PEER-LED TEAM LEARNING IMPLEMENTATION

PHYSICS AND CALCULUS UNITED AT THE UNIVERSITY OF PORTLAND

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For the past two years, one section of introductory physics and one section of first year calculus at the University of Portland (Portland, OR) have been linked in a tightly integrated program using peer leaders as a fundamental part of the program implementation. Our goals are to improve conceptual understanding and retention for students in mathematics and physics; to promote the ability of students to apply knowledge in an interdisciplinary context; to improve student satisfaction with and interest in mathematics and physics. To address these goals, we have implemented the following strategies:

1. Integrating calculus and introductory physics curricula and learning environments;
2. Engaging students in active discovery and fostering group learning;
3. Using technology to deepen the connection between physics and math and to empower students to explore mathematical and physics concepts;
4. Implementing peer mentoring by adapting the Peer-Led Team Learning model.

The integration is realized in three ways: syllabus design, pedagogy, and class- room design. In terms of content, we take full advantage of the integration by organizing the course around 'threads' in which the subjects reinforce and motivate each other. This goes beyond a "just in time" approach in which mathematics is often subordinate to physics. By carefully timing the math and physics content we take advantage of the opportunities each subject has to motivate and reinforce the other.

Both the physics and the math sections have a large workshop component in which students discover and explore the material in small groups with the assistance of peer leaders. In term of class structure, students work in small groups at stations designed to promote interaction within and among groups. Peer leaders, each taking charge of three groups of students, maintain and encourage student interest and focus on conceptual understanding through a Socratic questioning dialog.

Finally, in terms of the classroom, the stations incorporate a seamless interface with technology. The course is taught in a dedicated classroom with workstations, each serving one student group, and each with a computer networked to the other computers in the classroom. Mathematica provides a powerful set of software tools available simultaneously for both mathematics and physics. Using experimental tools and hands-on activities, students discover physical principles and model mathematical concepts, actively constructing their own knowledge. In physics, this common set of tools supports the use of recently acquired mathematical skills, while in mathematics the connection to physics drives deeper conceptual understanding of the mathematical concepts.

The sections have the same students, meet in the same room, and the math and physics syllabi are carefully coordinated. The student groups and the peer leaders are the same across the math and physics sections whenever possible. The workshop approach and the peer leaders have proven to be two of the most successful elements of the course and key components of the integration.

The threads that weave through both sections of the integrated course, throughout the semester, are supported by in-class workshops and integrated homework assignments. In the first semester, the threads include limits, vectors, derivatives and rates of change, the Riemann sum and total quantity, the fundamental theorem of calculus, and graphical interpretation of functions and physical behaviors. Second semester threads continue many of these, including vectors, Riemann sum and total quantity, and the mathematical and physical interpretations of the fundamental theorem of calculus. We also add threaded activities on modeling, on using differential equations, and on approximations.

As examples, we present here some details from one of the threads: the physical and mathematical interpretation of the fundamental theorem of calculus. The work energy theorem becomes a physical example of the mathematical statement of this theorem. In lab, students measure both the force on a cart as a function of position and the cart's kinetic energy. Traditionally, this serves to demonstrate the validity of the work-energy theorem. In our integrated course, it also serves as the basis for a discussion of the fundamental theorem of calculus and a review of the Riemann sum as a total quantity. The thread continues in the first semester as the idea of area integrals is developed using a Mathematica lab in the calculus class, followed by the application of the same lab in the physics class for calculating moments of inertia. In the second semester, we pick up the thread when finding the electric field generated by a line charge. Usually an argument for the validity of the method makes reference to the concept of Riemann sum which "you all remember from calculus." But, in an unintegrated physics and calculus sequence, perhaps the students haven't had it in calculus yet, or perhaps it wasn't emphasized, or no connection was made to a physical model of a Riemann sum. Our integrated syllabus and classroom make possible important improvements of this unfortunate (and common) situation. The physics instructor knows that the students are familiar with Riemann sums and integrals because they studied these topics just the previous week. Moreover, one of the motivating examples is the exact line charge problem that the students are faced with in the physics lab. Strengthening the connection is the repeated use of a common soft ware tool (Mathematica) to calculate and visualize the Riemann sums. Using Mathematica, students can also explore refined Riemann sums, reinforcing the important concept of the definite integral as a limit of Riemann sums, and a broad range of charge distributions and field locations.

The peer leaders are involved in most of the physics sessions and about half of the mathematics sessions. Each of our peer leaders works with three groups, each consisting of three or four students. This differs from many other implementations of the PLTL model in which peer mentors work with single groups of six to eight students. Whenever possible, each student group works with the same peer leader throughout the semester and across both components of the course. This is important in that it strengthens the connections between the subjects and builds social relation- ships vital to success in the course. The experience of faculty at the University of Portland and other institutions have been that the social relationships built between students and their peer leader and among students sharing a common peer leader have been very valuable in terms of student satisfaction, interest, and success in the course.

The impact of the peer leaders on the course, and of the experience on the peer leaders themselves, was evaluated through several interviews. Both the peer leaders and the students reported that they felt that the peer leaders added a component to the class that a professor could not. In particular, students felt like they could relate better with the peer leaders because they were closer in age to the students and had just been through the class. The peer leaders indicate that perhaps the greatest value of the PLTL model is the opportunity it provides students to make connections with other students, and to make students aware that they don't have to be a mathematics or physics major to enjoy the class and to realize that they can succeed if they try. An interview with a peer leader revealed the importance that the peer leader placed on making connections with students and helping students learn the material. The peer leader also reported a new appreciation of teaching, and a new attitude toward both teaching and learning: "I never realized how much I like to teach. I never have before, it's just really fun to...to walk up to someone who has a question and be able to help them. I never realized how much fun teaching was. I was always the kid in the back of the class making fun of the teacher."

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