HETS Online Journal
Volume 1, Issue 1: October 2010

Running Head: Using Computers to Teach Science

Can Computer Technology Improve the Quality of Science Education at Urban Universities?

Bamshad, Maryam [1], Foster, Gina Rae [2] and Kreuzer, Paul G. [2]

[1] Department of Biological Sciences, Lehman College – The City University of New York, Bronx, NY 10468, USA.
[2] The Title V Office of Supplemental Instruction & Technology, Lehman College – The City University of New York, Bronx, NY 10468, USA.
gina.foster@lehman.cuny.edu, paul.kreuzer@lehman.cuny.edu

Corresponding Author
maryam.bamshad-alavi@lehman.cuny.edu

Abstract

Research has shown that technology can be a powerful educational tool in facilitating a constructivist approach to teaching science. Research also shows that academic support for students and faculty development activities are positively linked to supporting science teaching and learning. However, despite the availability of these resources at many urban universities, instructors rarely engage students in collaborative learning. This article uses a case study to describe both the challenges and results of implementing a constructivist model of instruction at a mid-size urban college. The article demonstrates the successful implementation of an online interactive course management system and Supplemental Instruction in large classrooms, with the caveat that such practices require extensive training for instructors, staff and students to be feasible. At Lehman College of the City University of New York, both Title V grant and college

administrative support has enabled the creation of a model of collaborative engagement that has successfully fostered partnership among instructors, students and staff in constructivist learning and active use of computer technology at an urban college.

Introduction

As a junior science faculty member at Lehman College, the Bronx campus of the City University of New York (CUNY), I began my teaching career faced with the same difficulties that others at urban universities have experienced and described (Gaffikin & Morrissey, 2008; Kogan, 1984). Having had no training in modern educational theories and no experience teaching inner city students, I struggled in developing a relationship with my students whereby I could excite them about learning science. As the newly appointed course coordinator overseeing the curriculum and teaching for 10-16 course sections of Anatomy and Physiology each term, taught by graduate students with little or no teaching experience (who often taught courses at several institutions in addition to their graduate research workload), my lack of preparation was mirrored on both sides of the teaching and learning equation. Compounding the problem, the lecture hall in which I taught was not conducive to non-lecture pedagogical approaches, and the

laboratories were stocked with outdated and damaged equipment that neither students nor parttime instructors treated with the respect and protocols scientists are expected to honor as research investigators.

I based my teaching on the teaching I had received, lecturing and assigning work as in the tradition of the expert transmitting knowledge to novices, asking students to memorize and repeat what they had read and heard. When I discovered I had one of the highest failure rate courses taught at Lehman College, I realized that I had to change my teaching methods in order to reach out to my students and help them succeed. Hence, I began researching the modern educational theories and experimenting with various pedagogies. My experience led to the development of a collaborative engagement approach to teaching science courses through a combination of specific faculty development activities in teaching and technology, the 7 introduction of WileyPLUS as a course management support system, the implementation of Supplemental Instruction for peer-facilitated group study sessions, and close work with learning support services to match 1-1 tutoring and workshops more closely with student and faculty needs.

Lehman College and Science Teaching

Junior faculty members in the sciences often do not have sufficient time to learn new teaching methods though we often teach the courses that have the largest number of students. Like many of my peers, I was active in scientific research and was hired at the rank of Assistant

Professor, at the beginning of my research career. In addition to teaching, I was required to obtain federal funding for my research and be a productive member of my academic community by providing service to students, my department, and my institution.

When I arrived at Lehman College/CUNY, I found the laboratory equipment out of date and in many cases unusable. Each year, I bought new models and dissection kits for the labs and tried to set up the spaces for the most effective practices. I found to my dismay that setting up lab protocols and rules for adjunct faculty and students did not seem to help to develop care in scientific practice to improve student learning, or to increase the adjuncts' comfort and success in teaching.

As I began researching these areas and implementing some changes in my teaching, my new institution did not initially offer training or faculty development focused on science teaching and on working with and without classroom and online technology. These resources became available later, partly through my discussions with the College and a new commitment from the administration to STEM courses.

The lack of appropriate resources in partnership with the lack of faculty development opportunities was further compounded by the under-preparedness of the students. Lehman College is located in the Bronx, which has been identified as the poorest and most diverse county in the United States. Lehman is the only public four year institution of higher education in the

Bronx, and as such, provides access to education to students from a wide variety of backgrounds and needs who might otherwise not have the opportunity to attend college.

The students in my classes wanted careers in nursing and other health professions. They needed to pass Anatomy and Physiology with high grades to qualify for entrance into these majors. Unfortunately, many of these students were unprepared to memorize long lists of Latin and Greek-based terms and to attach those to physiological processes. Identifying these parts and processes through text, image, and physical models that often did not seem to resemble their namesakes was a further, nearly insurmountable challenge. I found the students often unprepared to read their textbooks and unwilling to do the homework and practice required to succeed in the course. The students struggled to learn what was essentially a new language and new culture (science) in what for many was a third or fourth or even seventh language rather than a first or second.

After deciding that I needed to modify my teaching habits and those of the adjunct instructors who taught with me, and having experienced difficulty in making these changes, I realized that to effect positive change, full and part-time science faculty must be provided with extensive training in student-centered learning to change their instructional roles from transmitters of knowledge to facilitators of knowledge. Furthermore, this type of change cannot occur without a commitment from the instructors' institution to provide reassigned time to

faculty and additional funding to support them.

I also recognized that technology would need to be a key part of revising my teaching and assisting my students in mastering the skills and content of the course. Although numerous online sites and computer software programs that provide learning activities appropriate for problem-based teaching and group learning exist, these resources are unknown to most research faculty or to adjunct instructors. As a group, the adjunct instructors and I were unaware of how to search for suitable resources or utilize them in our courses because we had not received training in science education.

Furthermore, given the large size of our introductory level science classes, it was not feasible for a single instructor to monitor small group discussions during class or to provide sufficient feedback to individual students so they could modify their learning strategies while solving problems outside of the classroom. Classroom sizes vary at Lehman as at other similarly sized institutions. Most class sections are limited to 25-30 students; in basic science courses, however, lecture sections may be combined into sections of 70 or more students while the lab sections remain at fewer than 30 students. This can cause problems for instructors in creating effective small groups and encouraging teamwork, especially if such combined sections are held in an auditorium with seats bolted to the floor and students forced to face forward, either looking up or looking down at an instructor who stands at a distance that makes facial expressions

difficult to discern.

Like most students at urban universities (Riposa, 2003), those taking the Anatomy and Physiology courses at Lehman College are from diverse educational, cultural, and socioeconomic backgrounds. The instructors teaching the course often found the range of student abilities so great as to hinder the establishment of a learning environment that was studentcentered and collaborative. Consequently, like most other science faculty, we continued to use traditional teaching methods. If we integrated computer technology into our classrooms, it was for the purpose of organizing our course material and presenting our lectures more efficiently (Hooper & Rieber, 1995).

As I tried to implement a constructivist approach to teaching in my classes, I found that obstacles impeding utilization of constructivist methods for faculty also exist for students. Students also lack time, training and resources. They attend large classes and often have a myriad of academic deficiencies. Most have had little opportunity to experience constructivist learning in their college preparatory classes. At the same time, most Lehman College students, similar to other urban university students, find it hard to adjust to an academic environment where they are told to assume control over their own learning (Rendon, 1994). The students are unaccustomed to collaborating with their instructor or working with other students in dyads or small groups. In conversations inside and outside the classroom, Lehman College students emphasize that they attend college primarily to receive instruction necessary to pass professional

entrance and qualifying exams which will help them obtain lucrative jobs and satisfying careers. However, a majority of students demonstrate some weaknesses in numeracy and literacy, thus creating further learning challenges in science courses that assume such skills as the basis for learning discipline-specific equations, processes, and terminology.

Furthermore, differences in culture, language, and academic skills, as well as age, educational background, and learning styles among these students make it difficult to maintain group dynamics without continuous support from the instructor or other members of the instructional team. When combined with academic deficiencies, the diversity students bring to the classroom may seem insurmountable for instructors like me who strive to use cooperative strategies.

Computer Technology: WileyPLUS

While students are challenged by traditional and often static presentations of academic material, instructors, even when they are aware of the availability of interactive software, often find that they do not have sufficient time to search for the online tools that might be useful in meeting their teaching demands. Although the Internet provides a wealth of interactive online tools for science learning, they are rarely organized for specific course objectives suitable to specific institutional guidelines and individual teaching styles. To meet this need, major textbook publishing companies such as McGraw-Hill, John Wiley & Sons, Inc., and Pearson Prentice Hall

Publishers have created learning networks to accompany their science textbooks (Stellin, 2001). Time investment was not the only motivation for the development of these networks. In response to an NSF mandate in the early 1990s to increase the number of minorities and women in the sciences, some of these publishing companies, like John Wiley & Sons, began forming a partnership with textbook authors and professors. Consequently, these publishing companies have developed interactive programs that are course specific and can be easily modified to meet the demands of the instructors, thus allowing for more focused searches for appropriate tools and integrating more instructors of diverse backgrounds into both the design and use of these learning networks (Jacobson et al., 2007).

Because products like these appear to provide help for students in learning to construct their knowledge base, and because I was interested in a constructivist approach to teaching, I began experimenting with one such product to teach Anatomy and Physiology at Lehman College. WileyPLUS, the online learning network created by John Wiley & Sons, Inc., is a homework management system that accompanies Wiley's Anatomy and Physiology textbooks and lab manuals. WileyPLUS has the entire textbook online, has numerous interactive exercises that can be assigned to students as homework and animations of physiological processes that can be shown during class. Using WileyPLUS, students and instructors have access to a large body of interactive resources. With animations and MP3 audio clips in WileyPLUS, instructors can

give students background information on various body systems such as nervous, muscular or cardiovascular systems and then show them neurons that are transmitting nerve impulses to stimulate muscle contraction or a heart that is pumping blood to the body. Thus, students are exposed to the same information multiple times, but in various formats.

Instructors can quickly assign problems, case studies, animations, and interactive activities related to a specific study objective. The integrity of assignments and exams is protected through algorithms that ensure each student sees different values and/or different orders of questions that test knowledge of the learning objective. As these assignments are automatically graded, they give instructors the power to assess the success of an individual student, a group of students, or the entire class. Other non-graded resources are also available, such as video, flash cards, and concept review. Such interactive textbook-based programs provide time and space for students and the instructor to experience how science works actively while covering both the theoretical aspects and the global impact of science.

Supplemental Instruction

To facilitate group learning, we introduced Supplemental Instruction (SI), a peer education program. The SI model, created by Deanna Martin at the University of Missouri at Kansas City in the 1970s, has proven particularly successful in helping students to master traditionally difficult course content and skills while learning transferable study strategies that

promote success in subsequent courses (Arendale, 1993). SI focuses on providing specialized peer education for courses that consistently post high (30% or more) D, F, and withdrawal rates over several terms. The peer educators are SI Leaders, "model" students who have shown success in these courses and who are trained as peer facilitators to lead review sessions outside of class. These review sessions use study strategies and small group work to assist students in learning transferable skills while they are mastering the content and skills of their current course. SI Leaders attend all regularly scheduled class sessions of the course to which they are assigned and speak regularly with the instructor about course goals and assignments. As students, SI Leaders assist their peers in learning challenging material; as advanced learners, SI Leaders are mentored by the instructors of their assigned courses and function as liaisons as well as models for their peers.

Since its implementation in the fall of 2007, the Title V SI program at Lehman College has offered SI for the two-course sequence in Anatomy & Physiology. Students must pass these courses with a grade of B or higher if they desire admission into programs in the health professions, such as nursing. For Anatomy & Physiology, SI Leaders plan review sessions that integrate WileyPLUS learning activities and resources with SI study strategies. These review sessions meet twice a week for a total of four hours. Student attendance is voluntary and is not included in assessing final grades.

Student Support Services

Lehman College is fortunate to have a variety of student support services available to meet student needs. In addition to the Title V Office of Supplemental Instruction & Technology, which provides SI and classroom technology assistance, the Instructional Support Services Program operates the Academic Center for Excellence (ACE) and the Science Learning Center (SLC), each of which offers individual tutoring and workshops for multiple disciplines. The Mathematics & Computer Science Department manages the Math Lab. The CUNY Higher Education Opportunity Program known as SEEK (Search for Education, Elevation, and Knowledge) provides tutoring, workshops, SI, and counseling for SEEK students. The Freshman Year Initiative offers faculty and peer support for first year students with interdisciplinary courses and coordinated activities within proposed fields of study. The Counseling Center and Student Disabilities Services office provide support for students looking for additional assistance.

Students have the option of attending weekly Science Learning Center workshops led by trained staff members. During these workshops, they can review course content and skills under the direction of the workshop leader. Mobile carts with laptops offer students the opportunity to practice with WileyPLUS and other interactive technology just as in SI sessions. The main differences between the SI sessions and the SLC workshops lie in the emphasis on peer

education and study skills in the former versus the more traditional transmission of knowledge and authoritative role of the workshop leader in the latter. The approaches we use provide for students who are most comfortable in traditional learning venues as well as for students for whom such venues have been unsuccessful.

Individual tutoring for science courses is available in a number of areas on campus through the Science Learning Center, SEEK, and the Math Lab (to support quantitative skills needed to set up and solve scientific equations). Students may sign up for individual tutoring in these programs (SEEK tutoring services are primarily used by SEEK students) and attend regular or drop-in sessions depending on the center providing services. Individual tutors are generally advanced undergraduate or graduate students who participate in CRLA (College Reading and Learning Association) training twice a year and follow the Master Tutor 12 step model. For students who would like more attention to their specific questions or are more comfortable not participating in small group and partner activities, individual tutoring offers a useful alternative.

Collaborative Engagement

The introduction of WileyPLUS, Supplemental Instruction, and faculty development led to further discussions with Paul Kreuzer and Gina Rae Foster, the Director and SI Coordinator of Lehman's Title V Grant. We realized that we had created a model for teaching and learning particular to Lehman that might well be applicable at other urban commuter colleges. We called

this a collaborative engagement model (Figure 1). A collaborative engagement model brings together student and faculty support to address specific teaching & learning needs, making the best of institutional resources and helping each program and participant to improve its services as well as its understanding of its role within the institution.

A collaborative engagement model emphasizes increasing faculty skills with teaching technology as well as faculty commitment to constructivist pedagogy. These skills improvements occur not only through college-sponsored workshops but through informal discussions, one on one work with peers and students, and teaching research supported by the institution. To this end, a collaborative engagement model also asks faculty to work more directly with academic support services to ensure consistency and quality of student resources with the consistency and quality of teaching.

Action

I began the work towards collaborative engagement in the fall of 2006. Initially, I implemented WileyPLUS only in my class lecture sections. With the tools and resources available in WileyPLUS, I prepared presentations that included animations of physiological processes, interactive anatomy overviews of body systems, and games that tested student knowledge of the course objectives. By changing the format of the lecture presentations, I am now able to capture and maintain students' attention, help them visualize abstract concepts, and

engage them in group exercises. With details of anatomical structures and physiological mechanisms readily available to students in WileyPLUS, I can spend more time on the process and history of the scientific inquiry that has led to understanding of the body structure and function. Hence, rather than bombarding students with facts, I can encourage them to think critically about the science of the human body. Furthermore, the tools provided in WileyPLUS has allowed me to make the presentations, assignments and tests I use in my classes accessible to adjunct instructors, thus facilitating consistency in teaching across different sections of the course.

Nonetheless, I realized that making computer technology available to adjunct instructors will not enable them to change their method of teaching unless they are trained. Thus, with the support of Title V Office of Supplemental Instruction & Technology, I began organizing faculty development workshops for the adjunct instructors teaching Anatomy and Physiology. Consequently, the adjunct instructors are trained in utilizing WileyPLUS resources in conjunction with course management systems such as Blackboard. Through these faculty workshops, experienced and inexperienced instructors are brought together to discuss challenges they face in teaching and are shown the power of computer technology in helping them meet these challenges. In addition, I share my positive teaching experience with other faculty around the country and mentor them in introducing computer technology into their classroom through

online seminars and nationwide workshops held by the Wiley Faculty Network.

Realizing the importance of peer-to-peer learning, I have collaborated with Gina Rae Foster and Paul Kreuzer to implement Supplemental Instruction in Anatomy and Physiology classes. Through one-on-one training and presentations given by John Wiley & Sons representatives, the SI Leaders are trained to use WileyPLUS. They attend lectures to observe how the instructor uses technology for teaching and then conduct small group review sessions after class where WileyPLUS is used in conjunction with group study strategies to help students acquire new learning skills. In addition, I work closely with the Science Learning Center at Lehman College to improve the quality of tutoring services and train the staff to incorporate computer technology in workshops that are held to prepare students for taking Anatomy and Physiology courses.

Results

WileyPLUS and Supplemental Instruction have transformed the way we teach at Lehman College and the way our students learn. Rather than transmitting information to their students, the instructors and SI leaders use the tools that WileyPLUS provides to facilitate student learning. Consequently, students acquire a deeper level of understanding as instructors guide them through interactive exercises on physiological processes and show them what would have happened had they not chosen the right sequence of events and why. After students have

completed the interactive exercises, instructors reemphasize the concepts by presenting the same information in a different format. Thus, rather than telling students how a muscle contracts, instructors guide them to actively learn the process, and are trained to reinforce the concepts by demonstrating a muscle cell in action. Students who attend SI review sessions gain time on task in active learning exercises that reinforce the constructivist activities of the class design.

Instructors and SI leaders no longer feel the need to bombard students with information. Having WileyPLUS as a resource that contains the background information, they have learned to connect the dots and narrate a story about the body. Students learn Anatomy and Physiology by doing exercises and not by memorizing facts. By assigning students interactive exercises and animations as homework, they not only learn the anatomy of the human body; they also understand that by selecting the right molecules and processes they can simulate the body's physiological activities. As instructors give outside of class access to the same interactive exercises that are demonstrated during class, students have a chance to repeat the activity either individually or in a small group with their SI Leaders. Thus, for students, reading and learning does not stop with class. By having access to WileyPLUS online, they can continue learning at home, at their own pace, and their own schedule. Working in SI sessions helps students learn how to learn.

Implementation of such a multipronged strategy since 2007 has improved student grades

and enhanced students' voluntary participation in the SI program. Figure 2A shows the overall grade distribution before and after the implementation of WileyPLUS and SI for students in my sections as well the grade distribution of those students who participated in SI. Figure 2B shows the same data for the second semester of Anatomy and Physiology. In both courses, the data indicate increase in the percentage of students receiving grades of A,B, and C and conversely a decrease in the percentage of D, F, and withdrawal grades. In addition, students who attend SI do significantly better than those who choose not to attend. Furthermore, through training and continuous support, adjunct faculty use of computer technology has increased and their resistance to follow a coordinated syllabus has subsided. We have also seen an improvement in workshop and tutoring services coordination with teaching.

Conclusions

Lehman College/CUNY is representative of many urban, non-residential colleges and universities faced with the challenges of meeting the needs of students who are often underprepared to succeed in entry level science courses, overscheduled with coursework, employment, and family obligations, and varied in background and experience to an extent that disrupts attempts to create learning communities within classrooms and institutions. Lehman College also represents the many institutions which rely largely on adjunct instructors to teach basic courses, a reliance that neglects the realities of part-time faculty whose time and efforts are

pulled in multiple directions by research, completing advanced degrees, and competing instructional assignments at two or more institutions.

Given the challenges that adjunct instructors have in implementing modern educational practices and the difficulties students have in adapting to collaborative learning, it is unrealistic to assume that without extensive training they will be successful in changing the way science is taught or learned at urban institutions. The access to sophisticated computer technology will not foster collaborative teaching and learning unless both the instructor and students are trained and supported in using computer technology appropriately. Although there are ample computer programs and software available to facilitate collaborative and group learning, without training it is likely that instructors will continue to use computers to instruct without using constructivist approaches and that students will continue to use computers to absorb information passively.

In spite of these challenges, the collaborative engagement model developed at Lehman has been effective in its initial years with both full-time and part-time faculty, leading to improved faculty development activities, increased familiarity with teaching technology and constructivist teaching methods, and better quality and consistency of academic support for students. The gap between preparedness and implementation still exists for faculty and students; we continue to work to provide more training and support for both in order to teach and learn more effectively.

As our results demonstrate, improvement in student learning and faculty satisfaction can be achieved when the institution allows for faculty development in pedagogical practice, use of technology and use of student learning support. Through funded faculty development for adjuncts, purchase of interactive laboratory technology, and the use of supplemental instruction, Lehman College is transforming its approach to a historically high-failure rate gateway course. WileyPLUS and the SI program have not only improved students' grades, but they have facilitated a greater cooperation among faculty, student leaders and their students. 21

References

Arendale, D. R. (1993). Foundation and theoretical framework for Supplemental Instruction. In D. C. Martin, & D. R. Arendale (Eds.), Supplemental Instruction: Improving first-year student success in high-risk courses (2nd ed., pp. 19-26). Monograph Series No. 7. Columbia, SC: National Resource Center for The First Year Experience and Students in Transition. (ERIC Document Reproduction Service No. ED354839).

Gaffikin, F., & Morrissey, M. (2008). A new synergy for universities. Education, Citizenship and Social Justice, 3 (1), 97-116.

Hooper, S. & Rieber, L. P. (1995). Teaching with technology. In A. C. Ornstein (Ed.), Teaching: Theory into Practice. (pp. 154-170) Needham Heights, MA: Allyn and Bacon.

Jacobson, T. C., Smith, G. D. & Wright, R. E. (2007). Knowledge for Generations: Wiley and the Global Publishing Industary, 1807-2007. Hoboken, NJ: John Wiley & Sons, Inc.

Kogan, M. (1984). Problems of the urban university: Great Britain and U.S.A. In H. Wasser

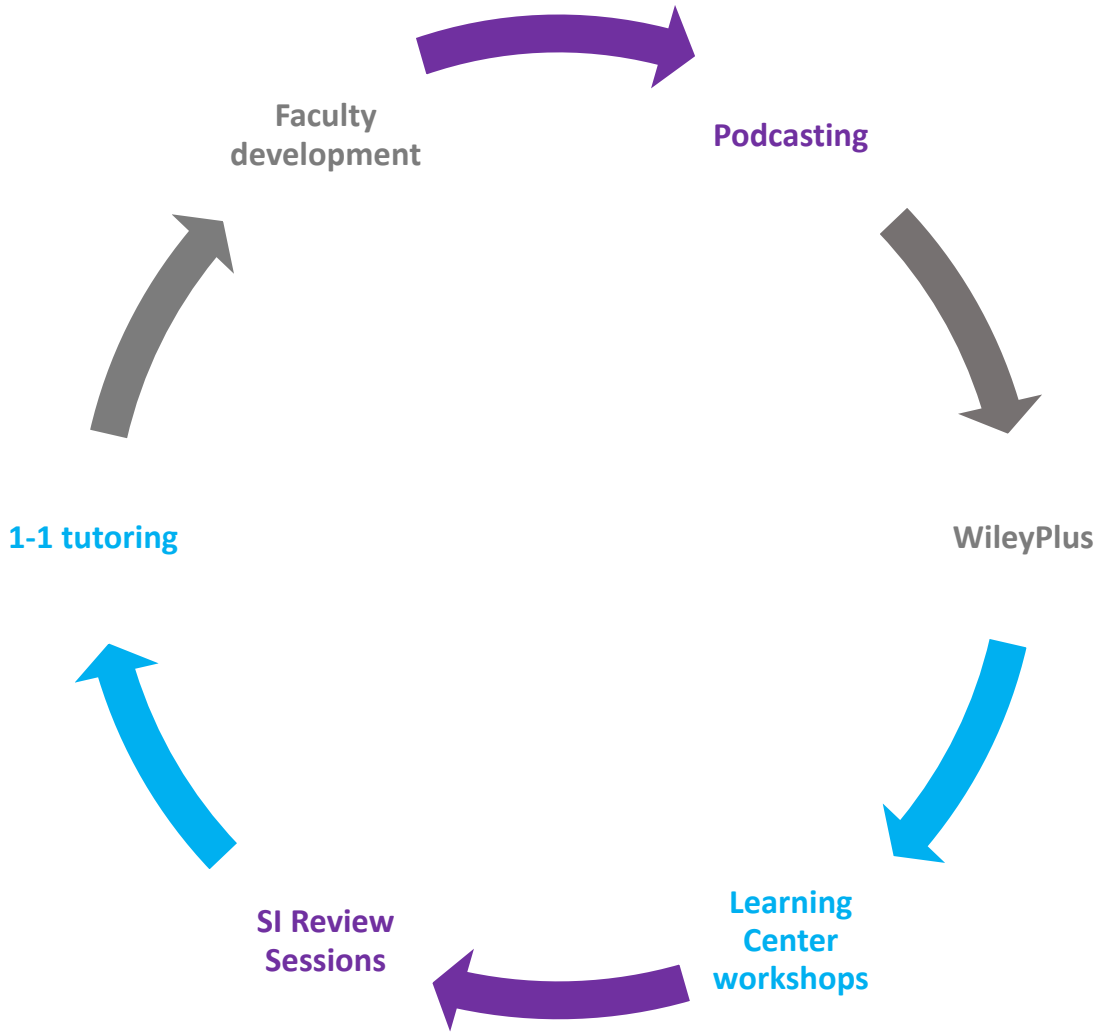
(Ed.), The Functions and Problems of the Urban University: A Comparative Perspective (pp. 46-53). New York: City University of New York.

Rendon, L. I. (1994). Validating culturally diverse students: Toward a new model of learning and student development. Innovative Higher Education, 19 (1), 33-51.

Riposa, G. (2003). Urban universities: meeting the needs of students. The Annals of the American Academy of Political and Social Science, 585 (1), 51-65.

Stellin, S. (2001, May 7). Textbook publishers try online education. New York Times Retrieved September 20, 2008, from http://www.nytimes.com

Figure 1


Faculty development
Podcasting
WileyPlus
Learning Center workshops
SI Review Sessions
1-1 tutoring

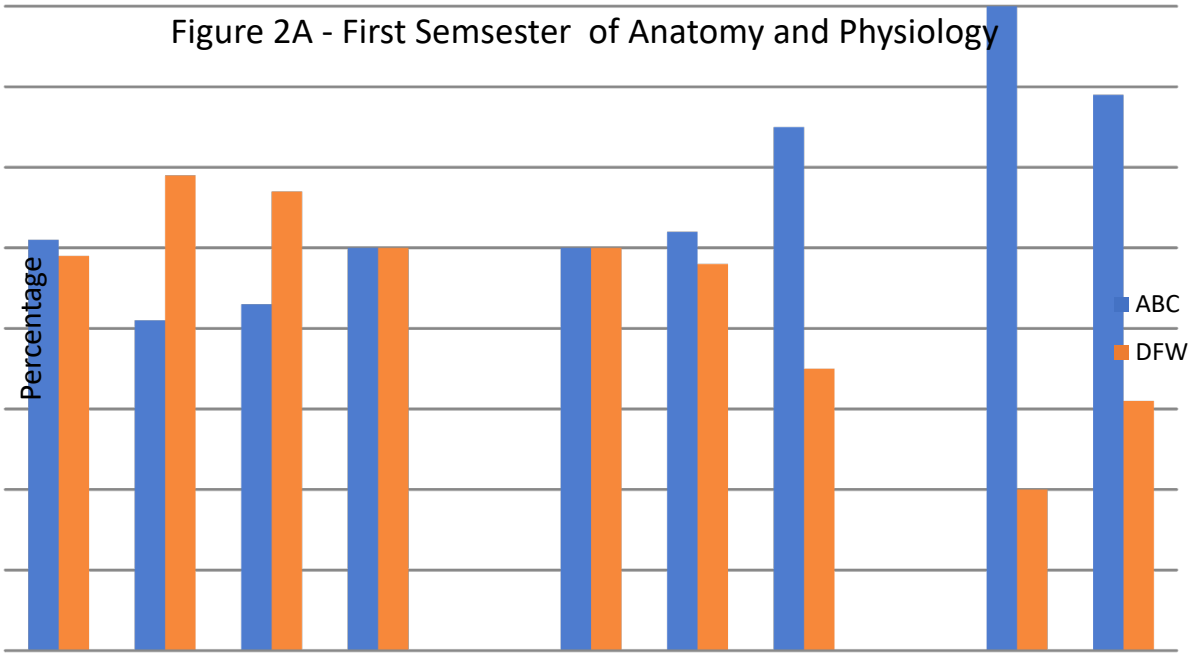


Figure 2A - First Semsester of Anatomy and Physiology
Percentage
ABC
DFW

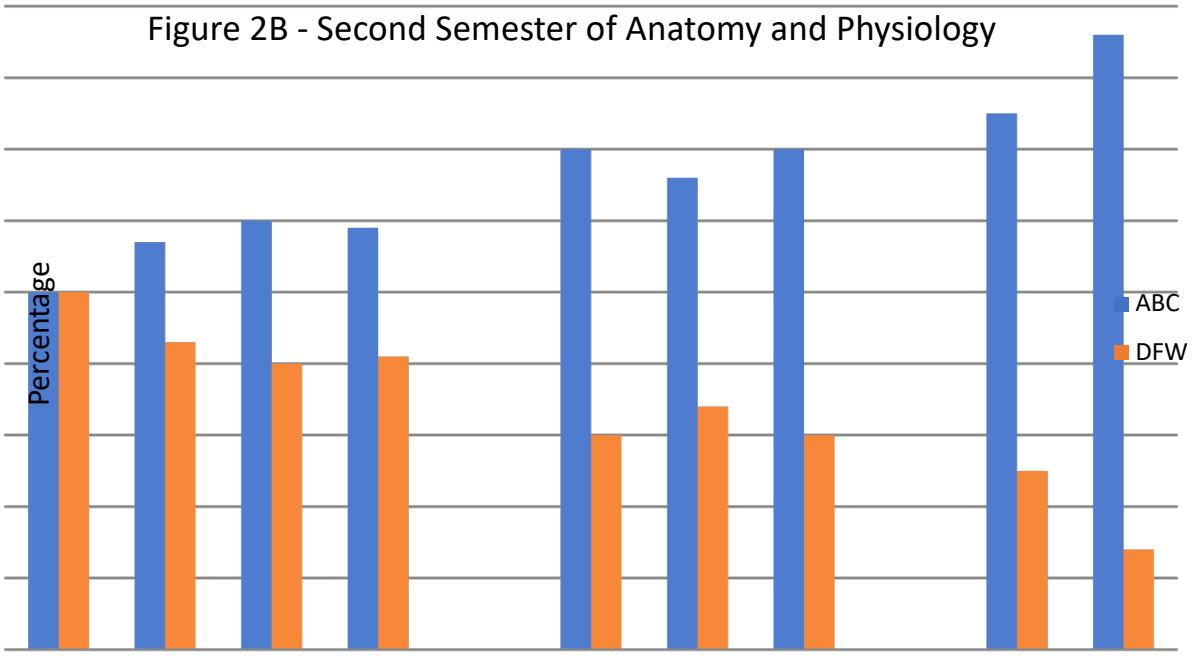


Figure 2B - Second Semester of Anatomy and Physiology
Percentage
ABC
DFW

Figure Legends

Figure 1 - A model for collaborative engagement in introductory science courses.

Figure 2A - Grades in my sections for the first semester of anatomy and physiology prior to and subsequent to the implementation of WileyPLUS and Supplemental Instruction (SI). The figure illustrates the overall percentage of students that received A, B and C grades (ABC), the overall percentage of students that received D and F grades or withdrew from the course (DFW), as well as the percentages for students who participated in Supplemental Instruction (SI). Supplemental Instruction and WileyPLUS were unavailable during 2004-2006. Average student attendance in SI in both fall 2007 and fall 2009 exceeded 10 hours.

Figure 2B - Grades in my sections for the first semester of anatomy and physiology prior to and subsequent to the implementation of WileyPLUS and Supplemental Instruction. The figure illustrates the overall percentage of students that received A, B and C grades (ABC), the overall percentage of students that received D and F grades or withdrew from the course (DFW), as well as the percentages for students who participated in Supplemental Instruction (SI). Supplemental Instruction and WileyPLUS were unavailable during 2005-2007. Students attended SI sessions for an average of at least 10 and 16 contact hours in spring 2009 and spring 2010 respectively.