

Promoting Nanotechnology Education to Midwestern High School Students for Higher Enrolment Rates in Engineering Education

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Abstract

Nanotechnology education has been gaining much attention worldwide, and offered by many universities and research centers globally because of its interdisciplinary and multidisciplinary approaches in many fields, such as engineering, physics, chemistry, biology, mathematics, pharmacy and medicine. One of the major challenges of nanotechnology education is to provide new and exciting technologies/developments to the students in these fields. Nanotechnology has already made new products' (over 1350 nanoproducts in the market now) lighter, stronger, smaller, functional, faster, reliable and durable. In the present study, we have selected 10 high school students in Wichita, KS, and trained them in Spring 2013 about how to make different nanomaterials and devices, such as nanoparticles, nanofibers, nanofilms, nanocomposites, nanotubes, hydrogels, and solar cells. These opportunities were aimed at enhancing the educational level of the local high school students and informing them about the educational, economic and social implications of developments in the field. We assume that these opportunities will likely attract many local high school students to the engineering education in the region. The survey studies showed that most of the high school students who attended this program were interested in joining the College of Engineering (CoE) at Wichita State University (WSU), and continuing their education here. Consequently, this study indicates that the nanotechnology education is one of the greatest options to increase the enrolment rates in the CoE at WSU.

Keywords: High School Students, Nanotechnology, Hands-on Experience, Engineering Education.

1. Introduction

1.1 Motivation

Engaging the high school students to nanotechnology education is one of the major educational activities in the College of Engineering (COE) at Wichita State University (WSU) because this will help the students understand new engineering concepts and the future opportunities in the field. For the first time, this activity was provided to the local high school students in Wichita, KS and most likely in the State of Kansas and entire Midwest. The high school students, as well as school teachers and families were all thrilled to have this opportunity at WSU.

The major goal of this study was to prepare the local high school students for the engineering education using the nanotechnology teaching laboratory at WSU. We assume that this will

considerably improve the enrollment rate in the engineering college. The specific objectives of this study were as follows: *i*) to educate high school students based on hands-on experience in different nanotechnology subjects, *ii*) to promote interest in this emerging technology, *iii*) to create an awareness of nanomaterials fabrication and characterization techniques, and *iv*) to provide the students with a fundamental knowledge and understanding of nanoscience, nanotechnology, and associated technologies.

1.2 Nanotechnology and Education

Generally, nanotechnology is the development of materials, components, devices, and/or systems at the nanometer level. One of the dimensions in nanotechnology is between 1 and 100 nm [1-3]. This technology involves in fabricating, imaging, measuring, modeling, and manipulating matter on this scale. It is impacting a broad range of highly interdisciplinary and multidisciplinary fields, such as engineering, materials, colloidal science, physics, chemistry, mathematics, medical, nursing, biology, as well as education, art and social sciences and businesses [4-7]. Because of substantial scientific and technological advancements, as well as massive public and private interest and investments in the field of nanotechnology, this technology has been growing faster than any other ones for over two decades [8-10]. Along with entrepreneurs, students from K-12 to graduate school explore educational and professional opportunities in this rapidly growing area.

Many engineering challenges exist in nanotechnology fields for designing, analyzing, and fabricating materials and devices at nanoscale; thus, highly talented engineers with nanotechnology and nanoscience background have been recognized by the industry for more than ten years [10]. However, the lack of courses/facilities/labs seriously reduces the number of skilled workers and engineers who enter the work force in these fields.

The Wichita area is home of many companies that depend on advanced materials and devices, including aircraft (Cessna, Hawker Beechcraft, Spirit AeroSystems, Boeing, and Bombardier/Learjet), wind energy (EnerTech, Siemens, and Sunflower), oil (Koch) and agriculture and other industries. These companies are traditional employers of WSU graduates and interns, and consequently, a sizeable number of alumni are on their staffs. We believe that the proper preparation of the local students for careers in nanotechnology is essential for the university's long-term success in this rapidly developing area. This opportunity will provide several benefits to WSU, local students and companies.

2. Methodology

2.1 Nanotechnology Laboratory

We have developed the nanotechnology teaching laboratory to fabricate a number of different nanobased materials. The Nanolab space (~1500 ft²) is located in both Wallace Hall and the Beggs Hall, and also utilized to support three existing courses. The major equipment include the following: electrospinning units, corrosion and degradation testing units, fume hoods, glow box, spin-coating apparatus, temperature and humidity chamber, sensitive balances, injection molding apparatus, autoclave, press, potentiostat, sonicators, centrifuges, DI water, air table, vacuum pumps, ovens, furnaces, VARTM, UV photolithography, UV-Vis spectrometer, zeta potential /

nanosizer, and Gamry unit. A graduate teaching assistant (GTA), who is currently a PhD student in the Department of Mechanical Engineering at WSU, was hired to operate these pieces of equipment. The GTA utilized his expertise and skills to train the selected high school students.

2.2 Hands-on Nanotechnology Experience

In the present study, we invited 10 high school students, and trained them in Spring 2013 semester. The research plan was to fabricate several nanomaterials, and test and evaluate their performances with the high school students. The nanotechnology training activity was the first such endeavor, and unique to WSU, the State of Kansas and the entire Midwest. We have conducted 10 different experiments for the high school students in the following areas:

- Week 1: Magnetic nanoparticles fabrication and characterization
- Week 2: Ferrofluid fabrication and characterization
- Week 3: Carbon nanotubes nanocomposites fabrication and characterization
- Week 4: TiO₂ nanoparticles fabrication and characterization
- Week 5: Annealing and crystallization of nanomaterials
- Week 6: Sol-gel-based nanomaterials fabrication and characterization
- Week 7: Electrospun nanofibers fabrication and characterization
- Week 8: Nanomaterials-based thermoelectric generators and working principles
- Week 9: Nanomaterials-based solar energy systems
- Week 10: Bionanomaterials



Figure 1. The photograph showing some of the high school students with the GTA in the Nanolab prior to the nano experiment.

Figure 1 shows the photograph of some of the high school students with the GTA in the Nanolab prior to the nano experiment. Following these experiments, the students were asked to write a short report about nanomaterials fabrication and characterization, and the fundamental reasons behind these experiments / materials / property improvements. We strongly believe that there is much need for and a strong correlation between improvement in the quality of academic success

and the rate of enrollment to the COE at WSU using high-tech research and teaching opportunities for the local high school students. These students were selected on a first-come first-served basis after an announcement was made on the webpage. At the end of the semesters, all the high school students who attended to the nanolab session received a nanotechnology training certificate to keep in their records.

3. Results and Discussion

3.1 Evaluation of Survey Questions

At the end of the semester, the high school students were given a list of survey questions to evaluate their strengths and observations about the nanolab sessions, whereby they list their personal strengths; improvement areas; and insights about their knowledge of nanoscience, nanotechnology, and nanomanufacturing. Some of the following survey questions were chosen for the assessment of the activities.

- What are the three strengths of these lab sessions?
- What are the top three things that you have learned?
- What are the three improvements that would help you learn better?
- How can these improvements be made?
- What action plans can be put in place to help you learn more?
- What have you learned about your own learning process during the nanolab sessions?
- Did the nanolab sessions change your mind after the completion of these events?

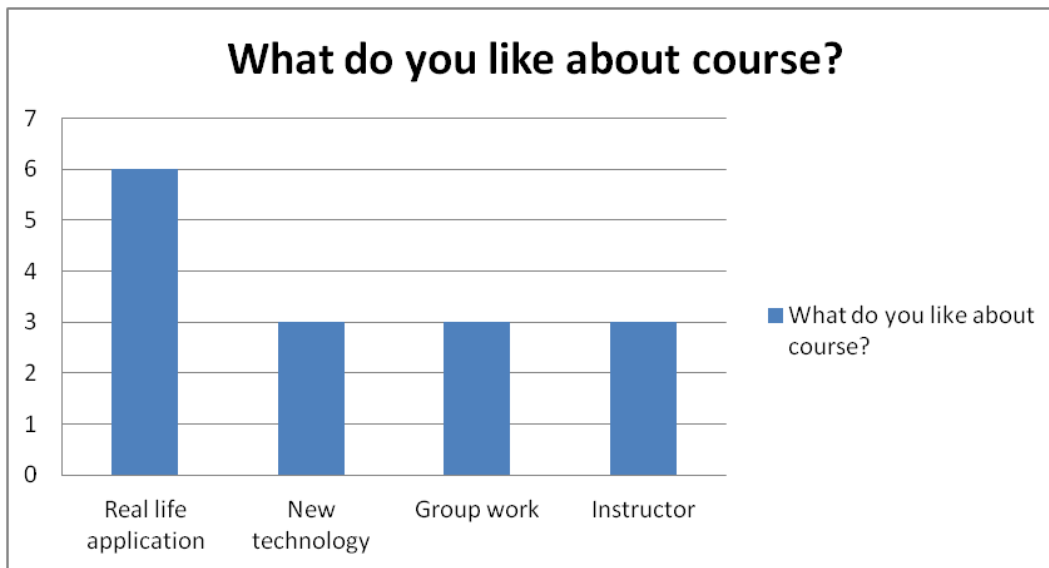


Figure 2. The results of the survey question "What do you like about the course".

Most of the high school students returned their questioners. Figures 2 through 6 show the results of the survey questions for the assessment of the nanolab activities for the high school students. These questions provided useful information about the students' interests, future plans, and their capabilities, and confirmed the types of learning styles (e.g., active learning, visual learning, deep learning, team work, etc.) that are most effective in the laboratory. The obtained answers provided in the figures guide us to get more high school students into the engineering education for their future careers.

Additionally, the results also explained if the nanolab projects have any influence on nanoscience, nanotechnology and research and development in the fields. Furthermore, student involvement in the nanolab sessions does not only contribute with the main objective of the program specified previously, but it also generates multiple secondary benefits, including [5]:

- Constructing the learning environment.
- Allowing students to discover by themselves about the early signals that affect their college education in general and engineering education in particular.
- Observing the peer academic mentoring, training and peer interaction on their performance in the high schools and colleges.

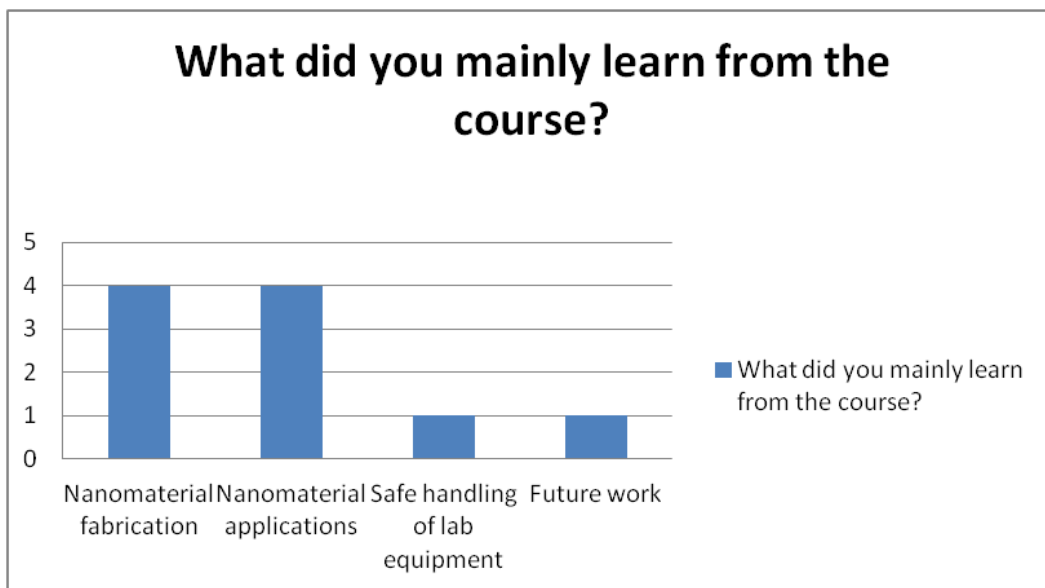


Figure 3. The results of the survey question “What did you mainly learn from this course”.

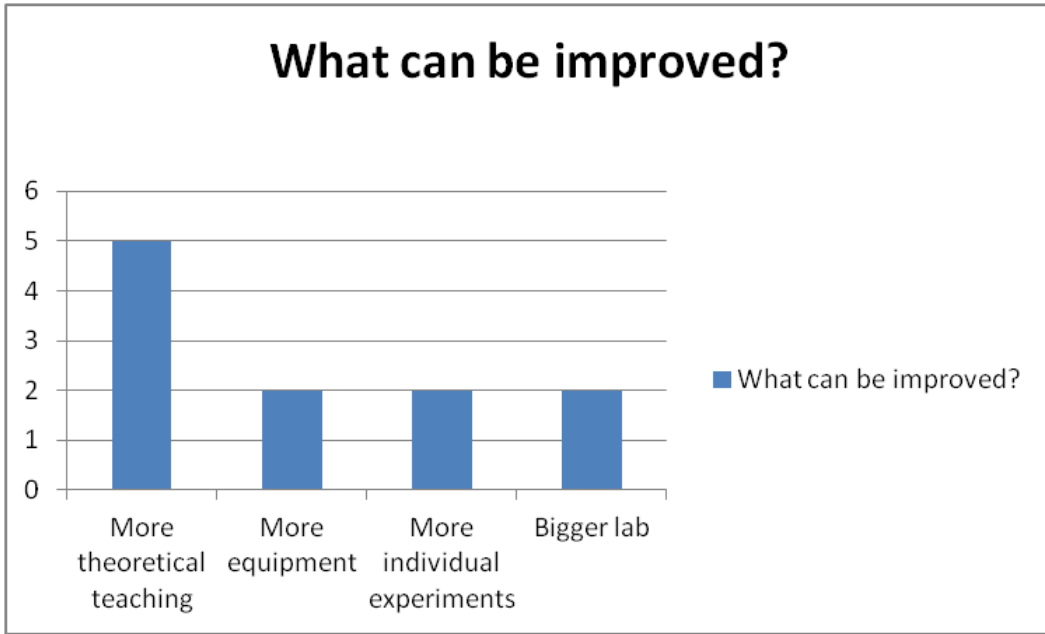


Figure 4. The results of the survey question “How/What can be improved”.

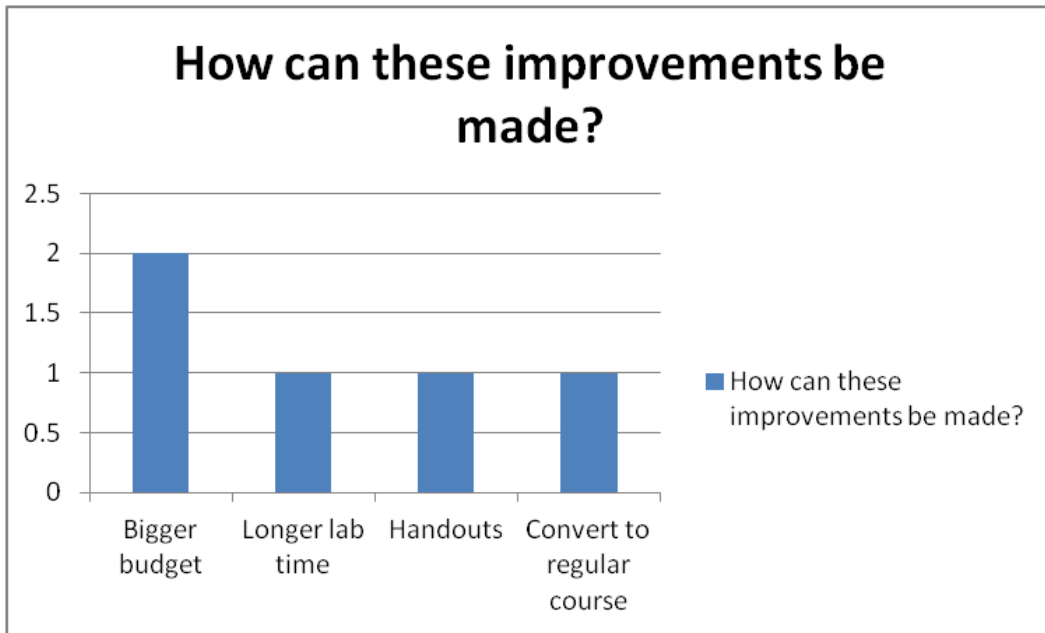


Figure 5. The results of the survey question “How can these improvements be made”.

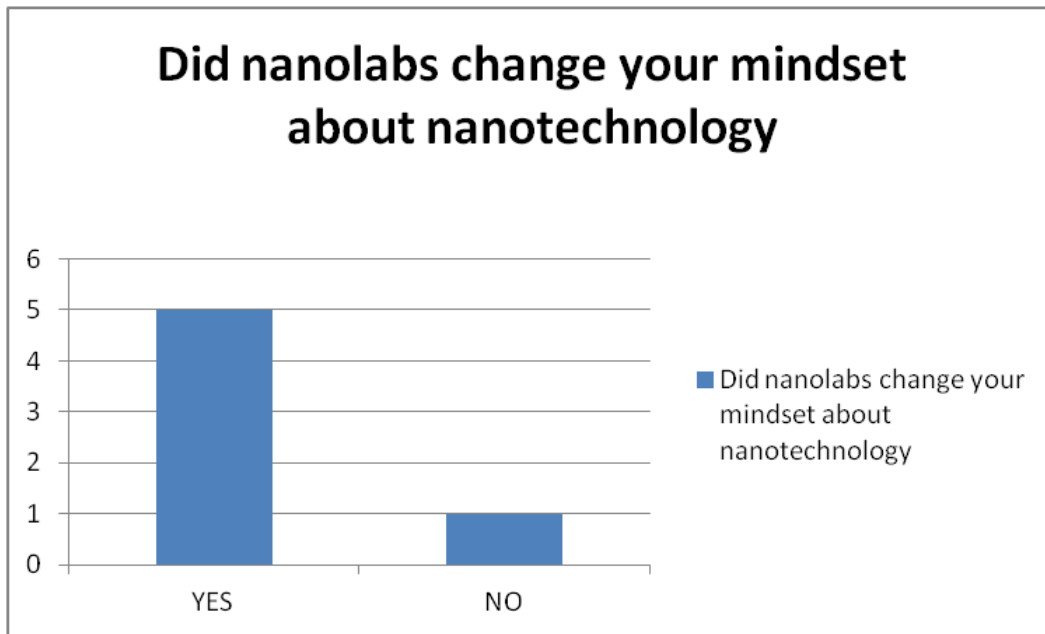


Figure 6. The results of the survey question “Did nanolabs change your mindset about the nanotechnology”.

3.3 Comments of High School Students

As a part of the program, total 10 high school students have been trained on different nanotechnology subjects. We had several conversations with the high school students about their goals and visions, which are basically summarized below:

- It is a great experience because everyone felt comfortable to ask questions and contribute to the discussions about the subjects.
- I like to learn more about nanotechnology, nanoscience, nanoproducts and their industrial applications.
- Hands-on nanotechnology experience program should continue with more experiments in the following years.
- This is a great opportunity for the Midwestern high school students.

Two of the high school female students, Ebru Barut and Nurseda Ergul, from Northeast Magnet High School and Andover High School, respectively, were so much excited about the lab sessions and opportunities and decided to continue their college degrees in the COE at WSU. Ebru said that “Being a part of the 2013 High school Nanotech lab class has influenced me a lot. It has given me a hands-on learning experience and opportunities about what engineers can do. With the helpful instructor, Muhammet Ceylan, we produced many substances, gels, and learned how to put together them. This will help me in the future because we learned how to build devices and create substances as a group by brainstorming and working together. Engineers must have good communication skills to form the top best invention; hence, “Two brains work better than 1.” We were also instructed to predict how much time it would take for the energy of a fan to run out and stop. All of these skills that we performed and naturally developed during this

experience are going to be very helpful for my future in engineering. I am glad that I have completed this class and am thankful to have the rewarded certificate in my possession”.

Nursedada mentioned that “My experience at WSU was really impressive. Being a high school student at Andover High School I didn’t really know how the college classes were held. Nanotech taught me so many things that my normal biology class didn’t in the classroom. My instructor was so great and helped me learn better. He explained everything very well and let us asks many questions during the lab sessions. In the Nanotech lab, I learned many chemical names and how they get mixed together in different solutions to make new products. I also learned many of the machines that are used in the colleges. I am grateful for being able to take this class and having experience on how the college system works. It also got me a head start in front of all the other high school students, so I’m more prepared and excited to join the engineering college soon”.

4. Conclusions

In the present work, we have selected 10 high school students in the different high schools in Wichita, KS and trained them in Spring 2013. The students were met once a week for 90 minute during the 14-week semester to improve the attentions of the high school students to the COE at WSU. The students were mostly involved in 10 different experiments in the field of nanotechnology. They learned the fundamental and practical knowledge on how to fabricate and characterize nanomaterials and devices using different techniques and procedures. The survey studies showed that the most of the high school students who attended this program were interested in joining the CoE at WSU, and continuing their education here after their high school degree. Overall, this study indicates that the nanotechnology education is one of the greatest options to increase the enrolment rates in the CoE at WSU by taking the interests of the local high school students.

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