

Rapid Prototyping: A Strategy to Promote Interest in STEM Careers

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Abstract - Rapid prototyping used as a strategy for engaging middle and high school students in STEM careers aligns nicely with the latest information in cognitive research. The technology used as a strategy is especially well-suited for 1) setting up learning environments that draw upon creative interests in young people and 2) using authentic experience as an anchor for learning. Both of these approaches support researched-based findings from the National Research Council and are described in the publication *How People Learn*.

Art to STEM, will use 3D design as a tool to engage middle school students who have expressed interest in art. During a discovery process, the students will use 3D and rapid prototype technology while designing objects of interest to them and therefore develop a knowledge base about potential future careers that can incorporate their creative interests.

Keywords - Career Exploration, Authentic Experience, Career Academies, STEM, and Rapid Prototyping

I. OVERVIEW

As public high schools in Nashville Tennessee began an effort to transform all high schools to career academies in 2008, those who were leading the effort discovered an extremely low level of interest among middle school students to participate in STEM related career academies in high school, while interest in career academies in arts and entertainment was extremely high, especially among girls. Career academies are multiple small schools within a larger school that incorporate academics within a career focus.

If low interest in STEM academies persists, all high school academies with a STEM focus will be at great risk due to low enrollment. The Art to STEM project, using rapid prototyping as a tool to engage student interest in art and to structure a journey of exploration for middle school girls so that they will discover that their interest in art, can be complemented and enhanced by science, technology, and engineering.

To be successful, the project leadership team has recognized that teachers who influence the students daily must also participate and understand the connection of art and design to the STEM career fields.

II. SETTING UP THE PROJECT: METHODOLOGY

This project, through a series of developmental experiences, will carefully and methodically take underserved and under-represented female middle school students and their teachers on a transformational journey to build a solid base of STEM knowledge and skills and to discover STEM-related careers for the students' future. Equally important, this project will create a wealth of relevant research data and lay a strong foundation for scalability and sustainability.

Matching the number of necessary future STEM workers to the number of graduating students who are adequately prepared and interested in pursuing a STEM career is a challenge for the city of Nashville and the public schools. The current transformation of all 12 comprehensive public high schools in the city from a traditional structure to thriving, hands-on, wall-to-wall career academies brings this challenge into sharp focus. In 2008-2009, 10th-grade students at each school began to choose among four to seven different career academies, with one of those a STEM-focus area. While the high schools are building teaching and student capacity for all career academies, there is a great need to ensure that an appropriate number of students choose to enroll in the STEM-related academies. This is an obvious challenge in light of student interest data that indicates most students are interested in pursuing careers in art and communication as a first choice. Below are samples of data from three of the comprehensive high schools:

| McGavock High School | |
|---|----------------------------|
| Those choosing STEM as one of top three choices | |
| 41.3% | Arts, AV, communication |
| 27.7% | Law, public safety |
| 25.7% | Marketing, sales |
| 25.5% | Human services |
| 24.4% | Education, training |
| 21.2% | Hospitality, tourism |
| 20.9% | Health science |
| 18.1% | Business, management |
| 14.0% | Architecture, construction |
| 13.7% | STEM |
| Those choosing STEM as first choice | |
| 5.9% | Overall |
| 10.8% | Males |
| 1.9% | Females |
| 5.0% | African American |
| 3.8% | Hispanic |
| 20.0% | Asian |
| 6.0% | White |

| Glenclyff High School | |
|---|----------------------------|
| Those choosing STEM as one of top three choices | |
| 39.9% | Arts, AV, communication |
| 27.9% | Education, training |
| 24.2% | Human services |
| 21.4% | Health science |
| 21.1% | Hospitality, tourism |
| 20.0% | Law, public safety |
| 19.9% | Marketing, sales |
| 18.9% | Business, management |
| 18.2% | Information technology |
| 18.2% | Architecture, construction |
| 16.0% | STEM |
| Those choosing STEM as first choice | |
| 3.3% | Overall |
| 4.9% | Males |
| 2.1% | Females |
| 3.8% | African American |
| 7.5% | Hispanic |
| 5.9% | Asian |
| 2.7% | White |

| Antioch High School | |
|---|-------------------------|
| Those choosing STEM as one of top three choices | |
| 37.7% | Arts, AV, communication |
| 25.4% | Law, public safety |
| 23.2% | Human services |
| 22.5% | STEM |
| 22.5% | Hospitality, tourism |
| Those choosing STEM as first choice | |
| 8.9% | Overall |
| 15.2% | Males |
| 3.7% | Females |
| 10.1% | African American |
| 8.1% | Hispanic |
| 11.8% | Asian |
| 6.6% | White |

Figure 1. Sample interest data from middle schools

In contrast, other sets of workforce data compiled by the Nashville Area Chamber of Commerce and numerous national sources point to a need for more workers with STEM skills. An analysis of these sets of data reveals a gap that must be closed if current workforce objectives are to be met.

A unique and comprehensive set of partners have collaborated to develop the plan for this project: the public schools and their teachers, the Girl Scouts, PENCIL Foundation (a community organization that organizes more than 500 local businesses in support of public schools), Tennessee Technological University, the Center for Innovation in Technological Education (a NSF regional ATE Center at Nashville State Community College), The Adventure Science Center, and Alignment Nashville, a 501c3 that connects local organizations with the schools and works out of the Mayor’s office. The project begins with team leaders from the community organizations who will be paired with a team of math and science teachers from each middle school. They will participate in a series of carefully planned professional development experiences that will provide them with expertise and resources to effectively implement the program. The project will then identify 200 (100 per year) underserved and disadvantaged seventh and eighth-grade girls who are enrolled in middle schools that feed into four of the comprehensive high schools that will house STEM-related academies. The students will be selected and mentored by the Girl Scouts and The Adventure Science Center.

Beginning with their own interest in art or other more traditional career areas, students will participate in out-of-school activities to learn to create 3D computer models using tools such as Creature Creator, Alice, and AutoCAD. The students will electronically send the images to a rapid prototyping lab at Tennessee Tech, and via the Internet, they can watch the real-time production of the physical models that will be sent back to them. Later, specially selected companies will bring the students on-site to explore the relevance of the knowledge they have gained to a variety of jobs that require a STEM skill set, particularly ICT skills. A summer week-long experience will immerse the students in the exploration and result in deeper understanding of STEM.

An important strategy in the overall program is to appeal to the girls at their interest and experience level. This approach is supported by the latest research in cognitive science. An appealing recruitment piece as depicted in figure 2 is being used in 2009 to appeal to and therefore help select girls who will participate. It

is important to note that, although the program will not discourage students who are interested in STEM at the middle school level, the research design of the project is intended to show the effectiveness of an intervention that begins with those who have not expressed an interest in STEM. The outcome will determine which strategies are effective in engaging those who would not typically engage on their own. Rapid prototype models of the designs the girls have created using the 3D software will provide gratification and intrinsic motivation for the girls to explore STEM and associated career options at a deeper level by enrolling in a STEM career academy in high school.

The community partner organizations are responsible for recruiting girls who fit the profile of the project. To accomplish this, the Girl Scouts and Adventure Science Center are seeking out girls at a variety of locations and events using very appealing materials as shown in figure 2 below:



Figure 2. Sample recruiting brochure

III. RESULTS

The evaluation component of the project will assess the growth in interest and understanding of the students and will also identify strategies and tactics that prove effective. The evaluator will also collect baseline data to assess the scale and sustainability of the project and its methods. Students, teachers, and after-school club leaders will complete surveys at several strategic intervals and the evaluator will visit team meetings and observe progress and interest of the girls as well as practices of the adult leaders and teachers. The project targets enrollment of 50% or more of the participating girls in a STEM career academy in high school as the

major outcome. The evaluation will identify successful practices along the way.

Although the project has just been funded and started in 2009, strong interest in participation from businesses, teachers, parents, schools, and girls is already evident. The biggest challenge for the leadership team is to structure the experience for the girls so that it is challenging and engaging and will launch them into discovering a lifetime of rewarding work.

IV. ACKNOWLEDGEMENTS

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