TEACHING & LEARNING

Improving Students' Attitude Toward Science Through Blended Learning

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Why Science is Important for Non-Science Majors

Regardless of one's major or profession, science plays an enormous role in everyone's life. From discovering cures for diseases, to creating innovative technologies, to teaching us how to think critically, science has become an indispensable feature of modern society. Controversial issues such as global warming, evolution, vaccination, HIV/AIDS, and the right to one's own DNA information are only a few of the issues being debated. Biology in particular has generated its share of controversies, including evolution, cloning and genetic engineering, global warming, premature species extinction, animal rights and animal suffering, human overpopulation, and the right to determine the timing and means of one's own death, to name a few (Leonard 2010).

Scientific discoveries shape the way we view the world and influence our decisions. Indeed, as reported in *Discover* (2010, 1) magazine, the scientific discoveries in the last thirty years have "touched nearly every aspect of our daily lives." Science teaches people how to think critically about not just scientific subjects, but all subjects. As Schafersman (1994; 1997) explains, the scientific method has proven to be "the most reliable and successful method of thinking that "results in the acquisition of reliable knowledge" (1997, ¶ 2), and therefore scientific thinking can and should be used in other human endeavors. People use the methods and principles of scientific thinking in everyday life, such as "when studying history or literature, investigating societies or governments, seeking solutions to problems of economics or philosophy, or just trying to answer personal questions about oneself or the meaning of existence" (Schafersman, 1994; 1997, ¶ 4). In short, whether we are aware of it or not, science is an integral part of our lives—even if we are non-science majors.

However, despite the fact that science informs our thoughts and behaviors, many people do not seem to place a high value on science. Studies report that the general public (that is, non-science majors) does not generally have positive feelings toward science and scientists (Rogers and Ford, 1997). These findings are unfortunate because such attitudes may have negative effects on the entire society. Since non-science majors are potential lawyers, presidents and managers of companies, politicians, and civic leaders, they will influence how research and development funds are spent, how scientific discoveries and technological innovations are implemented, and how scientific evidence is used in courts and other social organizations. An appreciation of science may provide a positive influence on these decisions (Rogers and Ford, 1997).

In addition, a positive attitude toward science may improve students' academic performance in not only science classes, but in other classes as well. Why should this be so? Science is a way of knowing and understanding through the exercise of reason, a construction of the mind based on actual observation to explain natural phenomena. Science, by choice, "is limited to questions that can be approached by the use of reason, questions that can be answered by the discovery of objective knowledge and the elucidation of natural laws of causation" (Futuyma 1983, 170). The practice of the discovery of objective knowledge involves observation of events (or the acquisition of data), followed by inference regarding possible causes (forming alternative hypotheses), and, finally, testing to select the best explanations (Cherif et al. 2001; Moore 1993). The mental discipline and rational approach of "the scientific method" have been successfully adopted in many other disciplines, such as business, law, the social sciences, and others.

It is therefore in the interests of society, and the responsibility of educators, to improve students' attitudes toward science, and to prepare students to live in a highly scientific and technological society. The future of our society will be determined by citizens who are able to understand and help shape the complex influences of science and technology on our world (Ungar 2010).

Why Negative Attitudes Toward Science Exist

Some students have developed negative stereotypes of science and scientists, whom they view as "nerds" or "mad scientists." Others describe scientists as "hard," "old," "frightening," and "colorless" (Rogers and Ford 1997). Several reasons have been suggested for these negative attitudes including students' undesirable experiences in previous science courses and with instructors, lack of needed skills to learn and apply scientific concepts, lack of motivation to work hard in science classes, home backgrounds, school and classroom environments, biases of peer groups, the media's portrayal of scientists, and students' perceptions of rewards associated with learning, to name a few (Rogers and Ford 1997). Science anxiety, the fear of science learning, and apprehension toward scientists and science-related activities are also results of these factors (Rogers and Ford 1997).

The way science is taught, both at the high school and college level, also plays a major role in shaping students' attitudes toward science. According to a study by Cherif and Wideen (1992), which addresses the question of whether a problem exists for science students moving from high school to the university, students are being presented with selected aspects of scientific dogma at the high school and university levels rather than being taught the innovative and visionary character of science and the value that such knowledge has to the educational process. Some of the students in this study reported that they were confused because the information they learned in college contradicted the information they gained in their high school science classes. As the study concluded, this dogmatic approach to teaching science, coupled with the drastic cultural changes that students undergo as they transition from high school to college, affect students' attitudes toward and performance in college-level science courses.

Though the development of desirable attitudes toward science is not the primary goal of introductory science courses, instructors usually recognize that attitude formation is one of the important aspects of instruction (Cherif and Wideen 1992; Garcia and McFeeley 1978). There is growing evidence that students who possess positive attitudes toward science will perform better academically. Russell and Hollander (1975), who created the Biology Attitude Scale—a tool designed specifically to measure students' attitudes toward biology—support this claim. "The tool was developed on the assumption that an important consequence of instruction is a positive change in the student's attitude toward the subject, and the authors argue the importance of focusing on attitudes by stating that there usually exists a positive correlation between attitudes and achievement" (Russell and Hollander 1975).

Most instructors, however, focus primarily on increasing the students' knowledge of the subject rather than increasing their favorable attitudes toward it. Many instructors assume that students will naturally acquire positive attitudes toward science as they learn more about it. However, a study by Garcia and McFeeley (1978) found that the positive attitudes of students toward biology in eighteen introductory biology courses at East Texas State University decreased by the end of the term. This necessarily raises the questions of how to improve students' attitudes toward science, and whether the way we teach science plays a significant role in this challenge. In short, it is not only what we teach but also how we teach that are important considerations in how to improve student success (Moore 1989).

How to Improve Attitudes Toward Science

Introductory science courses, such as biology, chemistry, and earth science, are usually required at the college level. It is important to keep in mind that non-science majors take science courses in college largely because they need to satisfy their liberal arts requirements, and not necessarily because they have a passionate interest in learning science. It is therefore not surprising that many students in these introductory science classes attend irregularly and do not take advantage of the extra help offered (e.g., meeting with the professor outside of class, going to tutorial and learning centers, doing extra credit). Studies show that students who attend all or most classes perform better academically, and good attendance is associated with high motivation. In other words, the most successful students are usually the most highly motivated; they are most likely to come to class, do extra-credit work, and attend help sessions (Moore 2006). A highly motivated student is usually one with a positive attitude toward the subject s/he is learning. Therefore, in order to improve students' attitudes toward science, faculty must motivate students, which they can do through their teaching styles and by showing them the relevance of the learning topics to their everyday lives. In addition, they must create the learning environment that helps motivate students not only to come to classes but also want to learn and enjoy learning.

Etkina and Mestre (2004) suggest that instructors of introductory science classes try to motivate their students by asking them to consider the preconceptions about science-related topics that they bring to the class. In a biology class, for example, teachers can ask students the following questions: "What do you know about HIV and about how AIDS is transmitted? What do you think is the reason that some cancers are curable and others are not? What do you think about genetic engineering, about cloning, about stem-cell research—are these good or bad things, and under what circumstances" (Etkina and Mestre 2004, 18). Questions like these will demonstrate to students that there are others in the class who have similar views and concerns, that there is a diversity of views in the class, and that they cannot all be scientifically correct. This divergence of views leads naturally to discussions about the process of doing science (experimentation, evidence-based model building, hypothetical-deductive reasoning), the application of scientific discoveries, and the impact of science on society (Etkina and Mestre 2004). The resulting discussions can also help instructors move away from a dogmatic approach to the teaching of science—to a more engaging and interesting approach that encourages critical thinking rather than just fact accumulation.

Furthermore, using controversial issues to introduce topics and concepts in biology classes helps to "raise questions that deserve answers and also generate interest among students, and interest can improve motivation to learn biology" (Leonard 2010, 407). In addition, making the learning and the teaching of the topics more relevant to students' lives helps them see the value of science and in turn motivates them to develop a better attitude toward science and science education.

Hybrid Courses as a Way to Student Improvement

In an attempt to motivate students and improve their attitudes toward science, one important opportunity, at a time when technology plays such a prominent role in our lives, is for instructors to redesign their traditional courses using a hybrid model. Blended (hybrid) learning is defined as "a coherent design approach that openly assesses and integrates the strengths of face-to-face and online learning to address worthwhile educational goals. . . . [Furthermore, it] is fundamentally different and is not simply an addition to the dominant approach" (Garrison and Vaughan 2008, x). In this sense, hybrid or blended instruction is the integration of some of the conveniences of online learning with the traditional face-to-face instruction in the learning process (Humphries 2009; Rovai and Jordan 2004; Colis and Moonen 2001). While both onsite and online learning can accomplish course and program objectives, in a blended system, these modes of learning are combined in order to enhance the learning and teaching experience for both students and faculty. Using computer-based technologies and web-based course delivery, instructors use the hybrid model to redesign some lecture or lab content into new online learning activities, such as case studies, tutorials, self-testing exercises, simulations, online group collaborations, and threaded discussions (Garnham and Kaleta 2002). Blended learning systematically incorporates the use of asynchronous teaching (facilitated by computer-based technologies) into the traditional onsite teaching in order to maximize both teaching and learning opportunities (Hrastinski 2008). Although integrating technology into the classroom in small steps is part of a natural evolution of teaching and learning, a blended learning system includes a committed, sustained, and well thought-out implementation plan, combining appropriate technology with traditional classroom interaction, so that it leads to better outcomes for students (Garrison and Vaughan 2008; Mayers et al. 2006; Bonk and Graham 2006).

Early evidence suggests that hybrid courses may indeed lead to better student performance on exams, better student perceptions of and attitudes toward the course, and higher attendance rates (Riffell and Merrill 2005). Hybrid courses may be especially appealing for college introductory science courses because they typically contain, in addition to lecture: a laboratory component, problem-focused threaded discussion, and group work. While the lecture portion of these introductory science classes might be very large (100–400-plus students), in some colleges and universities, the laboratory class is much smaller (about thirty students), and lab exercises are more interactive, group-oriented, and targeted toward problem solving. A study conducted by Riffell and Merrill (2005) aimed to determine if the more interactive and problem-solving nature of Web-based materials better prepares students for labs and enhance their performance. They found that the hybrid lecture format (two hours lecture plus one online homework assignment weekly) was at least as effective in preparing students to do well in the laboratory course as a more traditional course format (three hours of lecture per week). They also found that the hybrid course format appeared to help all minority groups in their student population perform better in the laboratory. These findings have significant implications since they suggest that incorporating online problems into science courses may be a valuable tool for narrowing the performance gap of minority students (Riffell and Merrill 2005). This study, along with many others, suggests that web-based learning combined with traditional face-to-face learning may serve as a good way to get students more involved and motivated in introductory science classes.

Hybrid Courses and the Constructivist Approach to Teaching

In seeking to improve student performance, satisfaction, and retention, teachers should consider adopting a constructivist approach to teaching. According to the theories of constructivism, learning is an active and constructive process; learners not only construct knowledge, but the knowledge they already possess affects their ability to gain new knowledge (Etkina and Mestre 2004). Constructivism thus has important implications for the teaching and learning of science. As stated earlier, one of the potential reasons for students having negative attitudes toward science has to do with their previous experiences. The study conducted by Cherif and Wideen (1992) found that students complained that what they were taught in their college science classes sometimes contradicted what they had been taught in high school. Constructivism recognizes that knowledge previously acquired by the learner will affect how s/he interprets what a subsequent instructor is attempting to teach (Etkina and Mestre 2004). If something contradicts what has been previously taught and learned, the new contradictory information may be disregarded. Therefore, an instructor should probe the knowledge that students have previously constructed in order to make appropriate instructional choices with respect to the content to be learned. The instructor should evaluate the sufficiency and accuracy of students' prior knowledge and decide if this background knowledge conflicts with what is being taught. If a conflict is apparent, the instructor should guide learners in reconstructing their knowledge using, for example, guided inquiry in a relevant context (Etkina and Mestre 2004). To ignore learners' prior knowledge and beliefs makes it highly probable that the message intended by the instructor will not be the message understood by the student (Etkina and Mestre 2004). A good understanding of the content being taught is essential for building motivation and a positive attitude. In addition, providing the opportunity and the learning environment for the students to reconstruct their own conceptual knowledge and understanding leads to a lasting improvement in students' attitudes toward learning and to greater chances of success in their studies and lives.

Teaching Biology Through the Blended Learning: Personal Experience

Recently, I redesigned and taught one my biology courses at Harold Washington College (HWC) in both hybrid and traditional delivery formats using the same textbook, learning materials, labs, quizzes, exams, and so on in both sections. The course is Bio 114, which is one of the most popular introductory science courses. It is a survey course intended for students majoring in non-science degrees. As stated in the college catalogue, Bio114 is a course emphasizing scientific inquiry through selected concepts of biology, such as organization, function, heredity, evolution, and ecology. The course also discusses biological issues with personal and sociological implications, enabling students to make informed decisions. This course is offered every semester and is four credit hours. In a face-to-face (traditional) format, students meet twice a week: one class meeting for lecture and one class meeting for laboratory. After two-and-a-half years of research and collecting data, I offered Bio114 in a hybrid/blended format during the Spring 2010 semester—this was the very first time this course was taught through the hybrid delivery model at HWC. The course met once a week with 60 percent of the class onsite and 40 percent online. The online components of the course include reading the lecture and lab materials, conducting virtual labs as practice and preparation for actual laboratories on campus, taking quizzes, participating in a threaded discussion, and research group projects. The onsite class meetings covered class lectures, exams, as well as actual laboratory work on campus. Assessing the success of the course was accomplished by teaching the same course content in both hybrid and traditional formats, conducting concept-based pre- and post-tests, surveying the students in Bio 114 at the end of the semester, and examining the overall grades of students in both the hybrid and the traditional Bio 114 classes.

The effectiveness of the hybrid Bio 114 course was assessed by measures of student success in terms of student performance, satisfaction, and retention—in comparison to the same measures for the traditional onsite version of the course. Based on these criteria, the students who completed the hybrid section of Bio 114 reported higher rates of satisfaction with the course than their traditional course counterparts: 91 percent felt they were helped and encouraged to learn and 100 percent would recommend the course to other students; while in the traditional class, 83 percent felt they were helped and encouraged to learn and 90 percent would recommend the course to others. Students of the hybrid section also performed better overall than students in the traditional section. Furthermore, analysis of the results for comparable questions from the students' class evaluation, which was administrated directly by the college, supported the findings of the study. The overall findings thus bore out the hypothesis that not only can non-science majors perform as well as the traditional class but may actually achieve higher success rates in taking Bio 114 in a hybrid delivery format than by taking the same course in a traditional onsite format.

Discussion

Scientific discoveries and scientific thinking influence our decisions and behaviors, regardless of our profession or major. Yet, despite the undeniably important role science plays in our lives, studies show that many people do not hold positive attitudes toward science. It has therefore become the responsibility of educators to help shape the attitudes toward science among students so that these students leave their classes with a positive view of the discipline. Non-science majors are potential lawyers, managers, and government officials, and they may influence not only how research funds are spent but also how science discoveries and technology can be applied in society. A positive attitude toward science may influence these important decisions. Finally, a positive attitude toward science may contribute to students performing better academically in all subjects and encourage them to think critically about scientific and non-scientific issues that arise throughout their lives. The design of our courses, namely the type of delivery model we use, becomes important then because the delivery model influences the content being taught and the level of student involvement with the content.

There is much research that supports the potential value of blended instruction. Osguthorpe and Graham (2003) found that blended instruction methods improved pedagogy, increased access to knowledge, fostered social interaction, increased the amount of teacher presence during learning, improved cost effectiveness, and enhanced ease of revision. Similarly, Chung and Davis (1995) reported that blended instruction provided learners with greater control over the pace of learning, instructional flow, selection of resources, and time management (Lim and Morris 2009). According to a study from South Texas College, hybrid learning can produce better outcomes than those that are delivered exclusively on the Web or in the classroom. Their data showed that, overall, 82 percent of students of hybrid courses were successful, compared to 72 percent in classroom courses and 60 percent in distance courses (Kolowich 2009).

There are several advantages to blended learning compared with completely online learning or traditional face-to-face learning. While completely online learning might create a sense of isolation among students, blended learning provides the effectiveness and socialization opportunities of the classroom. Students who would be reluctant to contribute in a face-to-face setting are more likely to contribute in an online dialogue and would perform better in a blended learning environment. An advantage of blended instruction in biology courses in particular is that it helps students, especially minority students, perform better in labs. Biology labs are becoming increasingly computer-dependent, and blended instruction provides the technical training to prepare students for these labs, thus increasing confidence and performance levels of all students.

Technology has the potential to enhance instruction as well as student engagement and learning. Blended instruction makes pedagogically significant use of the Internet and other technological tools while reducing seat time (time spent in the classroom). The National Education Technology Plan 2010 recognizes the role that technology plays in improving student success and states that "the challenge for our education system is to leverage the learning sciences and modern technology to create engaging, relevant, and personalized learning experiences for all learners that mirror students' daily lives and the reality of their futures" (U.S. Department of Education 2010, v–vi). A blended instructional approach answers this call for a learning system that utilizes technology to create an engaging and student-centered environment.

The hybrid delivery format has proven to be very effective in improving students' academic performance. Every month, there are major articles and/or government reports about the significant contribution of hybrid learning to student success and institutional improvement. Therefore, I believe that science departments should begin to systematically offer hybrid courses, starting with introductory courses. A broader selection of hybrid courses would also allow further comparative studies of student success in such courses against traditional models.

Finally, blended instruction does not only offer significant learning advantages for students, but also for faculty and institutions in optimizing access, learning, suitability, elasticity, and resources. However, faculty attitude toward hybrid and online learning delivery, which influences how they teach the course and how students learn, is shaped by the type of departmental and institutional support faculty receive. The need for faculty support in teaching hybrid and online courses has been reported in a number of studies (cf., Humphries 2009 2008; Morote et al. 2007; Rahmani and Daugherty 2007). The greatest reported need is support and training in best practices in hybrid and online instruction as well as consistency and fairness in allocation of time and schedules, assigning classrooms, labs, and computer rooms. Morote et al. (2007) identified four main categories of support that greatly influence faculty decision to develop and implement hybrid and online courses. These categories include technology, pedagogy, institutional policies, and faculty-centered issues. In the area of technology, for example, reliability of technology, technical support, hardware/software availability, and connectivity are the biggest concerns among many faculty who are teaching and/or thinking about teaching hybrid and online courses. In a study conducted among tenured and nontenured faculty at higher education institutions in New York, the researchers conclude that these four factors (technology, pedagogy, faculty-centered issues, and institutional policies) have the same influence on faculty decisions on teaching hybrid and/or online courses regardless of tenure status (Roman et al. 2008).

Summary and Conclusions

Taking a conservative position, we can conclude that hybrid instruction is at least as good as the traditional methodology. Hybrid instruction has the added advantage of being more efficient in its use of space (a real consideration to community colleges, which are space constrained), more flexible for working adults (who need to travel to campus less), and more conducive to the sharing of best practices among faculty in a department. In addition to student's success, these benefits provide some of the strongest reasons for the city colleges in urban settings, such as HWC in downtown Chicago, to support future efforts with hybrid learning across departments.

About the Author

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