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An Exploration of Students Needs for an App Based Interactive Nanotechnology Education

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An Exploration of Students' Needs for an App Based Interactive Nanotechnology Education

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Abstract

Nanotechnology education is being offered by more and more universities around the world as the field of nanoscience is growing exponentially. This paper explores students' needs on a mobile app based interactive self-learning for undergraduate nanotechnology education. The objective is to find baseline characteristics required to transform traditional instructor-driven and, lecture-intensive teaching to more engaging student-driven interactive learning based on mobile devices. In order to identify students' needs on the proposed concept, a content analysis and a prototype exploration were conducted with 80 undergraduate students.

Background

Nanoscience is the study of objects, structures, and materials on the nanometer scales. The field of nanoscience is growing exponentially over the past years and nanotechnology is impacting our daily lives in many ways [1]. The National Science Foundation (NSF) estimates that the job projection for nanotechnology will cover around several million workers worldwide and about $3 trillion in sales for nanotechnology related products by 2020[2]. With this demand, nanotechnology education is being offered by more and more universities around the world. This implies the importance of the education and training on a new generation of skilled individuals in nanotechnology. In other words, it is necessary to have an effective teaching and learning method in nanotechnology for college students. Many approaches have been investigated in order to increase the level of students' engagement in nanotechnology education[3-5]. However, nanotechnology in science and engineering is still generally being taught in a traditional manner that is typically based on lecture note slides along with a few multimedia supports such as movie clips and 2D/3D images. This traditional way of nanoscience education lacks high level of students' engagement.

A potential approach to address this challenge would be utilizing mobile devices which are getting more accessible by students and that would facilitate their participation and leverage their learning. We explore the needs of a mobile app based interactive nanotechnology learning method for undergraduate education. The primary objective is to transform the traditional instructor-driven, lecture-intensive teaching to more engaging student-driven interactive self-learning. The rationale behind the approach is that, in a nanotechnology class, discussions based on virtual experiments using the mobile app will greatly help students better understand the principles of nanotechnology.

Methods

Two methods - a content analysis[6], to review current teaching materials on nanotechnology education, and a usability testing[7], to evaluate the perception of students on a low fidelity prototype app for nanotechnology learning, were used as a low fidelity prototype exploration. Both methods were to identify the students' needs on mobile based nanotechnology learning with a goal to facilitate their learning experience both inside and outside the classroom. More specifically, the content analysis was chosen to analyze what forms of materials are utilized in teaching nanotechnology subjects. Teaching materials from four different subject areas including Introduction to Nanotechnology, Scaling Law, Devices, and Applications, were collected from existing Materials Science and Engineering (MSE) courses that were taught by faculty in the College of Engineering and Computer Science (CECS) and NanoScience Technology Center (NSTC) at the University of Central Florida (UCF). The prototype was a graphical mock- up screen shown in Figure 1. The graphical mock-up was designed to evaluate the feasibility of the mobile app based nanotechnology education. A set of pre-and post-survey was used before and after experiencing the graphical mock-up. A selected group of students aged over 18 years at the UCF majoring in disciplines related to nanotechnology participated in the study. An IRB was approved for the study (SBE-14-10083).

Figure 1. A Graphical Mock-Up for Nanotechnology Education

Results and Discussions

Content Analysis

Four lecture materials about the Concept of Nanotechnology, Scaling Law, Devices, and Applications were collected and reviewed in terms of the format of the lecture materials. All of the four lecture materials were Power Point presentation slides. All the slides had images and diagrams that explain nanotechnology related content. The images in the lecture materials were a mix of colored and black/white images and a few of them were 3D-designed visualizations. The diagrams were conceptual drawings, scientific charts and 3D-designed visualizations.

Certain subjects in the Power Point presentation slides included movie clips that were linked to YouTube.

Prototype Exploration

We contacted instructors who taught entry level courses related to nanotechnology in order to recruit potential participants for evaluating the prototype app of a graphical mock-up. A total of 80 college students participated in evaluating the prototype. The major portion of this group was comprised of students who were in their junior year (35%, 28 students out of 80) as shown in Figure 2. About 90% of the participants (72 students out of 80) heard about the name, nanotechnology or nanoscience. Although most students are familiar with the name, about 10% of the participants (8 students out of 80) never had a chance to know the description of the subject title. For those who heard about nanotechnology or nanoscience, they heard the name from the TV, the Internet and classrooms. The TV was the primary source where they heard the name, nanotechnology and the classroom was the primary source where they both heard and learned (to a small extent) about nanotechnology.

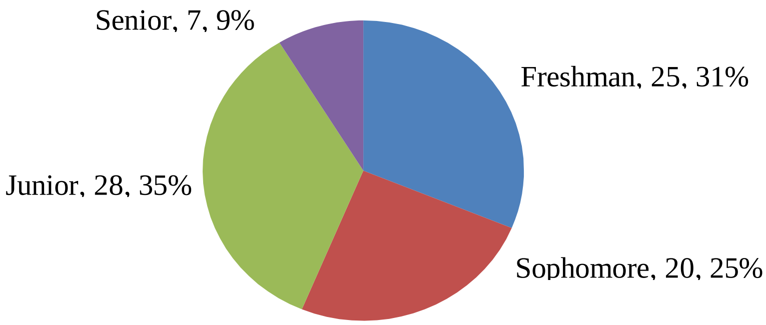
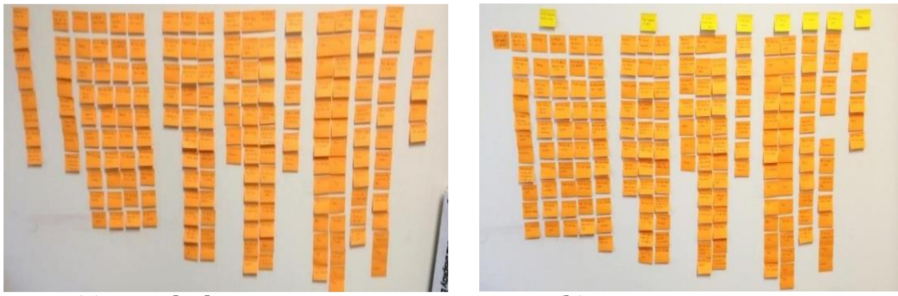


Figure 2. Participants Distribution

We asked the participants a total of four questions in the four subject areas of nanotechnology. It seems that the participants do not have a good understanding on the four subject areas based on a one sample t test ($p = 0.087$, $m=0.26$). We wanted to know what factors would hinder their learning of nanotechnology and asked the participants to list three items that most limit their nanotechnology learning. The participants provided a total of 182 feedbacks for the question. We invited two independent coders and asked them to do a card sorting placement as shown in Figure 3. It was an iterative process in which the two independent coders first placed all the feedback items as shown in Figure 3 (a), then reorganized them into groups of different categories as shown in Figure 3 (b).



(a) Initial Placement (b) Categorization

Figure 3. Snapshots of the Card Sorting Task

The card sorting identified the eight themes shown as the bright Yellow sticky notes in Figure 3 (b) that would hinder their learning of nanotechnology. The eight themes are 1. Lack of Informational Resources to Learn, 2. Little Background in Science, 3. No Involvement in the Subject Area, 4. Limited Human Resources to Communicate on the Topic, 5. Lack of Time to Learn, 6. Subject Difficulty, 7. Lack of Interest, and 8. Cost and Budget. Figure 4 shows the count of each theme. As seen in the figure, "The Lack of Informational Resources", represented as the number 1, was the major factor that the participants thought which affected their learning of nanotechnology.

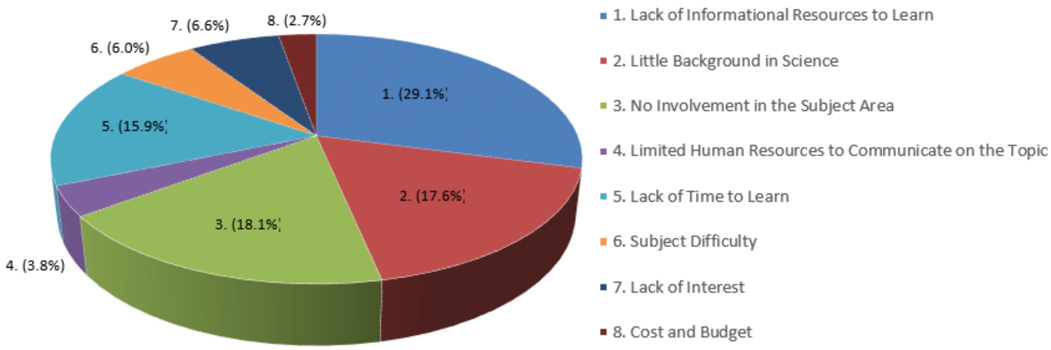


Figure 4. Distribution of the Eight Themes

In addition, we wanted to know what study aids they used for learning nanotechnology. We received a total of 82 answers. 56% (42 out of 82) of the participants used a certain type of study aid during learning. Among the population of students who used study aids (56%), 41% (34 out of 82) used the Internet, 8% (8 out of 82) used paper based aids, and 5% (4 out of 82) used TV or movie clips. An interesting finding was that 44% of the participants (36 out of 82) did not use any study aids. The distribution is shown in Figure 5.

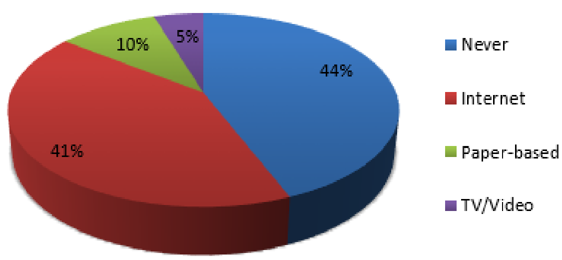


Figure 5. Distribution of Study Aids Used by the Participants

We hypothesized that students would like to study nanotechnology as a group rather than individually. The results showed that there is no significant preference between the two study types statistically ($p=0.128$, $m=3.5$). However, it was observed that the reason for studying together was to help each other with further understanding on nanotechnology by collaboration and interaction (36%) as shown in Figure 6. The other reasons for group study were to help each other to understand better on the subject (26%), enjoy the learning by studying together and reinforce each other in learning nanoscience (23%), and advance their knowledge by taking group study (15%). These answers were interpreted as "to make themselves engage in nanotechnology learning". Figure 6 shows the overall distribution of the feedback on the needs of a group study.

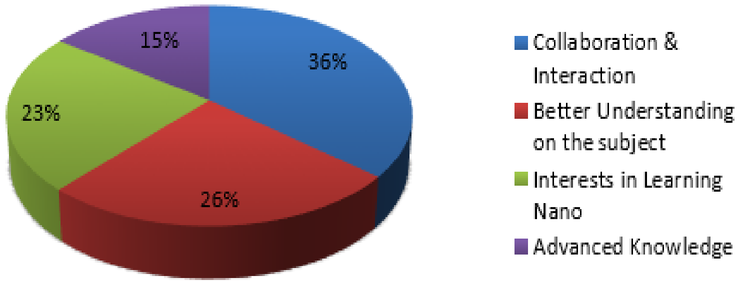


Figure 6. Distribution of Study Aids Used by the Participants

The participants seem to like both a web interface based nanotechnology learning method (p=0.036, m=6.5) and an app based learning method (p=0.02, m=6.5). For a question, which format of learning they prefer between a web interface based method and an app based learning method, there is no significant differences between the two methods (p=0.563). We asked the participants about the concept of an app based nanotechnology learning using the mock-up screen shown in Figure 1. It appeared that they think the prototype app is helpful for their nanotechnology learning (p=0.010, m=7.5). They liked the feature of the Virtual Experiment the most, followed by Assessment, Visualization, so on as shown in Figure 7.

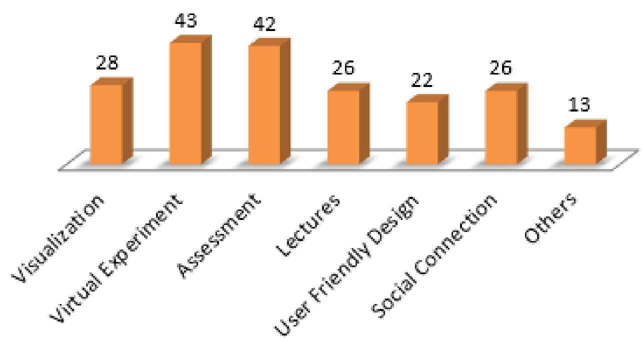


Figure 7. Participants' Preferences on the Features of the Mock-Up

For a question, what features they would like to include in an app based nanotechnology learning if they were part of the design team, the commented the following potential features: Social, Collaborative User Interface, Virtual Experiment, Multimedia, Assessment, Accessibility in User Interface, and Visualization. We asked what they would like to include in the app if they were a part of design team. They would like to include - nanotechnology examples in the real world, An actual nano lab that they can have as hands-on experience, effective visualizations as diagrams/interactive figures, tablets as a stereo scope, effective assessment module testing their learning progress periodically, persuasive module (e.g., comparison to fiend grades), and gamification concept rewarding their learning (e.g., scholarship). Figure 8 shows the overall distribution of their desire of features for an app based nanotechnology learning.

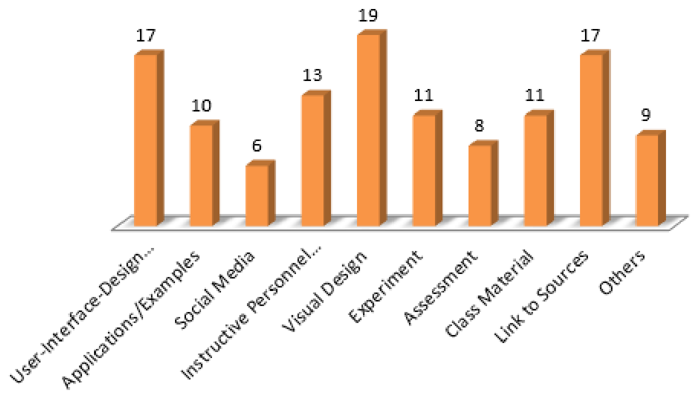


Figure 8. Participants' Desire of Designing an App

Conclusions and Future Works

This paper explored students' needs on an app based learning method for undergraduate nanotechnology education. A content analysis and a test on usability with a mock-up screen were conducted with a total of 80 potential users. The study revealed certain characteristics affecting their learning of nanotechnology that need to be taken into account in designing a mobile app and its content for nanotechnology education. The lack of informational resources was their primary concern in learning nanotechnology. Among survey participants, around 4 out of 10 students do not use any study aids for their nanotechnology learning. Regarding the proposed mobile app, the virtual experiment feature was what they liked the most among the other features. They would like to make the app more effective by putting together visual interfaces and information richness. The proposed app-based tool will facilitate students' learning by engaging them with rich information resources and virtual hands-on activities.

Acknowledgement

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