

Work in Progress: Creating High School Student Environmental Engineers

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Abstract - The National Science Foundation Research Experience for Teachers is an intensive six week program that allows teachers to work along side environmental engineers and find ways to bring this experience to high school students.

There are several results and benefits to this program. Teachers develop a well conceived activity that is rich in authentic engineering examples and based on sound educational practice. The case study presented is a typical lab in most high school chemistry classrooms that has been changed to have the students play the role of environmental engineers. Students have two days to separate a black mixture supposedly found flowing down the Ohio River, recrystallize one of the mysterious white substances and identify it based on physical properties and research. They must advise the water treatment plant if they should allow the material to pass or pump it in and purify the “goop”. An added benefit to the summer program is the educational professional development. Table of Specifications, Bloom’s Taxonomy and assessment methods are just a few of the tools that help enhance the lesson and remain with teachers and students throughout the year.

Index Terms – Environmental engineers, high school chemistry, high school students, NSF RET experience

IMPORTANCE TO THE EDUCATIONAL COMMUNITY

There has been a decline in the performance of high school age students in math and science. It should be no surprise that there has also been a decline in science majors, specifically in engineering, at the college level.

It is the direct intent of the National Science Foundations (NSF) Research Experience for Teachers (RET) program to address this problem. The intensive six week summer program at the University of Cincinnati was divided into two parts. Teams of teachers spent the mornings working along side environmental engineers in a cutting edge laboratory. The second half of the day was devoted to field trips, guest engineer lecturers and developing methods to bring engineering content into the math and science classroom.

THE “GOOP” ACTIVITY

The activity, developed through the RET experience by one of the 12 teachers in the project, was intended for a typical high school chemistry classroom. Most students have some intention of going on to college but may or may not major in math or science.

A traditional high school chemistry experience includes the purification and identification of an unknown substance. Students are typically provided with a mixture. They must separate out the contents and identify one of the chemicals.

The RET lab put a new twist on an old lab. Students were told that they were going to be an environmental engineer. They were told a mysterious plume of black goop has been identified coming down the Ohio River. It would reach the intake and the pumping station in two days. Students know that there are five possible substances in the mixture, one of which is a white crystal that they must identify. They have to advise the plant superintendent. The first day students analyze the black “Goop” (benzoic acid, salt, charcoal, glycerin and sand). They add boiling water, filter, boil down some of the water and wait for crystals to appear. The second day they capture the crystals and let them dry. During this time they do research on all five possible items in the mixture and find known chemical and physical properties and watch a short home movie of a tour of a water purification plant. Armed with their research, the melting point of the “unknown white crystal” and other observations, they determine the unknown.

ANALYSIS

The lesson was developed as part of the RET experience and was evaluated by a team of professional engineers and educators. Engineers rated the teacher’s technical report to document subject knowledge, lesson, and lesson poster. The evaluations by the engineers indicated that the presentation was very clear and informative. All participants seemed very knowledgeable and answered questions excellently and have very interesting lesson plans. The educators assured that assessment of student learning was appropriate.

The goop lesson was implemented in four eleventh grade classrooms. Prior to the lesson being taught, consents and assents were obtained from parents and students. Student demographics were gathered (Table 1) and students were administered a subject preference survey (Table 2) that indicated that only a few students were planning a career in math or science. However, overall students ranked science as

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the most useful area of study and ranked math as the third most useful subject of study. Males ranked science first and math second while females ranked art first and science second with math tied for last. Overall students ranked music first and social studies second as subjects of preference. Males rated Physical Education first and music second while females ranked art first and music second. The vast majority of students were intending to attend a four year college after high school.

TABLE 1
STUDENT DEMOGRAPHICS

Eleventh Grade	African American	American Indian	Asian	Multi Racial	White	Total
Males	3	1	5	4	49	62
Females	0	1	3	1	30	35
Total	3	2	8	5	79	97

TABLE 2
SUBJECT PREFERENCE SURVEY

Topic	Response	All	Males	Females
Plans for Career in Math or Science	Math Career	9	6	3
	Science Career	15	10	5
Most Useful Area of Study to Student	Art	11	3	8
	Language Arts	5	2	3
	Math	9	8	1
	Music	8	5	3
	Physical Education	7	6	1
	Science	17	12	5
	Social Studies	5	4	1
Subject Preference Survey	Art	320	152	168
	Language Arts	103	100	103
	Math	239	150	89
	Music	345	218	127
	Physical Education	298	235	63
	Science	216	153	63
	Social Studies	325	207	118
Plans After High School	4-year college	82	54	28
	2-year college	3	1	2
	workforce	0	0	0
	Technical/Trade	0	0	0
	Delayed college	0	0	0
	Undecided	5	3	2

At the end of the lesson, students were administered a Lesson Feedback Survey in which they could anonymously provide feedback on the lesson. 49% of the students indicated

some interest in the field of engineering. 19% of students indicated that their interest in engineering increased from the activity. 92% of the students indicated that they learned from the activity and 65% of the students indicated some confidence about their ability to learn math and science from the activity. The feedback received from students showed they were enthusiastic about the new method of learning.

The teacher who designed the lesson had indicated on a Curriculum/Instruction Checklist prior to the RET experience that the students had almost never utilized discovery learning. The teacher was observed prior to the RET experience and during the post RET lesson implementation with students. Several significant observations were documented as presented in Table 3.

TABLE 3
TEACHER PRE AND POST OBSERVATION

Pre RET Participation	Post RET Lesson Implementation
Class did not start on time.	Class started on time.
Students not always engaged in lesson.	Students engaged throughout lesson.
Classroom management problems existed.	Classroom management problems almost non-existent.
Bloom's lower level domains dominated instruction.	Bloom's higher level domains dominated instruction.

CONCLUSIONS

This paper illustrates how research experiences gained by teachers through the NSF RET project helped them to develop authentic learning activities in their classrooms. The teachers have become familiar with the importance of the scientific method of inquiry and the critical research skills that engineers use to solve open-ended real world problems. The feedback received from students after the RET experience showed their increased interest in engineering and increased confidence in learning science and mathematics. Further details about lessons and achievements can be found at the Project RET website [1].

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REFERENCES

[1] RET website, www.eng.uc.edu/dept_cee/research/ret, 2007