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Work in Progress - Instrumentation on a Truss Adapted for Pre-College Outreach

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Abstract - **Engineering content is a valuable addition to pre-college instruction in science, technology, engineering, and mathematics (STEM) since it applies scientific concepts, illustrates scientific relevance and technology, and provides measurement opportunities. Also, complex systems and interactions can be shown. This work describes outreach resources using a seven-member instrumented truss apparatus. This aluminum bench-top model is scaled to support up to fifty pounds. Electrical resistance gauges are installed on several members for strain measurement. The resource set includes the truss apparatus, instrumentation, a PowerPoint presentation, and a background document. The pre-college objective is a set of demonstration resources for middle or high school classrooms. Effective outreach design is modeled by tailoring to accommodate curriculum standards, level-appropriate concept terms, and grade continuity. The resources were developed by students in an interdisciplinary college class on sensors and structures. The development activities involved testing the models and measurements and refining the construction. Selected resources were implemented and evaluated in a local middle school classroom. The interdisciplinary content includes structural, force analysis, sensing, and measurement components.**

Index Terms – Pre-college Education, Engineering Outreach, Instrumentation, Sensors, Composites, Science Curriculum.

INTRODUCTION

Science, technology, engineering and mathematics (STEM) are essential parts of a pre-college curriculum. Not only is it necessary for students to understand STEM concepts to function in a technical society, but a familiarity promotes technical career choices. Many outreach activities are sponsored by STEM professional and technical societies and are targeted to high school students. This work gives an example of outreach resources for earlier grades.

Effective outreach programs are built on a partnership between pre-college teachers and STEM professionals [1]. The outreach resources are not intended to merely 'wow' the students, but they must be structured to reinforce and enhance the topics covered by state and local curricula. Specifically, engineering content should be tailored with learning styles and grade-level appropriateness in mind.

This work-in-progress describes a project in an interdisciplinary engineering course that was tailored for a middle school audience. The outreach exercise covered interdisciplinary concepts from civil, mechanical, and electrical engineering, and focused on instrumentation and measurements of truss structures. Related resource materials were developed and adapted for preliminary use in an outreach program for sixth and seventh grade students.

BACKGROUND AND OVERVIEW

I. Educational Environment

Early pre-high school education must provide students with a knowledge foundation for later education, and with the opportunities to apply that knowledge. STEM concepts are widely recognized as among the most challenging with respect to comprehension and retaining student interest. Resources must satisfy explicit curricula standards and must include hearing, seeing, and doing learning elements to accommodate the pre-college student needs. Reinforcement by repetition and continuity is needed as well. [2]

II. University Linkage

The outreach concepts were adapted from an upper-level interdisciplinary course at the Missouri University of Science and Technology related to structural monitoring. This course covered structural analysis and sensor instrumentation, with an emphasis on experimental results. The course project was a group presentation and background documentation that incorporated background research, structural analysis, experimental verification of results, and demonstration. An aluminum bench-top truss model with instrumentation was the project apparatus. The project purpose was to tailor the presentation and documentation to a pre-college high school audience of teachers. The materials were further adapted in a student project for middle school student audience. Preliminary implementation of the material and activities is the focus of this work-in-progress.

RESOURCES AND IMPLEMENTATION

I. Concepts Discussed

Engineering concepts related to the forces and analysis category in the Missouri science curriculum standards were selected [3]. Stress and strain, tension and compression, and measurements formed the three STEM content topics. Note that these concepts are incorporated in increasing complexity as grade level increases. The truss theme used rubber bands, clay beams, and the aluminum truss apparatus as physical items for demonstrations as shown in Figure 1.

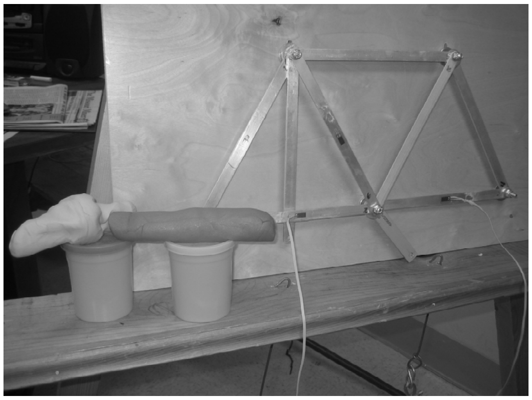

FIGURE 1
DEMONSTRATION MATERIAL.

The outreach Powerpoint presentation was designed for one hour and provided the hearing and seeing learning components. Pictures and videos of historical and local bridges such as the St. Louis Eads Bridge and the Tacoma Narrows Bridge were used to capture interest and to show scientific relevance. Each of the three topics was described in age-appropriate terminology, e.g. pushing and pulling, and related to the engineering terms. Student activities showed how a rubber band or a "snake" of clay related to the initial concepts. The changes in the shape of the clay were observed by the students and then related to the model trusses. The end activity was with measurements of the truss supported by a worksheet showing different types of trusses.

II. Preliminary Implementation and Summary

This outreach program was presented by a college senior in a local classroom setting to 6th and 7th graders separately. The survey shown in Table 1 was sent to all five teachers who observed the presentation, soliciting feedback on a scale from 1 through 10, where 10 was the highest ranking. Also, student feedback was solicited through the teachers. Their most interesting aspects included strain gauges and videos of poorly engineered structures, e.g. the Tacoma Narrows Bridge. The activities with clay and rubber bands received positive feedback, while the worksheets were less popular.

TABLE I
SURVEY QUESTIONS FOR PRE-COLLEGE TEACHERS

No	Survey Questions
1	I would recommend this program for 6th-8th grade students.
2	Stress-strain concepts related to assessment concepts & standards.
3	Structures concepts related to assessment concepts and standards.
4	The measurements concepts related to assessment concepts & standards.
5	Stress-strain concepts were presented in level/grade-appropriate terms.
6	Structures concepts were presented in level/grade-appropriate terms.
7	Measurements concepts were presented in level/grade-appropriate terms.
8	The demonstrations & activities (clay, worksheets,...) were effective.
9	The level of student participation was appropriate.
10	The engineering examples promoted an understanding of scientific relevance.
11	The presentation addressed multiple learning styles.
12	The students related well to a college-age/student presenter.

Figure 2 shows the teacher feedback. The average rating overall was an 8.2, with the highest scores received in the areas of student participation, multiple learning styles, and the college presenter (questions 9, 11, and 12 respectively).

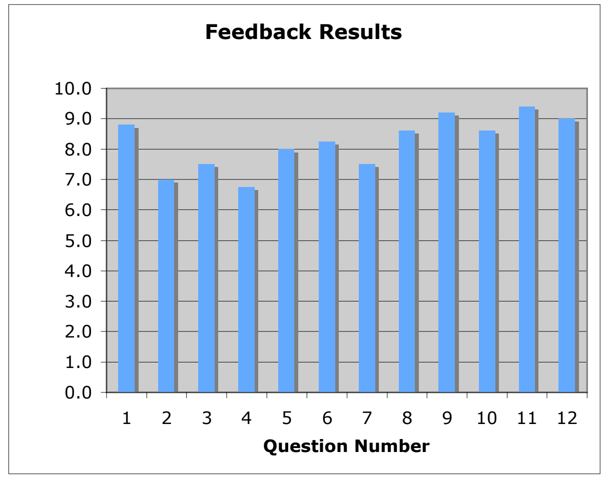

FIGURE 2
ASSESSMENT RESULTS FROM PRE-COLLEGE TEACHER SURVEY.

FUTURE WORK AND CONCLUSIONS

Future implementations will incorporate more content with the experimental measurements of the model truss. The authors will also create an outreach package, which will include all presentation materials and suggestions for adapting the lessons learned to future outreach topics.

This preliminary outreach experience illustrates how engineering content can be adapted for a middle school audience. Also, university course projects can be vehicles for developing instructional material. This subject matter was structural health monitoring, but many topics with practical applications are appropriate for such development. An effective program, utilizing both pre-college teachers and STEM professionals, will focus on curriculum standards, multiple learning styles, and grade appropriateness. The most effective aspects of this work were the college age presenter, the hardware instrumentation and apparatus, and the links to scientific applications.

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