Concepts of Nanoscience for Non-Scientists: A Distance Education Course Coordinated Among Three Universities

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Abstract

A nanotechnology and ethics course, joint among Auburn University, Tuskegee University and Auburn University at Montgomery, was developed and offered for two semesters. The course was structured as a distance education course, and broadcasting equipment allowed students at all three campuses to view the lectures in real time. The course material was formatted for a freshman level science elective, and lecturers spanned all three campuses and various disciplines including but not limited to: chemical engineering (4 instructors), biology (2 instructors), philosophy (2 instructors), English (1 instructor) and history (1 instructor). The course overview and outcomes will be discussed.

History, Goals and Framework

The course, "Concepts of Nanoscience" began as a proposal, "Ethics of the Nanoscale" to the National Science Foundation. The proposal included several education components, but this discussion will be limited to a distance education course joint among Auburn University (AU), Tuskegee University (TU) and Auburn University at Montgomery (AUM).

The goal of the course was to offer an introduction to the science and ethics of nanotechnology to students who would not otherwise be exposed to the topics. The course was structured for freshman non-science majors. One challenge was to find a framework for the course. At AU, freshman, non-science majors can enroll in a survey course, "Concepts of Science." "Concepts of NanoScience" was offered as one section of the multi-section "Concepts of Science" course. At TU, the course was administered through the Provost's office due to its interdisciplinary nature and non-scientist target audience. At AUM, offering the course as a lower division science course without a lab did not meet the requirements of the curriculum committee. Thus, the course was offered through the biology department due to its large nano-biotechnology and environmental components.

Content

Lecturers and content spanned various disciplines including but not limited to: chemical engineering (4 instructors), biology (2 instructors), philosophy (2 instructors), English (1 instructor) and history (1 instructor). Nanotechnology: A Gentle Introduction to the Next

Big Idea [1] was chosen as the primary text for the course. Table 1 provides a list of the course topics. The course begins with an introduction to nanotechnology and proceeds to outline basic chemistry and physics principles with respect to nanotechnology. Approximately three lectures are devoted to a discussion of various nanostructures with particular emphasis placed on carbon nanotubes. Next, two lectures are designated for the discussion of instrumentation required for research in nanotechnology. For example, students are introduced to the transmission electron microscope (TEM) for characterizing nanoparticles. Next, various applications of nanotechnology are introduced that include, but are not limited to, nanocomposites, nanoelectronics, nano-electro-mechanical systems (NEMS) and nanofluidics.

The next phase of the course is dedicated to an introduction to ethical theories and the ethical implications of nanotechnology. The allocation of one-fourth of the course to this discussion reflects the interdisciplinary course that was originally proposed to the National Science Foundation. Finally, the course ends with a discussion of nanobiotechnology and environmental implications of nanotechnology. Upon the introduction of each topic, a detailed overview is required because the students are freshmen with only high school science and math preparation. For example, prior to an in-depth discussion of nano-biotechnology, students are given foundational elements such as an overview of the principles of cell biology and environmental biology.

Table 1: Concepts of Nanoscience Course Topics

Topic	Lectures	Broadcast Origin
Introduction to Nanotechnology	4	AU
Principles of Chemistry and Physics on the Nanoscale	2	AU
Nanostructures	3	AU
Instrumentation	2	AU
Applications of Nanotechnology	3	TU
Introduction to Ethical Theories	8	AU
Ethical Implications of Nanotechnology	3	AU
BioNanotechnology	7	AU
Environmental Implications of Nanotechnology	7	AUM

Structure and Execution

Once the framework for the course was identified at each institution and the content was determined, several logistical issues needed to be addressed. First, each university is on a different class schedule. Both AU and TU offer Monday/Wednesday/Friday (MWF) and Tuesday/Thursday (TTh) courses, but AU starts on the hour and ends at ten minutes until the hour whereas TU starts at ten minutes after the hour and ends on the hour. AUM does not have class on Friday. The compromise was that the course would be offered MWF with forty minutes of core content. AU handled issues like homework and announcements for ten minutes before class, and TU handled those issues for ten minutes after class. All sessions were recorded, and AUM viewed the Friday session off-line.

Another issue was the scheduling of institutional breaks. Each institution had different spring breaks, semester start/end dates, holidays, etc. Long breaks such as spring break were coordinated by viewing recorded lectures during those periods. The semester start/end dates in some cases were close enough for all three institutions to coordinate and in other cases were handled by viewing recorded lectures.

Distance education equipment was purchased (as necessary) and configured for all three universities. All three institutions had access to views of the other two institutions during lectures, but, typically, the lecturing institution was viewed unless another institution was asking a question. Because the course was viewed in real-time, it could be and was very interactive. This opportunity for an improved extended-classroom dynamic couldn't be realized for a distance education course that is recorded and viewed off-line in its entirety.

Offerings and Enrollment

The course was offered during the Spring 2007 and Fall 2007 semesters. Course enrollment data is provided in Table 2. Enrollment (pre test participation) was significantly higher at Auburn University because the course was one section of an established course. At Tuskegee University, the course was acceptable for "science elective" credit, but, despite heavy advertising, students and advisors were accustomed to more traditional courses and chose those. Enrollment at AUM was affected by the lack of a laboratory offering, since even all majors must have two laboratory science classes to meet basic curriculum requirements. At AU, the lower division Concepts of Science course, which is targeted at non-science majors, has a recitation hour instead. The curriculum committee at AUM would not allow a recitation to be substituted for a laboratory.

Outcomes

Student learning for the purpose of assigning a grade was assessed using four in-class exams and a comprehensive final exam. However, the impact of the course was assessed by administering pre-course/post-course tests to the students. The results of the pre-test and post-tests are outlined in Table 2. The pre-test was administered to establish the baseline for student knowledge of the subject matter. Typically, the post-test was administered after the final lecture but prior to the final exam. The pre/post test consisted of 32 questions (24 True/False-type and 8 short answer). Table 2 shows the number of students participating from AU, TU and AUM and their corresponding pre/post test average scores. For AU, all students who completed the pre-test did not complete the post-test, and the pre/post assessments were not matched in the end. Consequently, it was possible that the students who scored the lowest on the pre-test did not take the post-test and thus inflated the score difference. To remove this error, the pre test results reflects both the average of all the students tested and the average of the students scoring highest on the pre-test corresponding to the same number of students who took the post test at AU. The second number reported in the score difference column gives the most conservative estimate of student learning because it is calculated from the arbitrarily higher pre-test scores. Another issue is that 24/32

questions were True/False-type implying a baseline of zero knowledge at a score of 12/32⇒37.5% for random guessing. Despite the aforementioned challenges with the assessment exercise, it is clear that the students' knowledge of the subject matter improved significantly ranging from 7.8 to 29.2%.

Conclusions

A distance education course joint among Auburn University, Tuskegee University and Auburn University at Montgomery was offered to introduce non-science majors to the concepts of nanoscience. The course was offered for two semesters during 2007. The majority of the lectures were conducted in real time so that students from all three campuses could interact with the various lecturers and students at other campuses. Although several logistical issues were encountered, the course ran smoothly for two semesters. Analyzing the results of assessment tests given to students revealed that their knowledge of the concepts of nanoscience improved by 7.8-29.2% as a result of completing the course. Moreover, it was demonstrated that three universities can offer a coordinated, real-time, distance education course to expose non-science students to the science and ethics of nanotechnology.

Table 2: Concepts of Nanoscience Enrollment and Assessment Data

School	Term	Pre Test		Post Test		% Diff
		# Students	Avg. score (%)	# Students	Avg. score (%)	
AU	Spr 07	31	68.1/75.7	16	91.2	23.1/15.5
AU	Fall 07	18	67.8/72.8	11	89.1	21.3/16.3
TU	Spr 07	4	62.5	4	70.3	7.8
TU	Fall 07	2	60.9	2	90.1	29.2
AUM	Spr 07	2	72.4	2	92.6	20.2
AUM	Fall 07	1	-	1	-	-

References

Ratner, M. and Ratner, D., Nanotechnology: A Gentle Introduction to the Next Big Idea, New Jersey: Prentice Hall, 2002.