Volume XXXII, Number 18

NISOD INNOVATION ABSTRACTS

Published by the National Institute for Staff and Organizational Development (NISOD) • College of Education • The University of Texas at Austin

21ST CENTURY PEDAGOGY AND TECHNOLOGY

When I started teaching college some years ago, my only teaching methodology was lecture. This, of course, I learned from my teachers and my teachers from theirs. Moreover, the only technological support tools available were overhead projectors, videos, and hand-held calculators, and they were not readily accessible.

Now, as we complete the first decade of the 21st century, fundamental changes in teaching and learning have transformed the instructional landscape. A time traveler would be amazed at the extent to which our technological support tools have multiplied, both in availability and capacity. Teaching has evolved into a dynamic process to promote student mastery of the material. Some of these techniques, known as the Keystone methodologies, are outlined below. While they are offered from the perspective of a mathematics professor, the basic concepts have been applied successfully in other fields as well.

Engaging Students Through Cooperative Learning

The ultimate issue in teaching is how to engage students with course content. What can the instructor do to create learning experiences in the classroom? How do we bring students to understand the general concepts, along with examples and applications? In contemporary mathematics, we often utilize an inductive approach to instruction. We start with simple cases and move to the more complex and abstract. This interaction leads to our objective: the broad generalization.

Ideally, this process itself engages students, but not always. Unfortunately, too often those engaged are not the neediest students—those who lack self-confidence or who are "lost" early in the process. One especially effective way to maximize student engagement is to change the structure of the class. This can be accomplished by dividing the class into small groups of mixed ability—usually four students, with each group including individuals across a range of academic standings. With guidance from the instructor, these groups interact by talking and discussing problems among themselves. Weaker students learn from stronger ones; stronger students reinforce their knowledge by refining their thoughts and articulating answers to the questions they receive. This cooperative learning deepens knowledge and deals directly with student passivity, increasing student engagement and assertiveness in the larger activities of the class.

Structuring Progress

An important tool for improving student learning is using frequent quizzes and tests. Expecting quizzes demands that students constantly practice and review the material. Immediate feedback provides students and teachers with information about what still needs to be learned. Beyond that, of course, quizzing contributes to the flow of learning and to student retention of the material. My experience, and that of many colleagues in mathematics, indicates that quizzes and tests are best when they are cumulative and time-restricted. The hierarchical nature of mathematics itself calls for cumulative testing.

But in all fields, when tests cover only new material and do not reinforce what has been learned earlier, students miss the integrative learning experience. That experience should develop through the term and then culminate in the final exam. In mathematics, time-restricted assessments, as in quizzes and tests, have proven valuable. Establishing limited time for tests and quizzes strengthens basic skills development by demanding that students fully concentrate on the task. Beyond this, we have found that it promotes development of mental mathematics through which students create images of the problems and mentally process their solutions.

Targeting Subject Mastery

Many students, especially in difficult subjects like mathematics, are content with passing courses by fulfilling the minimum requirements. Students tend to underestimate their potential and so contribute minimally to their own learning. This attitude results

in mediocre performance, attributed by the students to their supposedly dismal ability levels.

Our task is to help students experience step-by-step progress toward mastery. For such progress to be significant, of course, it must target and measure achievement based on actual mastery. Once mastery standards are set, students must be given every opportunity to meet those standards. Cumulative testing and peer support groups, as described above, are key to addressing them. By repeating troublesome problems or concepts until they are mastered, and supporting students with peer assistance, fewer students are left behind. Quick feedback documents progress for students who have mastered the material; it similarly identifies instructional areas requiring more attention. This sharp focus on progress provides students with motivation for continuous effort towards mastery. Beyond promoting performance in the class, developing mastery in one class can contribute directly to improved performance and success in other courses and disciplines.

Utilizing Technology

For the past three decades, personal computers and the Internet have been the predominant features of the educational scene. We marvel at this ongoing technological revolution and its increasing prevalence at all levels of education. Yet, at the same time, high schools continue to produce generations of graduates unprepared to begin college-level work. This is dramatically true in mathematics. The technology is amazing; however, the impact of technology on education has thus far been minimal. The reason, I suspect, is not the lack of access, but the temptation to use programmed learning as a substitute for the dynamics of classroom instruction. This is especially true in developmental classes in mathematics.

Technology is best used as a supplement in a structured pedagogy; for instructors, technology can be a major labor-saving tool and instructional aid. Contemporary software can instantly create and grade multiple versions of algorithmically generated quizzes and tests. This enables the instructor to quickly, easily, and regularly use tools in ways that would have been impractical in earlier years. Creating tests and quizzes requires little time or effort. The immediate tabulation of results helps the instructor identify problem areas and provides immediate feedback to students. The results are tightening the teaching/learning dynamic, increasing student engagement, and enhancing mastery.

Conclusions

Our research in developmental mathematics at Richard J. Daley College has shown that frequent assessment, cooperative group work, development of mastery, and time-restricted activities (collectively known as the Keystone methodologies), combined with state-of-the-art technology (for example, MyMathLab), has produced synergistic effects, contributing to significant improvement in learning and retention. These gains have been accomplished without requiring additional instructional resources from the college and without placing undue demands on the instructor. These methodologies are readily adaptable to other disciplines.

I invite my colleagues at other colleges and universities to join me in this synergistic approach, and I welcome opportunities to collaborate in its implementation.

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September 10, 2010, Vol. XXXII, No. 18

Innovation Abstracts (ISSN 0199-106X) is published weekly following the fall and spring terms of the academic calendar, except Thanksgiving week, by the National Institute for Staff and Organizational Development (NISOD), Department of Educational Administration, College of Education, 1 University Station, D5600, Austin, Texas 78712-0378, (512) 471-7545, Email: abstracts@nisod.org