## WHAT WORKS - A PKAL ESSAY

# INTERDISCIPLINARY: THE RENSSELAER POLYTECHNIC INSTITUTE STORY

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*Recognizing the growing sophistication and pervasive of computing tools, how can RPI (a Research I university) integrate computing more tightly into the learning of our undergraduates so that they see the computer as a complement to nearly everything they do? Further, how can the whole campus learning environment is transformed if computing were made ubiquitous to the learning of all students?*

In the mid 90's, as a result of a successful program of integrating computing tools and technology into a number of classrooms and courses, there was a request by the Rensselaer faculty for increased availability of computing resources. Up until that time, the demand had been met through the use of a large network of computing workstations that numbered over 700. However, the question then became: how can we integrate computing more tightly into the students' learning so that they see the computer as a complement to nearly everything that they do, not something that was confined to a few course experiences?

Additionally, we sought to determine how computing could be used to enhance the current use of interactive classroom models, specifically the Rensselaer studio teaching model for science and engineering. It is important to note that this question grew out of a nearly decade-long experiment that looked at how computing tools could be integrated into the students' learning. From this work a number of questions emerged that had to do not only with the work students would do with the tools, but also how the whole campus environment would be potentially transformed if we were to make computing ubiquitous to the students' learning.

This story emerged from the *Orientation Phase IV Seminar* held at Rensselaer Polytechnic Institute in Troy, New York.

This seminar was part of the 2004-2007 PKAL Leadership Initiative (LI) an NSF-funded initiative. The intent of this initiative was to nurture campus-based leadership teams tackling the interesting and challenging work of building and sustaining robust STEM learning environments for undergraduate students.

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In the 1980s, Rensselaer Polytechnic Institute, as the result of an extensive institute-wide planning process, developed major institutional goals, the first of which was an interactive active learning process, which was defined at the time as the more active engagement of students in their own learning with the aid of computing technology, team-based learning, or hands-on experimentation or design.

With the encouragement of the administration and through a process of engagement with the faculty, a number of strategic proposals were developed to advance this initiative.

Led by William Boyce from Rensselaer's Department of Mathematical Science, a group of five professors were awarded an NSF grant for comprehensive curriculum reform in the teaching of calculus.

The underlying philosophy was based on improving the teaching of calculus by placing less emphasis on pencil and paper calculations and more emphasis on mathematical concepts and their use in problem-solving, mathematical modeling, and the interpretation of results.

Computers, through the availability of symbolic computation tools, offered a means of doing this.  By the 1990-91 academic year, all of the first-year math courses had been converted to the new curriculum, making Rensselaer the first major research university to have all of its freshmen learning calculus using a computer algebra system on state-of-the-art workstations.

The computer made calculus more like a laboratory course in which students were actively involved in experimentation with various possibilities, not just solving a given set of problems.

This first step in the use of computers in calculus was expanded to reach other courses in a program called Computing Across the Basic Sciences, embracing chemistry, physics, and computer science.

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As the faculty embraced this new technology, the infrastructure of campus began to evolve and over 500 workstations were connected to the campus network in classrooms and in public.

Classrooms were updated with computer projection equipment to allow faculty to give spontaneous demonstrations during their classes, and a suite of software applications was provided on all the systems to facilitate their use across the curriculum.

It is important to emphasize that in all of these initiatives, the need for curriculum change drove the selection of the computers and software. A major criterion was the usefulness of a package throughout the curriculum and in a student's career, not just in a particular course.

In the School of Engineering there was an interest in taking more of a systems approach to understanding some of the broader software technology implications to the curriculum.  What developed was the notion of Strategic Applications Across the Curriculum.

The idea was to find strategic applications and understand their use in various courses in the curriculum as a student progressed in their field of study.

A strategy of vertical integration of computing tools was developed in the engineering curriculum. In order to have a lasting effect on the curriculum and learning process and eventually engineering practice, three goals needed to be met:

- a formal methodology for developing student's computing skills over several courses
- a synergy between instruction of computing skills and of engineering theory
- and identification of strategic applications for instructional computing.

Also defined were Core, Intermediate and Advanced skills that were then mapped into several application areas and outside the curriculum.

In the early 90's, through work developed by Rensselaer's Lois J. and Harlan E. Anderson Center for Innovation in Undergraduate Education, a new method of course instruction for basic science courses, entitled Studio Physics, was developed.

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The purpose behind Studio Physics was to integrate the various parts of a typical physics course (lecture, recitation and lab) into a single meeting while employing advanced educational technology to significantly impact student learning.

To support this new style of teaching a new type of classroom needed to be designed in order to hold approximately fifty students, workstations each accommodating two students, an open workspace, and space for equipment needed for the day's hands-on lab.

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There was considerable potential in improving student learning through educational technology, but this would not be realized unless it was tightly integrated into the course structure. The studio method enabled just that for introductory physics.

The successful studio physics model was adopted in several other basic science and engineering courses, and in 1994-95, Rensselaer embarked on an institute-wide self-study in all areas of the institute operations including the curriculum.

As a result of this study, it was recommended that Rensselaer standardize their curriculum structure on a template of four courses per semester at four credits per course. This became known as the '4X4' curriculum reform.

In addition, the committee proposed that the maximum number of credits for a BS would be 128, and that each curriculum would provide for 12 credits of free electives.

With over 800 workstations in classrooms and labs, faculty needs for computer classrooms and student needs for computing workspaces were still difficult to accommodate. After discovering that more than 90% of the students were bringing their own computers, it was decided in 1995 to begin a pilot program to test whether the computer-based curriculum could rest on a foundation of student-owned computers.

The 1995 laptop pilot began with a small group of students working in a core set of science, math, and engineering courses. The program continued for two more years, after which a group of faculty and staff charged to review the pilot program and its plan for expansion recommended a freshmen requirement to own laptops in the fall of 1999, increasing the number of students involved.

As a result of this decision, a number of challenges had to be met. These included educating the first-year faculty on the use of laptops in the classroom, the development of maintenance and service options, and creating more laptop-capable classrooms.

Workshops for faculty were held, curriculum development grants were made available, classrooms were renovated with faculty input, and service options were put in place.

With the introduction of laptop computing for all students and the growth of internet tools, a new era of curriculum reform had developed. New ways of using computing and integrating the internet in the classroom have been developed by the faculty and in some cases by the students as well.

As a result of these changes and incoming technologies, we should expect that we will see another institute-wide reform where new ideas about how education should be conducted will be explored and our standard notions of a time and a place for learning will be changed.

In the end, however, the success of all these changes was tied the faculty's desire to succeed. A good faculty wants students to learn. When faced with new facts and new ways to improve student learning, quality faculty members will want to study them, embrace them, and share them with their colleagues.

In the end, the desire to improve student learning through the smart application of technology in support of new pedagogy was a key to the success of these initiatives. Keeping learning at the center of the innovations, letting it drive the process rather than having technology drive it, resulted in a learner-centered environment where technology was an important enabler. ■