January 28, 2009

Study: Hands-on projects may be best way to teach engineering and technology concepts

WEST LAFAYETTE, Ind. - A Purdue University study has found that the best way to get students interested in engineering and technology at an early age may be to focus less on textbooks and more on interactive, problem-solving design projects.

Melissa Dark, assistant dean for strategic planning in the College of Technology, was one of the leaders of the study that looked at whether participating in engineering design modules helps students learn more, and if the effectiveness differs depending on gender, race/ethnicity and socioeconomic class.

The research was conducted with eighth-graders studying human impacts on water and water quality as part of the standard Indiana science curriculum. Half were taught using traditional methods and half were given the assignment to build a water purification device that demonstrated their grasp of the concepts.

"In every area we tested, the students who were involved in a hands-on project learned more and demonstrated a deeper understanding of the issues than the traditional group," Dark said. "This is a significant finding because it proves that with some students — especially groups traditionally underrepresented in science and engineering — the book-and-lecture format may not be the best way to engage students in learning."

The study of 126 eighth-graders from 10 science classes was conducted in a rural, racially diverse Indiana middle school. Nearly 30 percent of the middle school's population is ethnically diverse, and 57 percent of the total student population receives free or reduced-price lunches.

These students were chosen because the school was already taking part in a larger project through Purdue's Discovery Learning Center, as part of the National Science Foundation's Graduate Teaching Fellows in K-12 program, known as GK-12. Teachers at the school taught the traditional classes, and the graduate fellows taught the design classes.

Five science classes were taught through primarily traditional methods — textbook readings, lectures and tests with a small project — and the other

five classes were charged with designing a working water purification device. Although both groups used the same textbook, less than 10 percent of the total classroom time in the project-design group was devoted to lecture-based teaching.

To evaluate their knowledge of the subject, both groups of students were tested before the water unit was taught. Students were tested again at the conclusion of the unit to assess how well they learned the concepts presented. The results showed that the students who built the purification device had higher scores and a much higher degree of improvement than the traditionally taught students on both true/false and open-ended questions regarding water purification and water quality.

Dark said that while all students in the design group made gains, they were especially significant with students whose native language isn't English.

Jon Harbor, interim dean of the College of Science and associate vice president for research, also took part in the research.

"This study was the idea of three exceptional graduate students in science, engineering and education, working together with science teachers in a local school," he said. "The graduate students brought their enthusiasm for applied science and engineering to the classroom, and wanted to test the impact this would have on students. I think even they were surprised by the dramatic impact of their work."

Jody Riskowski, one of the graduate fellows who led the water purification design classes, said that gains with non-native English speakers may have been so significant because there was no language barrier involved in the design work.

"Students in the design group were able to use drawings, words or phrases to explain how their purification design addressed water quality issues, so this put them more at ease to express what they had learned," said Riskowski, now an assistant professor at the University of Texas at El Paso. "Also, we were very careful never to use the word 'engineering' because that scares a lot of students, but engineering is exactly what they were doing."

Dark said more study is needed to determine how well students retain the information learned in hands-on modules and how often students need to participate in them to benefit. She said teaching resources may prevent the implementation of some projects, if they take more time and preparation.

She pointed out that the Purdue study was made possible only because of the addition of three graduate fellows — Riskowski, Carrie Davis Todd (now at the University of Pittsburgh at Johnstown) and Bryan Wee (now at the University of Colorado at Denver).

"Further study is needed, but this is an exciting first step in proving the value of engineering/technology design modules in the classroom," Dark said. "As a nation, we want to increase engineering and technology

education in K-12 and also improve students' critical thinking skills, which we showed can be done though creative, hands-on design projects."
The study was funded by a grant from the National Science Foundation. The results of the study appear in the current edition of the International Journal of Engineering Education.

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ABSTRACT
Exploring the Effectiveness of an Interdisciplinary Water Resources Engineering Module in an Eighth Grade Science Class

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Engineering education has historically been given little attention in U.S. K-12 classrooms even though engineering incorporates scientific and mathematical concepts into meaningful, everyday applications. Including engineering and design projects in K-12 science and mathematics classes may improve student interest and comprehension, while also reaching a broader range of students than traditional lecture-based classes. For this study, the authors implemented an engineering design project focusing on water resources in 8th grade science classes. Students were exposed to either an engineering project (treatment) or a more traditional format (control) and their knowledge of water resource issues was evaluated using a pre-post assessment tool. Overall, students in the treatment classes showed statistically significant improvement in two areas – they displayed higher levels of thinking on open-ended questions and greater content knowledge. This research indicates the effectiveness of engineering in enhancing student learning and supports its inclusion in the middle school science curriculum.