Proceedings,
The 2013 ASEE North Midwest Section Conference,
October 17-18, 2013, Fargo, North Dakota.

ASEE-NMWSC2013-0051

Promoting Nanotechnology among Middle School Students: Development and Implementation of Lesson Plans

Achintya N. Bezbaruah*,#; Rajani G. Pillai**; Hannah Hood*; Holly Erickson***; Eric Dobervich***; Jane Laux***; Jamie Varholdt***; Adam Gehlhar***; Michelle Weber***; Harjyoti Kalita*; Talal Almeelbi*; Mary Pate*; Michael Quamme*; Mohammad Enayet Hossain*; Seydou Cisse*; Amanda Grosz*; Navaratnam Leelaruban*
*Nanoenvirology Research Group, Civil and Environmental Engineering Department, North Dakota State University, Fargo, ND 58108; **College of Business, North Dakota State University, Fargo, ND 58102; ***West Fargo School District, West Fargo, ND 58078
#Corresponding *author*: a.bezbaruah@ndsu.edu

Abstract

Hands-on experience on nanotechnology was offered to the seventh grade students at West Fargo STEM Middle School using grade appropriate teaching modules developed in collaboration with subject teachers from West Fargo Public Schools. The content of the modules complemented course contents in science and mathematics in the seventh grade class. Eighty six students from the school participated in this year long program. Pre- and post-surveys were conducted and additional information on students' perspective on various issues were collected to evaluate the effectiveness of the program. The results indicate that hands-on activities help in stimulating students' interest in technologies. The authors believe that these programs can be emulated by others in promoting engineering education and research. The pre- and post-survey data also indicate that the students do not have enough information to decide their career paths and there is a need for additional outreach activities on science, technology, engineering, and mathematics (STEM) education and careers among the students.

Introduction

Nanotechnology is said to the revolution of this century. Nanomaterials are used in various consumer and specialized products and services. Some of these products and services are cosmetics, sensors, electronics, biomedical tools, treatment of diseases, water purification, contaminant remediation, and fabrics. It is projected that nanotechnology market will grow by 19% during 2013 to 2017 [1] from its present market value of US$1.6 trillion [2]. There will a demand for nanotechnology workforce and the demand is projected to sustain over the years. Nanotechnology markets are growing in electronics, energy, healthcare, and

construction [1]. It is felt that there is a need to introduce nanotechnology to the future generation of scientists and engineers while they are still in their middle schools.

Project Description

Seven teaching modules involving various aspects of nanotechnology were developed and introduced to the seventh grade students at West Fargo STEM Center Middle School in West Fargo, ND. Pre- and post-surveys were conducted and the data collected were analyzed to measure the impact of these modules on the students. The surveys also collected additional information about the students and their perspectives on science, technology, engineering, and mathematics (STEM) in general. A team of undergraduate and graduate students from North Dakota State University's (NDSU) Nanoenvirology Research Group (NRG) led by the lead author sat down with the four seventh grade teachers and the principal of the school in the beginning of the 2012-13 academic session to get a sense of the need for hands-on activities to deliver specific contents in science and mathematics in the seventh grade level. The NDSU students worked on developing hands-on activities related to nanotechnology addressing the course needs identified by the seventh grade teachers. The activities were than jointly evaluated by the students and lead author and a few of the activities were selected for further evaluation and improvement. Once the activities were fine-tuned they were sent to the seventh grade teachers for evaluation and further edits and were finalized for implementation. The activities planned were first tested in the environmental engineering laboratory at NDSU to make sure that they could be performed by the seventh graders and would be exciting for them. Each module of activities was delivered to the students on a specified day keeping in pace with the progress of the course contents in the seventh grade class. On the specified day, an NRG team from NDSU travelled to the school and worked with the students for one to two hours. The students were given an introduction to the day's course (activities) by one of the NRG members. The introduction session typically included detailed instructions for the activities followed by a video (downloaded from YouTube) on a specific aspect of the topics covered that day. Then the students were divided into four groups and moved to four different class rooms for the activities. Instruction sheets were placed on each activity table where 4-5 students worked in a subgroup. The seventh grade teachers and the NRG volunteers worked with the students in performing the activities. However, the teachers and volunteers did not perform the actual activities letting the students learn through mistakes. The students were asked to record their observations and draw conclusions based on what they observed. The activities that were

performed by the students included (1) water filtration system testing, (2) working with nanofabrics, (3) preparing nano nail polish, and (4) appreciation of nanoparticles. Pre- and post-surveys were conducted to evaluate the impact of this program on the students.

Results and Discussion

The numbers of male and female students in the group were comparable with only 10 more male students than females (Figure 1). The school where the nanotechnology modules were offed was a middle school with STEM focus. As the research involved human subjects specific requirements were laid down by North Dakota State University's Institutional Review Board (IRB) for the Protection of Human Participants in Research. As stipulated by IRB, letters were sent to the parents and the students beforehand informing them of the nanotechnology program at the school. IRB also required the parents and students to sign consent forms for participation in the pre- and post-surveys. Given that the students are from a STEM school they were expected to be curious about new information given in the information letter and they might have looked up about nanotechnology over the Internet and/or discussed about it with their family members and friends. It is, therefore, not surprising that most of the students had heard of nanotechnology before this program was offered (Figure 2). It is also possible that they were aware of nanotechnology independent of the information letter. However, the knowledge on nanotechnology was cursory for many students as apparent from the number of students who had seen a product made using nanotechnology (Figure 3) and who a read any news item on nanotechnology (Figure 4). While more or less equal fractions of male and female students had seen something made using nanotechnology (Figure 3), a significantly large number of female students did not read any news item on nanotechnology (Figure 4). Those numbers significantly changed after the nanotechnology program was offered but the number of female student who did not read any news item (or similar) even after being introduced to various hands-on activities on nanotechnology remained high (Figure 4). While no further study was conducted to find out the reason for such an observation, the authors feel there is a need to address this minority group and figure out ways to excite them to explore further on new concepts/technologies introduced to them.

During pre- and post-surveys, the students were asked about their interest in pursuing engineering as a career. The post survey data show a marginal increase in their interest to pursue engineering among male students while their overall inclination for engineering remained high during the whole period (Figure 5). A

significant jump in their interest could be seen among female students and they could be seen inching towards engineering (Figure 5) even though the number of female students who were 'very interested' in pursuing engineering education did not change. When student were asked whether they had enough information to decide their career paths, majority of them indicated that they did not have the needed information (Figure 6). The authors feel that the outreach activities from various STEM and non-STEM disciplines may play a key role in helping the students take the initial steps towards deciding their career paths.

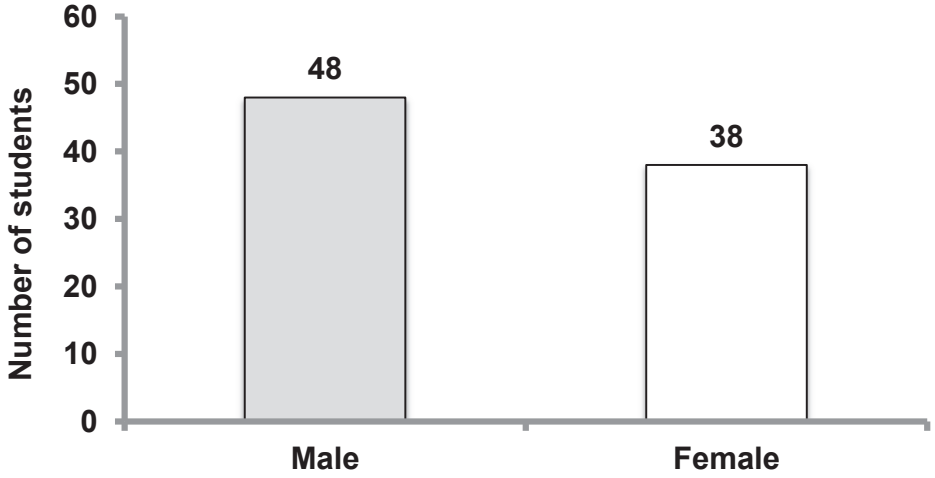

Figure 1. Male and female students who participated in the seventh grade nanotechnology program. Total number of students was 86.

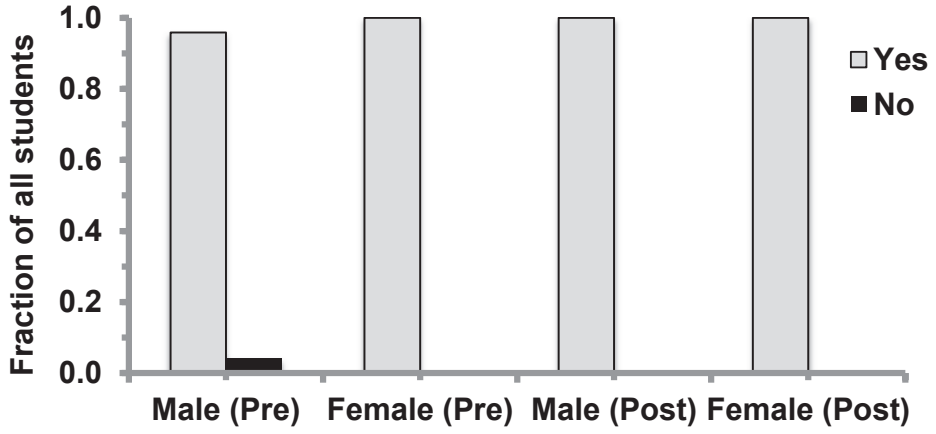

Figure 2. Fraction of students who heard of nanotechnology. It should be noted that the surveyed seventh grade students were from a STEM middle school and they were expected to be exposed to a number advanced topics in science and technology. Further, they were informed of the surveys in advance as per guidelines from Institutional Review Board (IRB) at North Dakota State University.

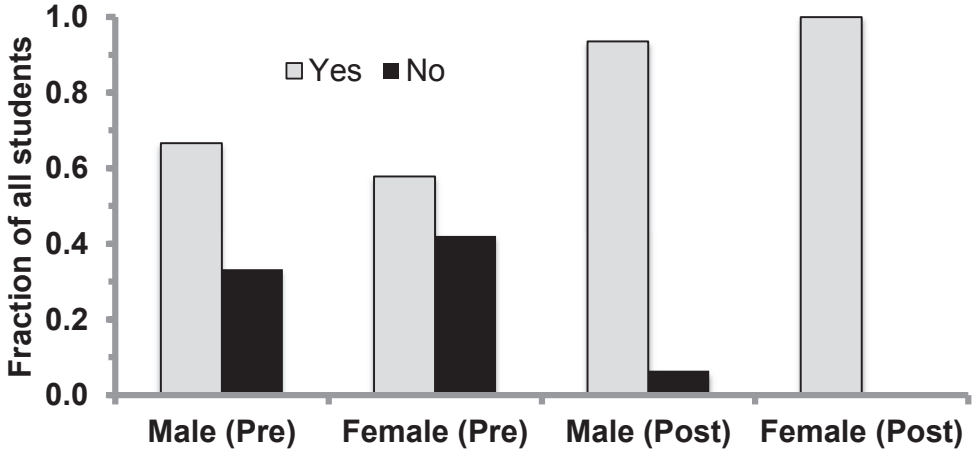

Figure 3. Fraction of students who had seen 'something' (e.g., a product) made using nanotechnology.

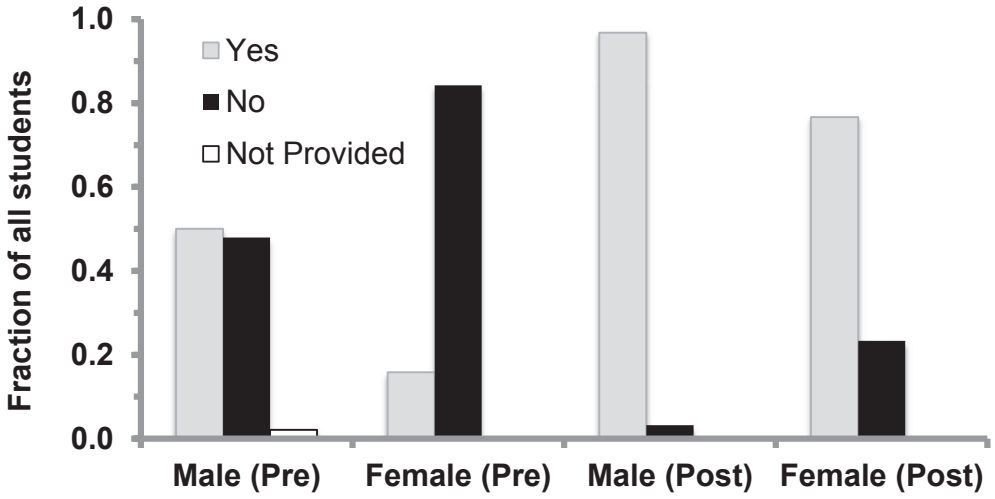

Figure 4. Fraction of students who had read 'something' (e.g., news item, booklet) on nanotechnology.

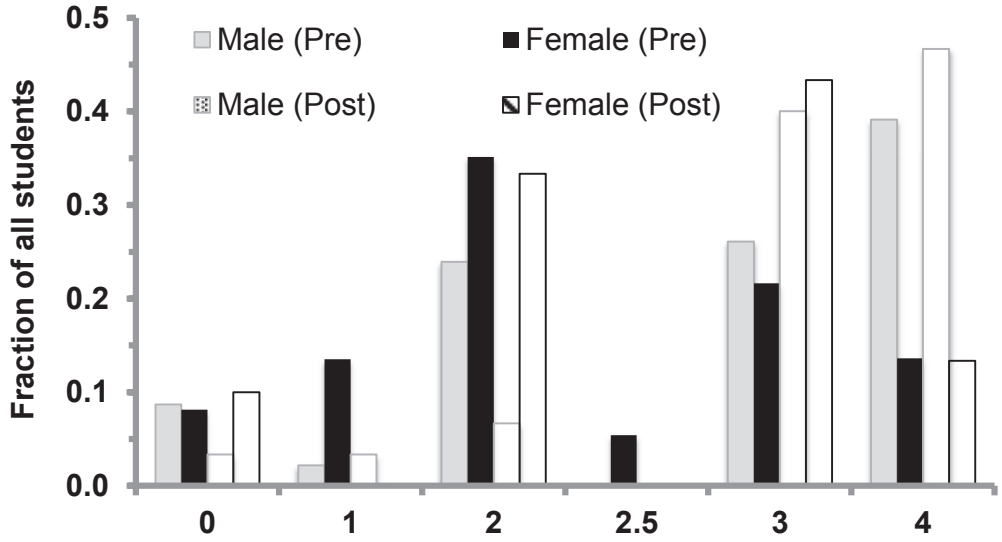

Figure 5. Fraction of students who were interested to become engineers. The scale on the X-axis indicates the interest of the students with 0 being least interested and 4 being very interested. There was no 2.5 point in the scale but some student selected a point in between 2 and 3.

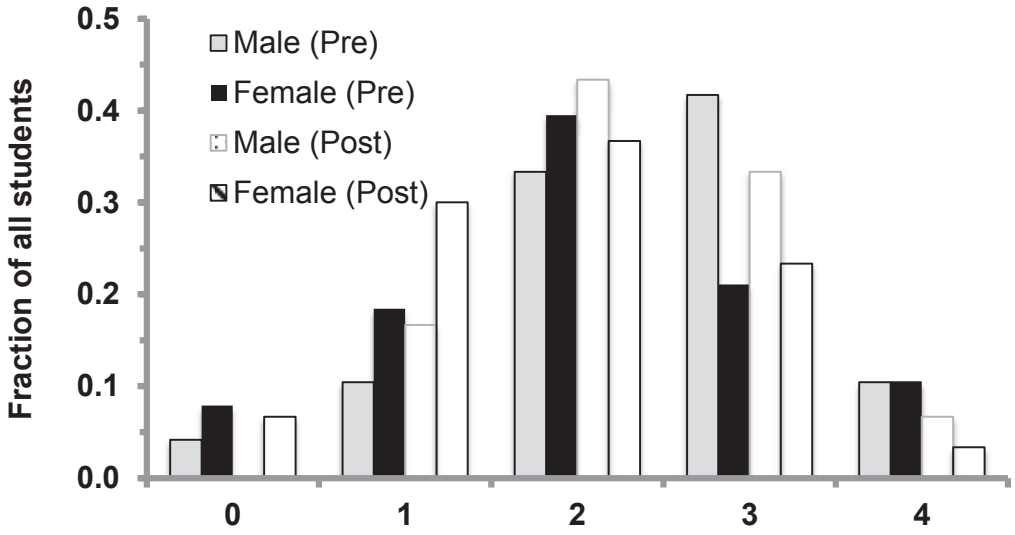

Figure 6. Fraction of students who felt that they had information to decide their future career paths. The scale on the X-axis indicates the wealth of information the students had with 0 being the least and 4 being enough information.

Summary

Pre- and post-survey results indicate that programs like the present nanotechnology outreach program can help students reduce the knowledge gap of students in the emerging areas and influence them in deciding their career paths. However, the students need to be exposed more to the scopes and excitements in engineering education to help them decide whether to pursue engineering education in the future. The students from whom the pre- and post-survey data were collected were from a STEM school and can be considered technology 'elites', and yet they indicated that they do not have enough information to decide their career paths. It is felt that there is a lot of ground to cover by the engineering community to popularize engineering as a career among the student more particularly among female students.

Acknowledgements

The BRIGE grant from National Science Foundation (grant#CMMI-1125674) is thankfully acknowledged. Civil and Environmental Engineering Department at NDSU, West Fargo Public Schools, and graduate students at NDSU provided organizational and logistic supports for the program.

Bibliography

1. RNCOS Industry Research Solutions (2013). Nanotechnology Market Outlook 2017, Noida, India.
2. Research and Markets (2011). Nanotechnology Market Forecast to 2013, Dublin, Ireland.