Promoting Science for All by Way of Student Interest in a Transformative Undergraduate Microbiology Laboratory for Nonmajors†

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In this study, we investigated a pedagogical innovation in an undergraduate microbiology course, Microbes and Society, for non-microbiology majors and education majors. The aim was to improve students’ understanding by connecting their science experience to their areas of interest. Based on this idea of teaching, we redesigned the laboratory portion of a microbiology course. We had students in the laboratory component choose their areas of interest and use the areas as a framework for understanding science and how it influences and shapes the world around them. This course was part of a longitudinal project (Project Nexus) which prepares, supports, and sustains upper elementary and middle-level specialist science teachers. We used a battery of data collection instruments. We analyzed all data in several dimensions including using active-learning techniques, forming linkages between science and teaching, and connecting science and society. Our hypothesis was that we could promote science for all by connecting the diverse students’ areas of interest in science to the laboratory’s curriculum. We assessed the success of achieving our goal by using researchers’ observations, the instructors’ perspectives, and students’ feedback. Our findings suggested that this course was appreciated by the students, especially education majors, who recognized the innovations as engaging and worthwhile.

In this study, we investigated a curricular and pedagogical innovation in an undergraduate microbiology course, Microbes and Society, for non-science majors. The aim was to improve students’ understanding of science by connecting their prior experiences and interests to the science content.

For several continuous years, the instructor of the course (Benson) promoted active learning. His strategies to enact active learning were a blend of research-based recommendations. The strategies included the encouragement of student questions, small group activities, whole class discussions, and the use of multimedia (e.g., videotape films) and instructional technology. The next step in the development of the course was to add a science-for-all focus (7). After careful deliberation, the strategy to promote science for all was via student interest.

Teaching science for all is a major goal in science education. The goal of science for all is to teach science with an appreciation for the unique needs and characteristics of students in the class, while responding to the individual learner’s background. Science instructors who aim to emphasize teaching for all have to decide what new approaches to include in their practices that are frequently absent in more traditional science lessons. Suinn (18) and more recently Potter and Overton (14) argue that taking differences among learners seriously will result in an educational environment that better enhances learning by each student.

Generally, most science courses are content driven and reinforce students’ negative view that science is a collection of facts unrelated to their world. Nonmajors and members from traditionally underrepresented groups experiencing science in a teacher-directed manner particularly had a diminished interest in the subject (6, 9). An established set of studies (see reference 20) reveals that most of these kinds of science courses that emphasize facts only use a reproductive model where information is presented in didactic lectures, memorized by students, and reproduced on assessments. Linking the material to students’ lives is not generally promoted in the courses. Instruction with an emphasis on lecture has been in common use because it is an efficient method for presenting a large amount of content in a short time. However, under this method, only a few students gain enduring learning; the majority of students do not (11). In contrast, an emerging body of research indicates that students who are intrinsically interested in an activity or topic are more likely to see challenging tasks as worthwhile, think more creatively, exert effort and learn at conceptual levels higher than those of students who are not intrinsically interested (see references 8 and 19). Schiefele, Krapp, and Winteler (17) in their metaanalysis of 16 studies published between 1965 and 1990 in a variety of subject areas show a significant correlation between interest and academic achievement.

We also believe it is potentially fruitful to promote the nature of science (NOS) and to take science-technology-and-society (STS) and socioscientific issues (SSI) perspectives to present science authentically (3). We believe these perspectives promote students’ engagement and interest in science. The STS and SSI approaches emphasize the application and
relevance of science to everyday life through engagement with salient issues and therefore are expected to increase students’ motivation to learn science (5, 10, 16, 21).

Based on these ideas of teaching, we redesigned the laboratory portion of a microbiology course that already used an active-learning approach in the lecture component. We decided to allow students in the laboratory component to choose their areas of interest and use them as a framework for understanding science and how science influences and shapes the world around them (13).

The microbiology course is part of a longitudinal project called Project Nexus. Project Nexus is designed to develop and test a science teacher professional development model that prepares, supports, and sustains upper elementary and middle-level specialist science teachers. Project Nexus is a funded project in the National Science Foundation’s Teacher Professional Continuum program (www.projectnexus.umd.edu).

In this study, we focused on (i) describing the way we used students’ interests in the lab, directing them to STS and SSI perspectives, and (ii) forming linkages between science and teaching, while introducing the students to scientific research through reading the literature, writing miniresearch reports, and sharing their data in poster presentations.

Our hypothesis was that drawing on the unique needs and characteristics of students in an undergraduate microbiology laboratory for nonmajors by connecting to their area of interest would produce an educational environment that would enhance their learning. We assessed the success of achieving our goals, which rest on the students’ engagement with the content, by the using researchers’ observations, course and lab instructors’ perspectives, and students’ feedback. We also used a pre- and post- Views on Science-Technology-Society (VOSTS) survey for effective measurement.

**Description of the course.** The course Microbes and Society is a four-credit course, with two 75-minute lecture sessions and two 1-hour laboratory sessions per week. Microbes and Society looks at the fascinating roles that microbes play in the world around us. The course helps students develop an understanding of basic concepts in biology: the unity of life, evolution, disease, antibiotic resistance, the roles microbes play in providing food and recycling waste, and roles that cultural and societal influences play in the spread and control of microbial diseases.

In the laboratory part, taught by a graduate student in science education (Schalk) with a Master’s degree in molecular biology, students design experiments, research microbial-related information, discuss how science is used to solve problems, and experience hands-on the world of microbiology through the lens of their own personal interests. The weekly laboratory sessions are designed with a focus towards letting each student explore scientific questions they have about life.

The laboratory sections were held in three different types of classrooms based on the nature of the different laboratory activities (Appendix 1 in the supplemental material summarizes the laboratory activities over the semester):

(i) **Wet-bench hands-on labs.** There were eight sections of wet-bench hands-on labs, which took place in the microbiology laboratory. Students exercised basic microbiology lab skills, such as culturing different types of microbes from different body parts (e.g., the mouth) on petri dishes and using microscopes to view different types of microbes and microbial cultures.

(ii) **Computer-based labs.** There were 14 sessions of computer-based labs, which took place in the education building. The computers were used for three different types of activities: performing microbiology genetic research using information from GenBank and from the National Center for Biological Information website, searching the web for scientific literature, and presenting the progress and final products of individual and group projects.

(iii) **Computer technology classroom.** Towards the end of the semester, students met at the computer technology classroom, which contained the technology needed for presentations (i.e., a PC projector and screen), to present their group end-of-semester project presentations. Each group had 20 minutes to present their project using a PowerPoint presentation.

Several different assessment tools were used throughout the semester to gauge students’ understanding, including weekly reflective assignments, laboratory reports, group project assignments, and a group presentation (available from the authors upon request). The assessment design itself was intended to further motivate students’ desire to learn and realize their level of knowledge through reflection and teaching their peers.

**The individual and group projects.** During the first two labs, students were asked to choose an independent project topic, based on their interests, from a list of categories: diet and nutrition, health and disease, your environment, language of life (DNA and genetics), technology, business, and money. For the next 6 weeks, students researched a question relating to the topic they chose, by examining the existing knowledge and debates about it. The individual projects were designed according to a given template (Fig. 1) and were presented as a KEEP poster (KEEP is free software for students to organize their research topics in a poster format that can be shared online, [http://www.cfkeep.org/static/index.html]).

Following presentation of the individual scientific projects, the instructor discussed with students how they could adapt their projects to teach 5th graders science according to the 5E inquiry model (engagement, exploration, explanation, extension, and evaluation). The 5E inquiry model is a well-established learning activity structure (4) promoted in science lessons for precollege students. This framework is designed to increase student engagement, motivation, and achievement. It provides a flexible yet consistent structure for developing and conducting effective lessons. Students were given KEEP templates (Fig. 2) to explain how their individual research could be displayed. Students presented their 5E model posters on the KEEP website to share with the whole class.
The next step was to work on group projects. Students collaborated in six groups on their final research projects. Groups included students with similar topics of interest. Groups used some of the lab sessions to research their topic online and develop ideas together. The students were asked to be creative and present their projects in an interesting way for different types of audiences. Since one of the course goals was to connect science to teaching, another specific task was to explain how the project could be presented to 5th graders. Each group prepared a 20-minute presentation, which included a PowerPoint component. Following each presentation, the class and the instructor asked questions and reflected on the project orally and on written feedback sheets. Examples for final project topics were “What are the health benefits of organic and conventional milk?” “How is the microbe Escherichia coli used in genetic therapy to treat individuals with pituitary dwarfism by growing the human growth hormone?” and “What are the positive and negative effects of Bt crops and should they continue to be used in the future?”

**METHOD**

**Sample.** Twenty-seven students enrolled in the course. They were recruited by proactive techniques such as the
posting of an engaging flyer for the course on bulletin boards throughout the campus, particularly in the College of Education and the various nonscience buildings. In addition, undergraduate advisors across campus were notified of the course and were encouraged to recommend it to students who needed a science course or wanted to experience learning science for all in an active-learning environment. Those majoring in education were especially encouraged to enroll in the course.

The recruited students represented much diversity across several dimensions. Figure 3 shows students’ demographic distribution \((n = 24)\) students who responded to the survey that included questions regarding students’ demographic background.

**Data collection and analysis.** In this study, we used qualitative and quantitative methods. For the qualitative data, all laboratory sessions were videotaped and observed by three university science educators (McGinnis, Marbach-Ad, and Dai). One observer was a female professor who serves as the director of the College of Chemical and Life Science Teaching and Learning Center at the University of Maryland, one was a male science education professor in the Curriculum and Instruction department, and the third was a female science education graduate student with a biology background. As a research team, we attended every class session and took extensive notes that focused on documenting and interpreting the nature of the classes and the degree to which the instructional objectives were achieved. We collected all students’ reflective assignments and class artifacts. We also collected students’ end-of-sememster feedback surveys. For the qualitative analysis of the open-ended questions in the students’ end-of-semester feedback, we used a modified content analysis strategy (15).

All of the participants, including the two instructors and their students, were interviewed by the three course observers. The pre- and post-course interviews with the laboratory and lecture instructors were semistructured and included several predesigned key questions which were followed by probing clarification questions about issues that were raised during the interview. The pre-course survey included four key questions:

(i) Describe your science course including the science content and your teaching style,
(ii) What are you teaching in your science course that you believe will benefit your students who become science teachers?
(iii) What assessment are you using in your course?
(iv) Are there features of your assessment that will benefit your students who become science teachers?

The post-course survey included three key questions:

(i) In thinking back over this course, what are some of the most beneficial learning experiences that you included in your course for those students who become future upper elementary or middle school science teachers?
(ii) In what ways would you say you taught science to benefit all students?
(iii) Thinking back over the course, what would you have done differently?

All of the interviews were transcribed and analyzed by a science education graduate student with a science background (Pease). She read all of the interview data and reported on themes that were relevant to our study (i.e., using students’ interests and active-learning approaches to promote learning, teaching science with an STS perspective, and using alternative assessments). These themes were reviewed by the research team and assessed as to their accuracy and level of insightfulness. Once consensus was obtained, the first author extracted from the report data to show the benefits and challenges of our innovation.

The quantitative data were obtained from pre- and post-course survey results. The VOSTS (available from the authors upon request) is an empirically-developed item pool, its conceptual scheme offers a taxonomy of STS topics (1, 2). Each VOSTS item displays the same multiple-choice structure: a stem poses a contextualized and specific STS problem, which is the stimulus (object) to elicit the respondent’s attitude; this followed by a list of empirically developed multiple-choice statements (from 5 to 13, mean about 7) which represent different reasons for the answer given. The VOSTS instrument does not employ a Likert-type selection style, since the developers of the instrument purposely wanted to expand upon the options to more finely tune their data collection. Instead, each item lists a range of options that are best reported as changes in

![FIG. 3. Student background information (self reported, \(n = 24\).](image-url)
frequency of response. The VOSTS empirical development process was based on open-ended questionnaires and individual interviews of a large sample of participants. Since its development as an instrument, researchers have used portions of it to investigate delimited areas of interest. In this study, we administered a subsection of the instrument (n = 15 items) that asked for students’ responses to questions that related to the cultural and social dimensions (see reference 2 for the “Miscellaneous” section). To determine possible changes to the participants’ STS perspectives, we selected the two most relevant items to report participants’ responses.

RESULTS

We analyzed all data in several areas, including students’ interest and the connection between science and teaching. We report on the following:

i. Researchers’ observations and field notes from a lab session.
ii. Interviews with the laboratory and course instructors.
iii. Students’ end-of-semester feedback and reflective journals written during the semester.
iv. Students’ responses to two questions from the pre- and post-course VOSTS survey.

Researchers’ overview. We documented the following strategies that were used by the lab instructor to increase students’ interest in science as a way to promote “teaching for all.” During all lab sessions, the instructor encouraged in-class and out-of-class student questions, which she answered in class or through e-mails. The instructor used multiple channels of communication with the students: PowerPoint presentations, white board, microscope demonstrations, computer-based labs, and wet-lab experiments. Students were also engaged in poster presentations. The students were asked to write individual reflective assignments following almost every lab section, where they reflected on their learning experiences and communicated with the instructor on their satisfaction with the course. Each student chose, from a list of set categories, an area of interest on which to do a research project. The students’ interest projects counted as 34% (86 out of 250 points) of the laboratory grade. The instructor emphasized the importance of this project by assigning it a high percentage of the final lab grade. Following the individual project, students collaborated to work in groups on their final research project, which was presented orally with the aid of a PowerPoint presentation to all participants assigned to the same lab section.

Other goals of the course included guiding students to the realization that microbiology has implications for everyday life and helping students develop technological fluency. The observers reported that lab activities were usually connected to the use of scientific knowledge to solve everyday life problems. For example, students were asked to compare a given protein sequence with known proteins in the National Center for Biological Information website and then identify the most likely human illness caused from the prokaryotic species most closely associated with this given protein. This lab assignment also highlighted the use of technology in today’s scientific research.

The group projects all dealt with aspects of science, technology, and society. Some questions within the reflective assignments were also concerned with science-society connection, for example, “Reflect on a specific example of interest to you that relates our scientific understanding of how microbes’ metabolic and/or fermentative processes can be used to benefit people or societies.” Students also used technology to find literature for their projects and to communicate with the instructor. A disadvantage for the course in terms of technology was the fact that the university had just changed the course management system from WebCT to Blackboard. Blackboard has a different interface than WebCT, which caused difficulties for the instructors and the students. As a result, both the instructors and the students had to learn new skills to successfully access and navigate the new system. Initially the difficulties with the communication technology provoked a negative reaction from many of the learners, but by the end of the semester their increased familiarity with the Blackboard system removed that issue as a chief concern.

To emphasize the links between science and teaching, the lab instructor made explicit and transparent the pedagogy she used and why she was using it, whenever possible. For example, she discussed why she put students into groups, why she encouraged discussions, and why she was asking them to reflect on the course using their reflective assignments. She explained to the students that these strategies were important, especially when one works as a teacher with precollege ages. She devoted an entire lab session to explaining the scientific process using the 5E model of engagement, exploration, explanation, extension and evaluation. The lab instructor also elaborated in a lab session on different skills needed when you are teaching: skills of communication to teach at the level of your audience; skills of leadership to motivate and engage your audience and have them believe that the lesson is important; skills of communication to reach different learning styles, ethnic backgrounds, and personalities; and skills of communication to recognize and remove confusion. Over the semester, she constantly encouraged students to share their different expertise and understandings of a topic in front of the class as a way to exercise teaching.

Lab and course instructors’ overviews. The lab instructor, when reflecting on the semester, provided her perspective along with a few suggestions for possible improvements. When asked explicitly about the way she used students’ interests in the lab, she shared the following viewpoint:

“…The goal of the course was to basically let each student pick their interest and then try to expand upon their own knowledge through their own enthusiasm for whatever it was that interested them. How did that work out? I would say that the beginning was very inspiring and all of the students
seemed very much engaged with it, which helped to form a community. . . . As the semester wore on and there began, as with all learning, which required work, time management skills and discipline, it got challenging at times, but I think that in the end the final projects gave the students an opportunity to successfully show where their interests lie and what they learned.”

According to the course instructor, who was also a major designer of the laboratories, the goals of the lab sessions were twofold. He hoped to (i) lead the students to the realization that microbiology had implications for everyday life and (ii) help the students develop technological fluency by requiring them to use the Internet and web-based tools to find information, develop presentations, and complete other assignments.

“[W]e use a web-based presentation tool called KEEP for presentations because part of the goal of this reformed lab, which was not a goal in the prior lab, is to help the students through the laboratory to develop technological fluency. And technological fluency is the ability to navigate the digital world in a way that allows them to find and assess information and to be able to transmit information.”

Commenting on the technology component of the course, the lab instructor suggested that in the future she might increase the number of hands-on activities while decreasing the number of computer labs, since she felt that the technology component could have become overwhelming for the students at times. Since the Microbes and Society course was a course for nonmajors, the goal of the course was not to influence the students to major in science, but more to open their eyes to the process of scientific research and to expose them to everyday scientific literature.

Another goal was to connect science to teaching, particularly to meet the needs of the education majors but also to give the nonmajors another way to engage actively with the science content. The lab instructor in the interview shared her wish to influence some of the students to consider science teaching as a career.

“[A]s we move on throughout the semester it’s definitely geared towards activities of what a teacher would do. They’re going to be designing an experiment and doing a research project, and these are all tools that, really when it comes down to it, are professional tools that you would use as a teacher. . . . I mean the true exercise is building skills for a teacher, more so than it is for other professions.”

**Students’ feedback.** The students’ end-of-semester feedback included answers to open-ended questions as well as multiple-choice questions. One open-ended question applied to the teaching-for-all thrust of the course. The question was this: “One goal of the course was to encourage students to feel connected to the science subject matter by use of active learning (i.e., student-centered learning) and by taking into consideration students’ backgrounds and interests (i.e., science for all). What elements of the course would you identify as aligning with this course goal?” Thirteen students answered that the lab reflective assignments and projects (mostly in groups) aligned with the course goals (“I thought they helped keep me engaged in learning.” “They were good and interesting,” etc.). Seven students mentioned the ability to choose an area of interest (“Letting us pick topics, asking for feedback—good communication”). Four students mentioned the lab work groups (“I thought they helped keep me engaged in learning”). Three students mentioned the wet labs (“I learned a lot because it was hands-on”). A few students suggested that there should be more wet labs in future versions of the course. Other students mentioned the positive value of the lecture, discussing the videos and the opportunity to design a lab and present it to the class.

Another multiple-choice question from the end-of-semester survey showed that 60% of the students thought that the selection of a personal area of interest for use in the reflective assignments and final project was very useful or helped them to understand the course material.

Another of the open-ended questions applied to the connection between science and teaching. Only students who considering teaching science were asked to answer the following question: “What teaching practices and techniques did you see modeled in this course that you think would benefit your science teaching? Explain.” Seven students answered this question. Responses included: “Peer-to-peer learning, working in groups,” “I would provide feedback to my students as well as facilitate discussions in lecture,” “I liked how the videos illustrated the information. It made it easier to understand certain material,” “The best way for your students to learn is if they are invested and see it done hands on,” and “Relating science with everyday life.”

The last reflective assignments of the semester asked students to report if they thought the course stimulated them to think at all about a career in teaching and if not if they felt that it helped them at all to educate other populations (like their future children). Twenty-one students responded to this question. Twelve students reported that the course stimulated them to think about a teaching career. Ten of the twelve students already had thought about a teaching career prior to taking the course, but they reported that the course contributed to their teaching skills.

Nine students reported that the course did not stimulate them to think about a teaching career, but most of them (seven students) wrote that the reason was that they came into the course with the notion that they wanted to do something else with their lives. They did stress that the course helped them in different ways, “…the class did help me understand the way
children think,” “The class did teach me how to explain things to people who are new to a subject,” “As a journalism major, I have a passion for informing the masses about important issues, especially health. This class has definitely fueled that passion further by allowing me to explore different aspects of nutrition and health and broaden my background in this subject by examining it through a scientific perspective. … I could also see myself teaching college one day. … Also, the 5E’s are really applicable to teaching as a parent, and they are a tool that I will always keep in mind now.”

Two students said that they didn’t feel that the course contributed to their teaching abilities at all.

**Students’ responses to two questions from the pre- and post-VOSTS survey.** Figure 4 shows the analysis of the students’ responses to the 15 miscellaneous statements. The pre- and post-course survey results are presented in bars, coded by color for options. For example, for item 20411 (“Some cultures have a particular viewpoint on nature and man. Scientists and scientific research are affected by the religious or ethical views of the culture where the work is done.”), on the pre-course survey four students selected option (a) “Religious or ethical views do influence scientific research, because some cultures want specific research done for the benefit of that culture” while on the post-course survey seven students selected it. Trends for the 15 statements suggest that the students’ views changed over time. While in some instances the changes were minor, in more instances they were more pronounced (that is, more than one initial option was changed by two or more students). An example of a small change was for item 20521, “The success of science and technology in the United States depends on how much support the public gives to scientists, engineers, and technicians. This support depends on high school students—the future public—learning how science and technology are used in the United States.” In this instance, students stayed very similar over time with only one pronounced movement (from six to two students) away from option (e) “No, support does not depend on students’ learning more about science and technology. Some high school students are not interested in science subjects.” Similar items with minor changes were 20511 and 70711.

An example of a more pronounced movement was item 40451, “We have to be concerned about pollution problems which are unsolvable today. Science and technology cannot necessarily fix these problems in the future.” In this instance, students moved from several options. Option (e) “Science and technology alone cannot fix pollution problems. It is everyone’s responsibility. The public must insist that fixing these problems is a top priority” started with 13 students selecting it and ended with 9; option (a) “Science and technology cannot fix such problems, because science and technology are the reasons we have pollution problems in the first place. More science and technology will bring more pollution problems” started with no students selecting it and ended with two.

Other items with more pronounced changes were 20411, 20511, 40413, 40421, 40431, 40441, 60111, 60311, 20711, 40221, 70212, and 70711. A general trend in the movement suggests that as the students became more familiar with science and technology, their beliefs became more nuanced, especially concerning the unquestioned benefits of science and technology.
A closer examination of item 40413 highlights the growing awareness of the students concerning the complicated relationship between science, technology, and society. This item (Fig. 5) asked students to choose one response that reflects their position regarding the statement: “Science and technology offer a great deal of help in resolving such social problems as pollution and overpopulation.” The mode of the class (eight students on the pre-course survey and nine students on the post-course survey) selected the choice most aligned with the aim of the course, (a) “Science and technology can certainly help to resolve these problems. The problems could use new ideas from science and new inventions from technology.” Changes in response between the pre-and post-course surveys were noted in options (b), (c), and (d) (Fig. 5). We interpret the changes to reflect an increased understanding by the students that while science and technology can solve many social problems, they also may be associated with many of the problems. This view is supported by those advocating a more sophisticated STS and/or SSI view(s).

In another instance, the students’ pronounced change related to their increased understanding of the nature of scientific knowledge. This item (Fig. 6) asked students to choose the option that best reflected their position regarding the statement, “In your everyday life, knowledge of science and technology helps you personally solve practical problems (for example, getting a car out of a snow drift, cooking, or caring for a pet).” The mode of the class (seven students on the pre-course survey and six students on the post-course survey) selected (a) “The systematic reasoning taught in science classes (e.g., hypothesizing, gathering data, and being logical) helps me solve some problems in my daily life. Everyday problems are more easily and logically solved if treated as a science problem.” Changes in response between the pre- and post-course survey were noted for answers (b) and (c). We interpret the changes to reflect a more sophisticated view of the nature of scientific knowledge, which was a desired learning outcome of the laboratory. For option (b), three students moved from supporting the statement to not supporting it, therefore indicating that the scientific process is directly useful. Since the instructors of the course stressed using a scientific process to solve questions in the course, the students’ responses on the post-course survey showed movement in the desired direction.

Q 40413. Science and technology offer a great deal of help in resolving such social problems as pollution and overpopulation. Your position, basically:

- a. Science and technology can certainly help to resolve these problems. The problems could use new ideas from science and new inventions from technology.
- b. Science and technology can help resolve some social problems but not others.
- c. Science and technology solve many social problems, but science and technology also cause many of these problems.
- d. It’s not a question of science and technology helping, but rather it’s a question of people using science and technology wisely.
- e. It’s hard to see how science and technology could help very much in resolving these social problems. Social problems concern human nature; these problems have little to do with science and technology.
- f. Science and technology only make social problems worse. It’s the price we pay for advances in science and technology.
- g. I don’t understand.
- h. I don’t understand enough about this subject to make a choice.
- i. None of these choices fits my basic viewpoint.

FIG. 5. Frequencies of students’ responses to the VOSTS question about science and technology.
**DISCUSSION**

Microbiology impacts people’s lives everyday in many ways. Even if an undergraduate is not majoring in microbiology, knowledge of the microbial world is useful to individuals in many different areas of their lives ranging from health, to food safety, to environmental concerns (http://www.uwlax.edu/microbiology/html/non-major.html). In the Microbes and Society course, non-science major students were introduced to science and the process of scientific thinking. The course was taught with an emphasis on scientific inquiry, reasoning, and communication. Students used basic equipment in the laboratory experiencing hands-on wet labs and using computers for data analysis, literature searches, and retrieval of data from reliable databases. Following these experiences, students were asked to demonstrate the ability to read and understand scientific literature for educated lay readers and then to use the scientific method to design a group project and present it to their peers in oral (using PowerPoint presentations) and written forms (using KEEP posters).

Throughout the semester, the laboratory sections were held in three different types of classrooms based on the nature of the different laboratory activities: a wet-bench lab, a computer lab, and a computer technology classroom. This setting modeled and supported the message of the nature of contemporary scientific research. Experiments were carried out in scientific labs individually or in groups, but a large part of the research was done through the use of technology, either with technological instruments in the lab or using technology as a platform to share and communicate scientific ideas.

The main innovation in the nonmajor’s microbiology course was to promote science for all in an active-learning

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<th>Q 21. In your everyday life, knowledge of science and technology helps you personally solve practical problems (e.g., getting a car out of a snowdrift, cooking, or caring for a pet). Your position, basically:</th>
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<tr>
<td>a. The systematic reasoning taught in science classes (e.g., hypothesizing, gathering data, and being logical) helps me solve some problems in my daily life. Everyday problems are more easily and logically solved if treated like science problems.</td>
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<td>b. The systematic reasoning taught in science classes (e.g., hypothesizing, gathering data, and being logical) gives me greater knowledge and understanding of everyday problems. However, the problem solving techniques we learn are not directly useful</td>
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<td>c. The systematic reasoning taught in science classes (e.g., hypothesizing, gathering data, and being logical) and the ideas and facts I learn from science classes sometimes help me solve problems or make decisions about such things as cooking and staying healthy.</td>
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<td>d. The systematic reasoning and the ideas and facts I learn from science classes help me a lot. They help me solve certain problems and understand a wide variety of physical events (e.g., thunder or quasars).</td>
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<td>e. What I learn from science class generally does not help me solve practical problems; but it does help me notice, relate to, and understand the world around me.</td>
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<td>f. What I learn from science class does not relate to my everyday life; biology, chemistry, and physics are not practical for me. They emphasize theoretical and technical details that have little to do with my day-to-day world.</td>
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<td>g. What I learn from science class does not relate to my everyday life; my problems are solved by past experience or by knowledge unrelated to science and technology.</td>
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<td>h. I don’t understand.</td>
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<td>i. I don’t know enough about this subject to make a choice.</td>
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<td>j. None of these choices fits my basic viewpoint.</td>
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![FIG. 6. Frequencies of students’ responses to the VOSTS question about nature of scientific knowledge.](image-url)
manner based on the diverse students’ personal interests. Our findings suggest that this course was ultimately well received by the students (including our targeted education majors), who recognized the innovations as unique and worthwhile. Most of the students in the laboratory expressed that studying a personal area of interest was useful in helping them to understand the course materials, and something they believed would assist them in being better parents even if they did not decide to pursue teaching as a career.

In addition to their positive comments, the students also shared ideas on how to improve instruction in the laboratory. In particular, they recommended more wet labs and fewer computer sessions. Both the researchers and the laboratory instructor concurred with that recommendation, because they thought that the computer labs, which involved research, reflective assignments, and other communication through electronic interface, were sometimes overwhelming and too difficult for the students. Compounding the problem was the need for the students to adjust to a new course management system, an unexpected distraction.

Our hypothesis was that we could promote science for all by connecting the diverse students’ areas of interest in science to the laboratory’s curriculum. While we could not compare the content learned in this course to that in previous courses (different instructor, etc.), we believe that our findings suggest that we implemented a nonmajor’s science course especially suited for education majors that enhanced students’ motivation, satisfaction, and view of science.

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