Creating a STEM School Using Engineering Connections

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Recent attention in K-12 education (and post secondary as well) has been focused on increasing emphasis on science, technology, engineering and mathematics (STEM). Efforts to create STEM schools are wide-spread, but there is no single paradigm under which this development is taking place. Some schools emphasis one part more than another, while others have a more integrated approach, even bringing in other subject areas such as arts and the humanities. The state of North Carolina represents a microcosm of the rest of the country in terms of these efforts. Many county school systems are implementing their own definitions of STEM, even as the state Department of Public Instruction defines its own definitions of STEM schools. This paper will discuss how the Colleges of Engineering and Education at a public institution have worked with a set of schools to define themselves as STEM. The paper will discuss how the schools addressed their look and feel, as well as how they defined their curricular approaches, even writing some of their own curriculum. The role of engineering in the various approaches will be highlighted. The STEM rubrics from the state of North Carolina will be used to evaluate the various schools and their approaches.

Introduction

Across the state of North Carolina, many school systems are joining the STEM movement, motivated by many reasons. North Carolina has been a strong Project Lead the Way state for some time, involving 100 schools in offering either the middle school or high school courses. In addition the state Department of Public Instruction has a series of courses that it has supported that relate to engineering and technology in middle and high school as well. As effective as these courses can be, they are still stand-alone and do not provide a complete approach in integrated STEM education. Also, these courses, offered through Career and Technical Education, do not have any elementary school analogs.

Previous papers have discussed some of the approaches that the state of North Carolina is taking to implement STEM schools[1,2]. A recent presentation at the World Engineering Education Forum described some of the assessment done on STEM schools offered as engineering magnet schools[3]. More recently, the state DPI has worked with the Friday Institute for Educational Innovation to create STEM implementation rubrics that will be used to certify STEM schools in the state. These rubrics are available online at http://www.ncpublicschools.org/stem/. The rubrics include engineering connection rubrics which were developed by an engineering task force to highlight the vowel in STEM and illustrate how engineering can be used as an integrator for STEM across the grade levels and across the curriculum.

STEM Schools in Wake County

A notable highlight of the state STEM initiative is Wake County, NC. This county, with almost 150,000 students has named twenty schools to be integrated STEM schools. An additional, unknown, number have chosen to self-designate. The county has appointed a STEM advisory committee of school system, high education, business and industry representatives to guide policy and support for the implementation of these schools. The draft strategic plan for the county, as advised by this committee, is below.

Priority 1: Integrate STEM throughout all curricula.

Goal 1 : Create a section in CMAPP [*] devoted to Integrated STEM curriculum for K-12 teachers across disciplines to implement regularly in their classrooms.

Strategies
1.1 Utilize a common language of the Engineering Design Process throughout STEM schools 1.2 Access a bank of activities that support STEM learning **1.3 Construct student learning activities using Understanding by Design and Project Based Inquiry Learning Frameworks** 1.4 Professional Learning Teams will focus on STEM learning throughout the year **1.5 Re-define the role of CMAPP for STEM schools** 1.6 Provide Professional Development on PBIL and the Engineering Standards **1.7 Contract and coordinate curriculum writing K-12**

Success Measures after 3 Years

- Integrated STEM units aligned with the Grand Challenges of Engineering are in CMAPP for K-12
- Increase in number of teachers implementing Integrated STEM lessons in the classroom as measured by walkthrough tool, teacher evaluations, and teacher surveys

Leading Indicators for Years 1 and 2

- Continued district funding allocated for Curriculum Writing
- Teachers contracted for Curriculum Writing
- Partnership with Kenan Fellows Program for a Kenan Fellow to develop curriculum and professional development
- A section is created in CMAPP devoted to Integrated STEM curriculum
- Increased inclusion of Integrated STEM lessons in classrooms

Priority 2

Increase Network schools STEM achievement.

Goal 1: Increase STEM schools' students' proficiency on state assessments, the number of students taking advanced STEM courses, and ultimately the number of students choosing STEM career pathways upon graduation.

[*] CMAPP is an online tool used by teachers and administrators for sharing ideas and curriculum.

Strategies
1.1 Educate STEM schools on the NC STEM Attributes and Rubric and support them with goals they establish 1.2 Determine curriculum connections 1.3 **Target underrepresented groups** 1.4 Create real-world experiences for teachers and students **1.5 Develop authentic assessments that measure PBIL and support teachers with implementation**

Success Measures After 3 Years

- Increase in percentage of STEM schools that are "Prepared" on the NC STEM Attributes Rubric
- Increase in students with positive attitudes towards STEM subjects and careers based on the MISO survey
- Increase in the number of students, including underrepresented students, in advanced STEM courses
- Increase in math and science scores K-12

Leading Indicators after Years 1 and 2

- Communicate indicators of success
- Establish goals and benchmarks for achieving success using the NC STEM Attributes Rubric
- Increase teacher and student understanding of STEM's relevance
- Increase use of PBL and use authentic assessments to measure student learning

Priority 3: Collaborate with business and community partners to connect STEM's relevance to workforce demands and to jointly seek STEM resources.

Goal 1: A WCPSS District STEM Advisory Board composed of district, school-based, and business/ community partners that develops, communicates, and monitors a strategic plan for the STEM Network schools.

Strategies
1.1 Establish a STEM Advisory board composed of district and school leaders, higher education, and business/ community partners 1.2 Meet regularly throughout the year with the advisory board to develop a strategic plan, share progress and get input for improvement on network goals **1.3 STEM Advisory board will establish a monitoring system for ensuring successful implementation of STEM education in network schools**

Success Measures after 3 Years

- An effective monitoring system is in place that measures schools' success on their STEM education plans

Leading Indicators after Years 1 and 2

- STEM Advisory Board is formed
- STEM Advisory Board establishes a Strategic Plan for the WCPSS STEM Schools Network
- STEM Advisory board establishes a monitoring system for the network

Goal 2

STEM Schools will establish STEM Leadership Teams composed of district, school-based, and business/ community partners that develop, communicate, and monitor the school's STEM Plan developed based on the NC STEM Attribute Rubric.

Strategies
2.1 Schools establish a STEM Committee that includes business/ community members to develop a school-based STEM Plan that is incorporated into SIP **2.2 Schools have a process for communicating**

Success Measures after 3 Years

- Increase in percentage of STEM schools that are "Prepared" on the indicators of the NC STEM Attributes Rubric

Leading Indicators after Years 1 and 2

- All STEM schools have a STEM Plan aligned with the NC STEM Attributes Rubric and are working toward "Prepared" or higher on the indicators.
- Schools establish a STEM Committee that meets regularly

the STEM plan to faculty and regularly update faculty on progress for goals
2.3 Schools will report progress on their plans twice yearly to the district

Goal 3

Business and community resources are fully integrated into the district and schools' efforts to extend the classrooms' walls creating a variety of STEM experiences for teachers, school leaders, and students.

Strategies

3.1 Take teachers on field trips during work days
3.2 Create opportunities for teacher externships
3.3 Create opportunities for teachers to job shadow
3.4 Facilitate creatively designed career events
3.5 Advocate for hiring a full-time STEM Coordinator or CDC at each school
3.6 Create opportunities for student internships
3.7 Teachers receive professional development for making and maintaining connections
3.8 Teachers collaborate with business and industry professionals on curriculum development

Success Measures after 3 Years

- Increase in percentage of STEM schools that are "Prepared" on the indicators of the NC STEM Attributes Rubric

Leading Indicators after Years 1 and 2

- All STEM schools have a STEM Plan aligned with the NC STEM Attributes Rubric and are working toward "Prepared" or higher on the indicators.
- Increase in partnerships with business and community at the district and school level
- Increase in opportunities for teachers and students to engaged with business and industry
- All STEM schools hold one STEM event yearly

Figure 1: Wake County, NC STEM strategic plan draft

Staff development

For STEM schools defined under the above paradigms, the need for staff development is acute. In Wake County schools were named at the beginning of the 2011/2012 school year to be assessed at the end of the year. So far, staff development workshops with entire staffs have been conducted at ten schools and workshops with representatives for every middle and high school in Wake County, the Kenan Fellows Program, the MSEN program and others. These workshops

take a particular form, based on the needs as expressed by teachers and administrators and the definitions developed at the state and county level. A typical list of topics appears in table 1.

Table1: Typical professional development workshop plan

Topic	Approximate time	Interactivity level
Defining STEM and engineering	30 minutes	Powerpoint presentation
Engineering in the everyday	30 minutes	Facilitator led analysis of shoes of group
Activity modeling	30 minutes	Group executes design activity
Microteach	3 hours	Small groups STEMify and teach example activities
Designing an activity	30 minutes	Powerpoint presenation
Teaching creativity	1 hour	Activity followed by powerpoint presentation
Defining modeling	20 minutes	Powerpoint presentation
Group analysis/discussion/planning	1 hour	Whole group activity

During the group analysis and planning stage, the facilitator leads the participants to make plans for STEM in their own schools. Some examples of things that have been done include:

1-designing hallway displays
2-incorporating integrated STEM projects once a quarter
3-planning for partnership between two specific classes on a project (middle and high)
4-reworking the school day to include an integrated STEM time (elementary and high, so far)

Some pictures of hallway displays are shown below.

Figure 2: Pictures of hallway displays designed by school staff

The integrated STEM projects designed by school staffs take many forms. An example project that has been used in kindergarten, first and second grade classes is the design of a labyrinth. The students were given various materials to use for the walls and asked to design a pathway for a HEXBUG Nano Robotic Bug to traverse. Depending on the grade level, various math and science objectives were to be met, including using nonstandard measurements, changing the sound that the bug made while moving, changing the motion of the bug, etc. (The evaluation and implementation of this particular project will appear in a future paper.) Figure 3 shows some pictures of the design and some of the STEM notebooks created by the students.

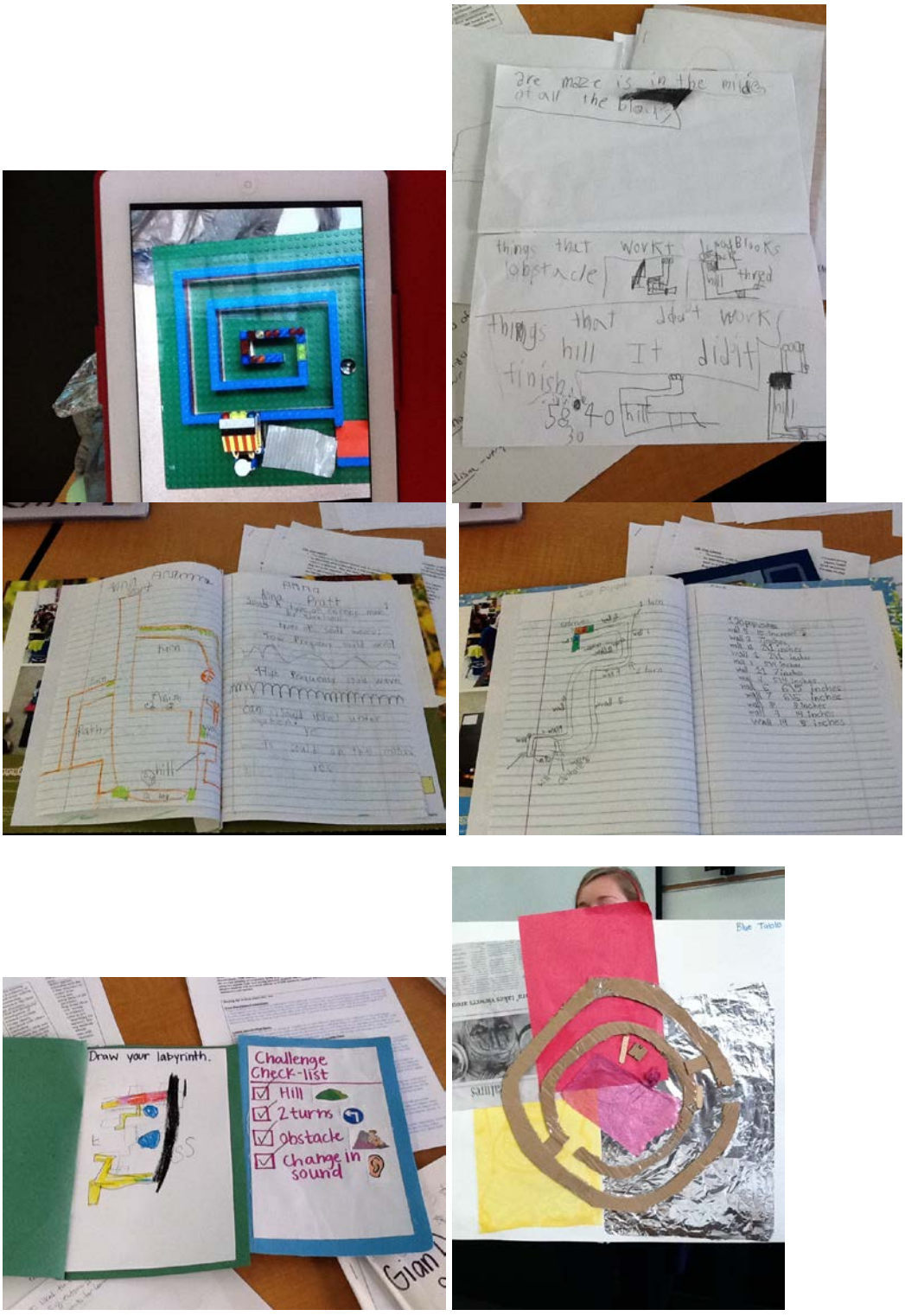

Figure 3: Example Integrate STEM activity for grades K-2

Finally, the NC STEM rubric is being used to evaluate the implementation of STEM in schools across the state. The rubric for elementary schools is given in figure 4. Most schools are still at the early or developing level.

North Carolina Department of Public Instruction's **STEM Attributes**	**Early**	**Developing**	**Prepared**	**Model**
Integrated Science, Technology, Engineering and Mathematics (STEM) curriculum, aligned with state, national, international and industry standards				
1) Project-based learning with integrated content across STEM subjects				
2) Connections to effective in- and out-of-school STEM programs				
3) Integration of technology and virtual learning				
4) Authentic assessment and exhibition of STEM skills				
5) Professional development on integrated STEM curriculum, community/industry partnerships and postsecondary education connections				
6) Outreach, support and focus on underserved, especially females, minorities, and economically disadvantaged				
On-going community and industry engagement				
7) A communicated STEM plan is adopted across education, communities and businesses				
8) STEM work-based learning experiences, to increase interest and abilities in fields requiring STEM skills, for each student and teacher				
9) Business and community partnerships for mentorship, internship and other STEM opportunities that extend the classroom walls				
Connections with postsecondary education				
10) Alignment of student's career pathway with postsecondary STEM program(s)				
11) Credit completion at community colleges, colleges and/or universities*				

Figure 4: **STEM Attribute Implementation Rubric ELEMENTARY SCHOOL, authored by Friday Institute for Educational Innovation and North Carolina Department of Public Instruction**

Conclusions

The implementation of STEM in North Carolina has proceeded in a less than coordinated manner, but as of this writing, a plan for successful and coordinated implementation is taking

shape. Future analysis will include a comprehensive assessment of schools across the state using the defined rubrics, as well as an analysis of how well the coordinated efforts are proceeding in our extremely diverse state.

References

1. Parry E.., Day, L., et al. *Gearing Up For The Future: A K 12/University Partnership To Create An Engineering Magnet Elementary School*, Proceedings of the American Society for Engineering Education Annual Conference, Pittsburgh, PA, 2008.

2. Ernst, Jeremy, Laura Bottomley and Elizabeth Parry "Term Analysis of an Elementary Engineering Design Approach," Proceedings of the American Society for Engineering Education Annual Conference, San Antonio, TX 2012.

3. Bottomley, Laura and Elizabeth A. Parry, " Integrated STEM Education in Elementary Schools Using Engineering: Every Teacher, Every Student," Proceedings of the World Engineering Education Forum, October 2012, Buenos Aires, AR.