Outreach to K-12 Students with Bio-Nano Concepts

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Abstract

We report a unique, engaging and interesting scenario to make K-12 students familiar with concepts of nanoscale. The approach incorporates an anchored instructional scheme supported by highly motivating and attention-grabbing hands-on activities followed by a visit to Nanotechnology Research and Education Center (NanoFab). The tutorial content is carefully designed to integrate basic and application-oriented knowledge to teach students with dissimilar knowledge-base and diverse backgrounds. The learning objectives are achieved by taking examples from daily life and demonstrating the underlying principles with simple but highly convincing hands-on activities. Practical demonstration of in-class learned concepts motivate the students to explore the new territory of bio-nanotechnology. Their excitement, thought processes and quest for exploring this field deeper is evident from the burst of questions and exchange of knowledge from their side. A tour of the NanoFab and Nano-Bio Lab is a very exciting addition to their learning environment and has helped better assimilation of the learnt concepts. The reported schemed has been repeatedly (3-4 times every year) implemented to educate K-12 students with bio-nano concepts. The exceptional outcome observed in result to the applied technique has established its efficacy over the past couple of years. The approach provides an appealing method to facilitate K-12 students with information, self-learning motivation and research aptitude development. The approach may cultivate next generation of engineers

dedicated to working in life science applications. Many collaborative efforts at academic and research levels are well-established already and these students can fuel our efforts to revive US higher education and high-tech research superiority in the world.

Introduction

Innovation and technological development requires skilled, trained and devoted citizenry. Modern electronic gadgets and other technological advancements trigger the natural curiosity and quest to explore these gadgets nurtures insights of students from very early parts of their lives. But, over the past few decades, students with engineering as their major have declined even in technically advanced countries like the United States.[1] Therefore, the youngsters should be encouraged and facilitated with tutorials, seminars and educational programs to augment their interest and knowledge in advanced technologies in order to expand a capable work force for next generation.

Nanotechnology has rapidly emerged among other fields of science and engineering. Growth and development of this field over the last few years has convinced researchers and scientists that it can sustainably knock over the prevailing technological models.[2] It has been speculated in many reports from last decade that nanotechnology would be a $1 trillion industry by 2015 and would accommodate more than a million employees in the United States. Evolution of this technology has been forecasted to incorporate approximately two million personnel all over the world engaged with this field by that same time.[3-6] Integration of biology and nanotechnology promises a great impact in life sciences. Collaboration of scientists and engineers can stimulate innovative ideas at the interface of the two streams (Biology and Nanotechnology). They can together possibly resolve various health issues by interrogating a certain disease at molecular level and offering an innovative, rational and realistic solution to the matter. Such a gigantic implication of bio-nanotechnology demands for a carefully designed academic program that merges basic and application-oriented knowledge from biology and nanotechnology to introduce bio-nano concepts to young students. Knowledge of this evolving technology at early stages of life would frame mature and skilled technological workforce that can revolutionize the characterization of diseased cells to predict their behavior and contribute towards early disease diagnostics, rapid drug discovery and localized drug delivery for better interventional therapies.

The growing field of bio-nanotechnology requires more individuals to dedicate their time and effort in making new discoveries about life at nanoscale. These individuals must be sought out and introduced to these concepts at a young age when their minds are capable of freely exploring and brainstorming new and creative ideas. K-12 students are at a perfect age to be taught the basic principles of nanotechnology so that they may gain an interest and pursue a career in this rapidly growing field. Teaching K-12 students is an important concern because their knowledge and interests will transform the future of nanotechnology. These students need the motivation to instigate a thought-provoking interest in bio-nanotechnology. This instituted curiosity will help them to bring in more innovations and reach greater achievements in the field. With students learning more about nanotechnology at a younger age, a much vibrant future in this field will be guaranteed. Also, it will induce a research aptitude in our youngsters and can result in cultivating our next generation with larger number of researchers in the field. Having trained and dedicated scientists/engineers would maintain the lead of the United States in key areas of nanotechnology innovation.

Educating K-12 students about new technologies and concepts has always been a challenge. Many efforts have been made to equip the K-12 students with nanotechnology that include various educational programs, teacher development plans and distant education services.[7-10] We report an appealing, straightforward and productive strategy to outreach K-12 students with bio-nano concepts. The students are approached with fundamental concepts supported by practical demonstration of the core impression through engaging activities, design problems of common interests and finally visit of the labs. This learning scheme has proved to be extremely helpful for the students to absorb the new concepts in a very exciting and inspiring environment.

Design and Description

The reported scheme incorporated three key elements to ensure a factual and effective assimilation of bio-nano concepts by K-12 students as shown by Figure 1. The first element involved a vigilantly designed integrative instructional material that combined basic and application-oriented knowledge from biology and nanotechnology. The second part incorporated various hands-on activities that were intended to demonstrate the learnt concept in a more convincing manner. Third and the most important component included a tour of the NanoFab for better internalization of the in-class learnt concepts.

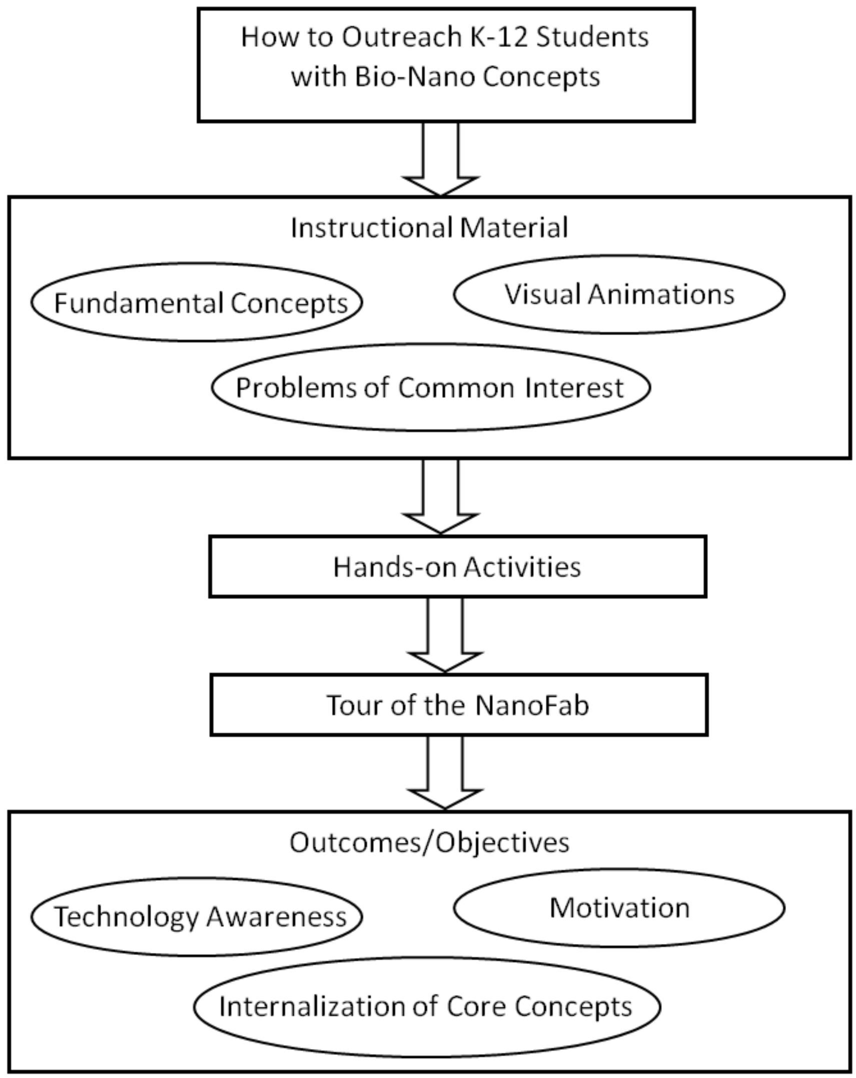

Figure 1. The design and intended outcomes of the learning scheme.

Developing Instructional Materials

The tutorial session contents were carefully designed with an aim to address K-12 students with varying backgrounds and different grasps of fundamental knowledge. The program course was offered to all students from elementary to high school grades. Therefore, students with a clearly indicated disparity of fundamental knowledge made up the class. This incongruity was sorted out by educating some very basic concepts and determining the students comfort level on these fundamental concepts. The students were triggered off to think of smallest things in their routine life. It helped to develop an interactive network in the class at the very beginning of the session. Verbal examples and visual paradigms from their daily life were deployed to take the students down the scale. The students were familiarized with different size scales by introducing interesting and exciting images of relatively larger objects step by step. Similarly, they were taken down the scale with the aid of fascinating images for smaller and smaller objects so that they could visualize nanoscale on comparative basis.

After establishing the nanoscale concept, the students were made acquainted with the significance and power of manipulating things at nanoscale. Nanoscale material properties (color, hardness, absorption band, biological behavior, etc.), its significance in daily routine life and potential impact in future was brought out in a very interesting fashion. The visual and electronic materials like videos and animations were employed for better internalization of the concepts and making it more attention-grabbing for the students. Several impressions and notions were demonstrated by certain hands-on activities which were carefully designed and embedded in the course contents to implement the just-in-time learning. The students' understanding of the concepts was also monitored after regular intervals by initiating a relevant problem-based activity. The tutorial material was developed in such a way that conclusion of every major concept was followed by hands-on activity or a problem-based activity. Integration of theoretical concepts, animations, practical activities, short questions and daily life examples into one course made it a very successful format to approach K-12 students with bio-nano concepts.

Hands-on Activities

Bio-nanotechnology broadly encircles nano-scale devices and biological entities. Awareness of K-12 students with the concepts of nanofabrication and behavior of biological molecules at nanoscale were the core objectives of the class. Oftentimes, comprehension of bio-nano concepts could be difficult for K-12 students. Therefore, the theoretical concepts were extended to practical hands-on experience for better understanding and absorption of the core concept. The students were facilitated with certain hands-on activities in order to grasp a particular concept. The activities were carefully devised with the clear intention to attain explicit objectives. Practical demonstration of theoretical concepts made the students more convinced in their understanding and motivated them to learn more about bio-nanotechnology.

Hydrophilic and Hydrophobic Surfaces

The activity intended to comprehend hydrophilic and hydrophobic surface incorporated colorful crayons, glass slide and a bowl of water. The students were provided an opportunity to make any pattern or writing on glass slides with crayons, followed by dipping the glass slides in water. The hydrophobic nature of crayon didn't allow the water to spread on its surface while hydrophilic glass surface permitted water to flow on its surface smoothly. This practical exercise directed the students to a quick, simple and comprehensible understanding of hydrophilic and hydrophobic natures of the surface.

Self-Assembly

Molecular self-assembly is present throughout the nature and technology. A wide range of complex biological structures owe their formation to self-assembling processes.[11] Therefore, knowledge of self-assembly is incredibly vital in bio-nanotechnology. The hands-on activity designed to demonstrate this concept involved a bunch of 3-4 cm long cut pieces of plastic drinking straws and a bowl of water. The students put a few of these straw pieces into water bowl and observed the movement of these hydrophobic tubes. Without external intervention, the hydrophobic straw tubes showed a tendency towards getting close to each other and form bundles. This autonomous patterning of the tubes stemming from their hydrophobic nature assisted the students to understand the concept of self-assembly in a very inspiring and pleasing manner.

Tour of the NanoFab

The NanoFab consists of a 10,000 sq. ft. cleanroom. The cleanroom has a large range of state-of-the-art instruments and equipment for fabrication and characterization, maintained by dedicated staff. The ever-increasing list of NanoFab equipment includes AFM, electron microscopes, focused ion beam and e-beam writers, nanoimprinter, mask aligners and standard silicon fabrication apparatus. The floor-to-ceiling glass panels make it easy to see all the activities going on inside. The students were taken on a walking tour of the Nanotechnology Research and Education Center (NanoFab). This activity worked as a catalyst for young students' motivation. They excitedly observed the researchers working in their white bunny suites in the cleanroom. Their excitement was evident from the continuous stream of questions from their side. This part of the learning scheme not only provided the students with an opportunity to experience the working of different nanotechnology equipment, better understanding of various bio-nano concepts but also induced a research aptitude in them. They were tremendously energized to pursue their career as research scientists after visiting the lab. This activity proved to be a crucial element for promoting interest and knowledge of advanced technologies in these youngsters who could be our next generation workforce for engineering and life sciences.

Conclusion

A simple yet very effective scheme has been developed to reach out to K-12 students with bio-nano concepts. The instructional system design and contents were intended to accommodate students from different age groups with assorted knowledge-base. An integrative tutorial content was designed to guide students' natural curiosity. The objective to familiarize the young students with bio-nano concepts was successfully achieved through visual-aided lessons, persuasive animations, supportive hands-on activities and thought-provoking problems. The practical display of in-class learnt concepts and visit of the lab electrified the K-12 students and provided them a more interesting and exciting environment to assimilate the core concepts. Focused learning of the new technology concepts increased the confidence in K-12 students. They showed more interest and pledge for scientific knowledge and it may result into a step forward towards technological development of our society.

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