AC 2011-1238: USING ENGINEERING ACTIVITIES TO SUPPORT COMMUNICATION AND COLLABORATION SKILLS IN A SPECIAL NEEDS CLASSROOM

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The purpose of this paper is to provide a description of a program, which was developed by way of an ongoing collaboration between a 5th grade special needs teacher in a culturally diverse urban area and a staff member from the K-12 outreach division of an engineering college providing graduate courses, professional development, and in-class mentoring teachers in school districts throughout the state. The goal of the program described in this paper is to determine to what extent utilization of age-appropriate engineering activities can improve the 21st century skills of communication and collaboration that special needs students often have difficulty mastering.

Background

CIESE (Center for Innovation in Science and Engineering Education) is the K-12 outreach division of Stevens Institute of Technology, a technological university in New Jersey noted for its distinctive educational and research programs. The collaboration between the special needs teacher and the CIESE staff is an outgrowth of a five-year (2010-2015) $11.5 million National Science Foundation Math Science Partnership grant program PISA^2 (Partnership to Improve Student Achievement) designed to increase student learning and motivation, teacher preparation, and district capacity to deliver high quality, standards-based and research-based STEM programs. The special needs teacher whose class is studied in this paper will be a two-year participant in this grant-funded program. Currently in the first year, this grant provides graduate courses, professional development, and in-class mentoring to teachers of grades 3-8.

CIESE research and other studies have shown that students' and teachers' science learning is positively impacted when engineering design is a key component of science instruction.[1] Based on findings in the 2009 report from the Committee on K-12 Engineering Education, very few schools expose K-8 students to engineering and engineering ideas.[2] CIESE continues to address this problem by demonstrating the need, value, and impact of engineering education. Therefore, as in previous CIESE programs, participants are given support in implementing engineering activities in their classroom and integrating engineering into existing science curricula.

Rationale

The purpose of this study is to determine the effectiveness of using engineering activities to foster not only critical thinking and problem solving but also the 21st century skills of communication and collaboration that need considerable attention in a special needs class. The essential question addressed in this paper is "Do students improve their 21st century skills as a result of their engagement in engineering activities?"[3]

The specific skills of communication and collaboration were selected for analysis because the soon after the PISA^2 in-class support sessions began in October, 2010, the teacher of the class noticed that the students' behavior was considerably more appropriate and focused when they were working on engineering activities. Therefore, she and the CIESE staff member began observing and documenting improvement in skills targeted in the students' Individualized

Education Plans (IEPs) – two of which are skills of written and oral communication and collaboration.

It is important to know that, in New Jersey, special needs teachers are expected to follow the state core curriculum content standards through the general education curriculum, and that special needs students take the same tests as the regular population. The state has a goal of increasing teachers' awareness of the growing emphasis on 21st century skills in teaching and learning and on providing strategies to facilitate student achievement of these skills in classroom settings.

NJ Core Curriculum Content Standard 9.1: 21st Century Life and Career Skills describes skills that prepare students to engage fully in civic and work life. The standard includes six strands, which reflect the Framework for 21st Century Learning.[4] For the purpose of this study and as mentioned above, we are focusing on the skills of collaboration and communication, although it is expected that engaging the students in a variety engineering activities will also improve their ability to think critically and solve problems. That topic will be addressed in a larger study of all of the students whose teachers are part of the NSF funded PISA[2].

Partner Class

The partner school is located in Jersey City, the state's second largest city. The school district has 28,218 students; 3.396 are classified as special education students. The class studied in this paper is a self-contained 5th grade taught by a teacher with a master's degree, who also holds special education and language arts certifications. There are ten students in the class, and all are classified with specific learning and emotional disabilities. The students are of average ability, but have low frustration levels and problems with self-control.

These students were administered the NJ Grade 4 ASK (Assessment of Student Knowledge) test in May 2010. Using raw scores, student scores on this test are reported as *Advanced Proficient*, *Proficient*, and *Partially Proficient*. A *Partially Proficient* score in language arts/literacy targets the student for remediation. The 2010 test results show that nine of the students scored *Partially Proficient* on the language arts/literacy test and one student scored *Proficient.* There are five test subsets and those scores are reported in percents. It is the expository writing sample score that is of interest in this study because that is the writing genre that the students will use to explain and describe their engineering experiences. The scores of the partner students ranged from 40%-60%.

The 2011 Grade 5 NJASK scores will be administered in May 2011, but the results will not be available to the schools until mid-August.

Approach/Methods/Materials

The CIESE staff member visits the class twice per month and leads the lessons with the assistance of the teacher. The approach to instruction is to present engineering activities that will, by their very nature, give students practice in communication skills (both written and oral) and in collaboration skills, since working in groups or teams is an important part of the engineering design process. The students are led through several introductory engineering activities before

they are presented with a series of design challenges in which the students use the engineering design process. All activities provide practice in using effective oral and written communication, and all are completed in pairs or teams. Photographs of the students participating in these activities, most recently the design and construction of balloon cars, are posted on the (name of project) website and updated regularly.

Varieties of sources are being used, including but not limited to the following:

- Engineering is Elementary (EiE): A set of curricula developed by the Boston Museum of Science that integrates engineering and technology concepts and skills with elementary science topics. Each EiE module contains lessons that feature a specific field of engineering and includes hands-on activities that engage students in the engineering design process. Note: The EiE materials are structured to follow the engineering design loop: "Ask, Imagine, Plan, Create, Improve[5]
- Lessons from TeachEngineering, a searchable, web-based digital library that provides teacher-tested, standards-based engineering content for K-12 teachers
- Elementary level engineering lessons developed by the K-12 outreach division of the partner college; these lessons can be found on the CIESE website
- Design Squad (PBS), an online resource that features elementary level hands-on challenges that focus on the engineering design process; they use simple materials and allow for multiple solutions
- eGFI Teachers' Newsletter, an electronic newsletter with lesson plans and activities, resources, feature stories, and the latest developments in K-12 engineering education; eGFI (Engineering, Go for It) is part of the American Society for Engineering Education (ASEE)

Assessment: Collaboration and Oral Communication Skills

Teacher/staff observations with rubrics, anecdotal records, and/or checklists will be used to evaluate students' oral communication and collaboration (group participation) skills. The purpose is to determine how well students communicate during group activities and to monitor their level of participation and cooperation. Rubrics and checklists are teacher created and based on the educational and behavioral needs of the students. Plans include recording students as they work in groups.

The students will be evaluated on their mastery of the following skills:

- Positive interactive communication with other students during activities, planning sessions, etc
- Peer collaboration and teamwork (see sample rubric below)
- Ability to present information in an articulate way so that others can understand
- Ability to organize and express thoughts

- Ability to give clear explanations and directions
- On-topic response to questions posed by teacher or other students

Sample Rubric for pairs and group larger work:

Category	4 (highest)	3	2	1
Working with Others	Almost always listens to, shares with and supports the efforts of others; tries to keep people working well together	Usually listens to, shares, with, and supports the efforts of others	Often listens to, shares with, and supports the efforts of others, but sometimes is not a good team member	Rarely listens to, shares with, and supports the efforts of others; often is not a good team membe
Listening Skills	Student listens to others' ideas with respect and courtesy	Student usually listens to others' ideas with respect and courtesy	Student rarely pays attention to other's ideas	Student interrupts when others are contributing to the group ideas

Assessment: Written Communication Skills

Written communication skills will be evaluated with reference to the NJ Core Curriculum Content Standard 3.2, which mirrors the Common Core Writing Standards for Grade 5, the emphasis being on writing in clear, concise language.[6,7]

Portfolios containing samples of student work produced in conjunction with the engineering lessons will be maintained throughout the school year. Samples will include written reports, reflections, explanations and directions, as well as labeled drawings and diagrams. Written work will be evaluated with the New Jersey Registered Holistic Scoring Rubric, which scores a student’s command of the following skills on a scale of 1-5:

- Content and Organization
- Usage
- Sentence Construction
- Mechanics

Other evaluative tools include responses to writing prompts that accompany the 5th grade language arts/literacy program (a comprehensive school district reading and language arts curriculum with periodic writing assessments) and, as explained above, the results from the 2011 5th grade state language arts/literacy assessment, which will be available in August 2011.

The school district writing prompts are administered in November, January, April and June. For each collection period, students submit two writing samples, one speculative and one expository, and they are scored 1-5 using the New Jersey Holistic Scoring Rubric. The November and

January scores for the partner class were limited to scores of 1 or 2 on both tests. The April and June scores will indicate to what degree and in what areas the students' writing has improved.

Note: Students' understanding and ability to engage in the engineering design process will be assessed by an instrument developed by CIESE. These students will complete the same science/engineering posttest as the students of all of the PISA[2] teachers. These results will be available in July 2011.

Conclusions

As this is a work in progress, not all of the data from this qualitative study is available. However, preliminary findings (based on anecdotal data collected over the last five months) indicate that making engineering a part of the students' educational experience provides a vehicle for practicing oral communication skills as well as experience in collaboration with peers.

Students are given a purpose for communicating and cooperating with other students. They feel comfortable and successful in using the engineering design process as a team. They learn that there are different ways to solve problems and that all group members can contribute to the solutions. The students are active learners, and motivation is positively affected. Because they are interested and excited, they are less likely to engage in disruptive behavior and more likely to contribute to group work.

In inspecting the writing that the students have produced in conjunction with the engineering lessons, the teacher has observed that the students are becoming more skilled at using transitional words such as first, next, and then when writing directions on how to complete a task or reporting on procedures that were followed in a design challenge. They also appear to have a more positive attitude toward writing when it involves describing or reflecting upon an engineering experience. The CIESE staff member was surprised to find how quickly the students learned engineering terms and were able to use them in their writing.

It is the conclusion of this writer that engineering can be introduced to, and have a lasting impact on, special needs students. It is hoped that the results of this study will support this statement and will demonstrate the need and value of engineering education as a way to facilitate student achievement of 21st century skills in classroom settings.

References

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