capture the student's interest as early as possible an implementation at all three grades is important.

At the school level

The first stage of implementing such a program starts at the individual school and requires a few major considerations. This effort starts with an agreement of understanding within the faculty that this is not about a lack of teaching ability in some teachers; this is about furthering the context of the skills. With this understanding the rigor and relevance is achieved by all teachers and could improve the experience for the student. In most school environments it also requires a change in the daily schedule to allow for the time need to make this work. The chart shows the current and potential schedule for a school, based on East Cobb’s schedule. Currently, grades 6-7 are in four 65 min academics and to accommodate A.C.E.S those classes would be cut to 50 min periods allowing for the addition of a 50 min STEM period. Once the school has addressed the teachers and the schedule, the next major issue is physical space for the class. With the current economics in most schools the cost for the teachers and the need for space can only be addressed by the district.

Time allotted	Current Course	Time allotted	Potential
65 min each	6 th & 7 th Academics (M,S,LA,SS)	50 min each	6 th , 7 th , 8 th Academics (M,S,LA,SS)
50 min each	8 th Academics (M,S,LA,SS)		
50 min	8 th Foreign Lang. or Reading	50 min	6 th & 7 th STEM 8 th For. Lang / read/ STEM
50 min	Connections/Exploratory everyone takes two	50 min	Connections/Exploratory everyone takes two

At the district and state levels

The district’s first order is to support the implementation of such a program and assist in the submission to the state for all needed approvals. As the school tackles the internal support and schedule issues, the district must start with the teacher financial requirements and any potential space additions. The district will also need to work on the proposal to the State Department of Education to allow for the addition of such a course, as most states require the submission of new courses to originate from a school district. Once the district is prepared to make this work, the next phase of implementation has to happen at the state level. The state Department of Education has the final say in making such a program work based on the approval of the courses for the program. If the state does not approve the courses, the district and school cannot validate the appropriation of the funds for the teachers and space to offer the program. The other state-level factor in the program implementation is the certification requirements for the teachers of the A.C.E.S courses. What certification is appropriate for a teacher for a course that integrates all subjects including technology? The current proposal from East Cobb requests that the teacher be certified in Math or Science, and that they have received an add-on in Technology/STEM. This add-on would involve the teacher taking a collection of professional development courses that provide instruction on the integration of engineering and technology in math and science. Developing this add-on Technology/STEM certification is one of the roles that Georgia Tech’s Center of Education Integrating Science, Mathematics, and Computing (CEISMC) is playing in the development of the program.

Conclusion

Given the current conditions in education and the workforce, the need for students with an interest in STEM is critical to the success of the country. Most current initiatives designed to address this need tend to be concentrated at the secondary and post-secondary level, rather than during the elementary and middle grades. Our data suggests that early intervention and a concentration on making the work rigorous and relevant has a positive effect on the student’s perception of STEM and helps develop a strong work ethic and overall student. This program is still in the

developmental phase and is awaiting approval from the State Department of Education, so East Cobb will continue to pilot the program in the 2009 school year by implementing the 8th grade course along with connections classes for the 6th and 7th grade. With all of these factors taken into account, our belief is that with early implementation of STEM programs, we can capitalize on that the student's are still interested in the content.

REFERENCES

- [3] Ben Brierley and Dr. Lyn Haynes, *Studying STEM: what are the barriers?*, IET, United Kingdom, 2008, pg.7
- [4] Brian Wells and H. Alex Sanchez, "Modeling Student Interest in Science, Technology, Engineering, and Mathematics," BHEF, pg.4
- [5] U.S. Department of Education, "The Nation's Report Card on Science", U.S. Department of Education, Washington D.C, 2005, pg.1
- [6] Willard Daggett, International Center for Leadership in Education, www.daggett.com/rigor.html, New York

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Fred Stillwell is a STEM teacher at East Cobb Middle School that is certified in Science and Technology and is the faculty advisor for the school's many engineering based competition programs. Fred is a sitting member of the Board of Directors for the U.S F1 in Schools program and with his students has represented Georgia and the U.S. in numerous competitions around the world.

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Jeff Rosen is a Program Director in Georgia Tech's Center for Education Integrating Science, Math and Computing (CEISMC), leading up K-12 student activities in technology. Before arriving at Georgia Tech, Jeff was a veteran high school mathematics and technology teacher at Wheeler High School in Cobb County, Georgia, and organized the school's extensive robotics program.