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# Water You Thinking about Water?

## An Engineering Project to Enhance Student Understanding of Drinking Water and Water Resources

Jody Riskowski[1] and Carrie Davis Todd[2]

A common goal for science education is to aid students in developing meaningful connections between science theories and concepts as well as to broaden their understanding of the everyday world. One proposed curriculum development is the incorporation of engineering modules into science classes. While there has been considerable research in constructing engineering projects and engaging students with real-world applications and activities at the university level, there is a lack of understanding in the efficacy of these modules at the K-12 level. Therefore, the purpose of this activity was two-fold: 1) to engage middle-school students with a real-world application of water quality and resources and 2) to examine the learning affects of an engineering module. The student project was to design, build and test a portable drinking water apparatus. In conjunction with this project, students also participated in a study to assess the effectiveness of an engineering module (treatment group) compared to the more traditional lecture-based class (control group). Student knowledge of water quality and resource issues was evaluated using a pre-post assessment tool. Overall, students from the treatment group demonstrated higher levels of thinking with open-ended questions and greater content knowledge compared to the control group. This project has implications for the effective teaching and learning of complex concepts through engineering design applications and inquiry-based education. Our results support the inclusion of engineering modules in the middle school science curriculum.

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# WATER YOU THINKING ABOUT WATER?

## An Engineering Project to Explore Student Understanding of Drinking Water and Water Resources

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## INTRODUCTION

Water quality and water accessibility are important areas of global concern and significance for many individuals and humanitarian agencies. Reflecting the critical importance of water resources, the Indiana 8th grade curriculum contains a unit focused on human impacts on water and water quality. However, due to the perceived lack of relevance to students' lives, they may not fully grasp what is needed to ensure safe drinking water. A key approach to resolving water quality issues in the U.S. may reside in providing education that presents accurate information in an engaging manner.

Incorporating engineering modules into science classes may aid students to develop meaningful connections between science theories and concepts as well as to broaden their understanding of the everyday world [1]. While there has been considerable research in constructing engineering projects and engaging students with real-world applications and activities at the university level, there is limited research into the efficacy of these modules at the K-12 level. Therefore, the purpose of this activity was two-fold:

1) To engage middle-school students with a real-world application of water quality and resources.
2) To examine the learning affects of an engineering module.

## THEORETICAL FRAMEWORK

This study draws from two areas of literature: 1) social constructivism and 2) community of practice. From these frameworks, students generate meaning from the experience and activities of the community and relate their understanding to prior experiences and existing concepts. For this study, the shared experience for the students was to create a safe drinking water system. The learning of the science and engineering concepts is developed through the interaction between peers and instructors (i.e. community members) and generates knowledge for the student [2]. The understanding inherent in the student's scientific conception is embodied in the student's experience and discourse through the activity (practice). Consequently, student learning is a reflection of their unique social, educational, and cultural experience of the practice.

## METHODS

Students from a rural Indiana middle school participated in this study (n = 126). This student population was chosen as they were already taking part in a larger grant, and the two co-investigators were regularly involved in classroom activities through the National Science Foundation (NSF) GK-12 program. These particular classes were selected because the science teachers were implementing concurrent units on water and water quality using different pedagogical techniques.

*Curriculum & Instruction*

Five science classes were taught using instructional formats such as lectures, notes and videos (control, n = 60), while an additional five classes experienced a more inquiry-based approach to teaching and learning (treatment, n = 66).

The control classroom instructor used a more traditional model of teaching, relying heavily on lectures and notes. The faculty instructor of the five control classrooms estimated 60% of the classroom time was spent on lectures and notes, 20% on hand-outs and worksheets, and 20% on a final project. The final project for these students was designing and drawing a future city.

For the treatment classes, the design project of constructing a working water purification device was the student project. Students also had to detail and present their work, explaining how they decided on a design and how their device was able to purify water. Two graduate fellows were utilized throughout the project in the treatment classroom. The treatment classroom teacher, focused more on active learning approach, with less than 10% of the total classroom time devoted to lecturing and note-taking.

*Analysis*

Students responded to an eleven question pre-post evaluation designed to elicit their conceptual understanding of water purification processes, as well as their thoughts regarding water quality. Five open-ended questions focused on the human impact on the availability of safe drinking water, and five true/false questions taken directly from the textbook were included to test factual knowledge. The final design question required students to describe and explain what was needed to ensure safe drinking water and how their purification design addressed the water quality issues they identified.

Student pre-post evaluations scores gains were calculated using POMP transformations. Subsequent statistical analysis between the control and treatment group as well as between demographic groups utilized ANCOVA (pre-evaluation score being covariate). Statistical significance was set at p = 0.05.

## RESULTS

In the treatment group, female students, low socioeconomic (SES) students, and students whose primary language at home is not English experienced the largest percentage of gain in science content (48.5%, 42.9% and 63.3%, respectively) significantly higher gains than their equals in the control classroom (Fig. 1). These gains were further seen within the engineering evaluation, with the treatment group experiencing significantly higher gain than the control students.

POMP score analysis revealed 'A' and 'D' students achieved similar gains (57.3% and 53.3%, respectively) through the activity (Fig 2.).

In the open-ended questions, treatment students displayed a more complex response, revealing an increased awareness and understanding of drinking water issues (Fig. 3).

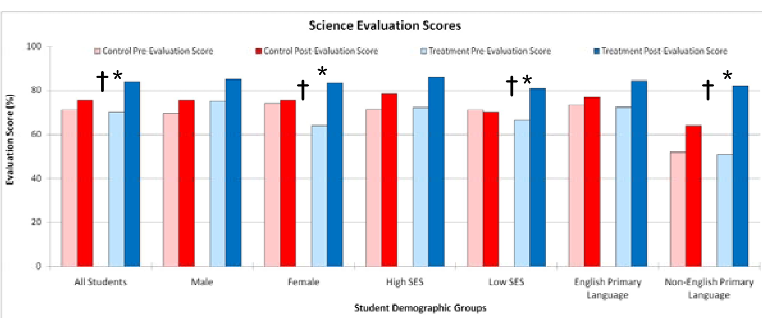


Figure 1

## DISCSSION

Our aim was to investigate how an engineering module would influence student understanding of water and water quality, relative to a lecture-based style of instruction. The students exposed to the engineering module improved their scientific understanding about drinking water quality and resources even though they were not "taught" in a traditional sense.

Despite the lower pre-evaluation scores, treatment students from traditionally disadvantaged backgrounds (ethnic minority, low SES) reached an end point equal to their counterparts in terms of science and conceptual understanding, and 'D' students improved as much as 'A' students. This suggests that the engineering module was effective in reaching a wide spectrum of students, leaving no child left behind in this particular activity.

The successes of students in the treatment class illustrate the benefits of incorporating engineering elements into 8th grade science classrooms. Students who participated in the design activities showed a greater increase in factual knowledge of water quality and resources, as well as a deeper, more complex understanding of water quality and purification processes.

## REFERENCES

[1] Coyle, E.J., et al. (2006), *JEE*, 95, 7-11.
[1] Bishop, B., (1985), *Learn Math*, 11, 24-28.

## ACKNOWLEDGEMENTS

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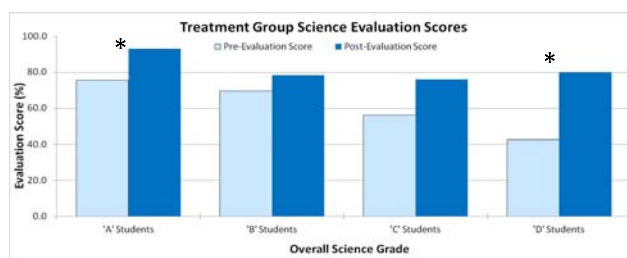
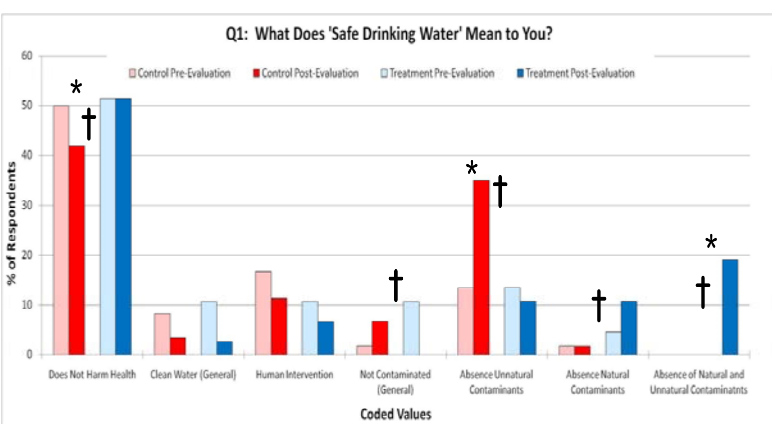



Figure 2



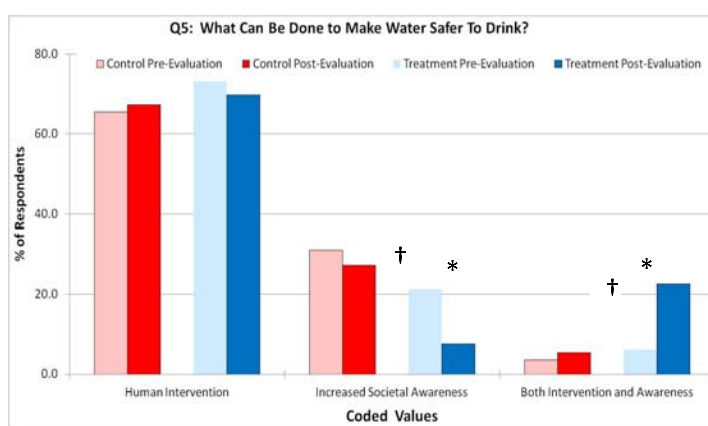




Figure 3

† = significant difference between control and treatment classes
* = significant difference between corresponding demographic groups within class