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INNOVATION ABSTRACTS

Redesigning Mathematics for Student Success

Recently I asked first-level developmental math students to locate seven-eighths on the number line. Sixty percent of the class located it between seven and eight. On another occasion, I asked the class if someone would come to the board and plot nine-elevenths on a number line. Only one person was able to guess its location. Unfortunately, these scenarios are not uncommon to many mathematics teachers. Students who place into first-level developmental math are lacking the ability to make sequential connections. By continuing to teach mathematics through the traditional sequence of topics, instructors do not address this barrier, and it can prevent students from moving forward. Sometimes sitting in front of a computer doing practice problems with a calculator may lead to immediate positive results. However, these methods do not provide the opportunity for students to understand what is being done and why. If you are curious about your students' knowledge, ask them any of the following questions:

- When we are subtracting numbers and need to borrow, why do we cross out a number, make it a ten, cross out another number, and make it a nine?
- Why do we count decimal places when we multiply decimal numbers?
- Why do we find common denominators when we add fractions?
- Why do we move decimal points when we divide by a decimal?

Students who answer these questions incorrectly are part of the increasing number of students placed into the first level of developmental math. It is my belief that learning and retaining information should include understanding *why*, as well as *how*, to solve the problem.

Course Redesign

Concepts of Numbers for Arithmetic and Prealgebra was developed in 2008 to provide an alternative approach to teaching mathematics. The goal of the course is to address the challenges of students referred to mathematics in two ways. First, it presents course content thematically rather than topically. For example, fractions, decimals, signed numbers, and algebraic expressions appear together in almost every chapter of the course text, reinforcing their relationship to one another. This reordering is designed to help students make connections across ideas that may have previously seemed unrelated. Second, it employs a discovery-based pedagogy that openly builds on students' prior knowledge, allowing them to clarify concepts they did not understand in the past. Combined, these two components aim to increase students' confidence and foster a new-found appreciation of how numbers work.

The Concepts Curriculum

The course is comprised of eight units covering the material typically taught in a mathematics/pre-algebra course. These units include: History of Math, The Real Number System, Comparisons, Addition, Subtraction, Multiplication, Division, and Combinations. Students feel demoralized when placed into mathematics because they assume it will begin with traditional mathematics topics and instructional methods. However, the first unit focuses on the history of math, including information on African, Egyptian, Roman, and Babylonian number systems, which demonstrates how our present numeration system evolved from the ideas of many cultures and nations. This unit creates a positive tone in the class and promotes a different understanding of the nature of mathematics.

In the second unit, students investigate all real numbers. By locating various types of numbers on the number line and classifying them as whole numbers, integers, rational, and irrational, students begin to realize the relationships between different types of numbers. For example, they begin to see that fractions are no different from decimals, which helps to dispel the myth of, "I can't do fractions." These opening units provide a foundation for the mathematics topics covered in a traditional course, but are rearranged within these conceptual units. The course ends with a combination unit that deals with multiple-step problems, synthesizing many of the skills learned in the course.

Once the history of math has been presented, discovery becomes the main teaching tool. Instead of the traditional teaching approach, *Concepts* asks students to solve problems by drawing on previous mathematical experiences and knowledge before a rule is given. Although adult students referred to arithmetic have holes in their mathematical knowledge, most have been exposed to the course content in their previous educational experiences. When the teacher facilitates discussion among students through the discovery approach, that prior knowledge emerges.

Under this model, instructors encourage students to experiment with shortcuts, memory aids, and formula application. A calculator is a tool to be used only when the calculations become cumbersome, which is rare. Instructors listen to students' discussions in class in order to answer the important question—do they understand? If they don't, then the teacher must tailor class discussions to fill in the blanks and bridge any gaps

that remain. *Concepts* involves students in the learning process by asking questions, giving students time to ponder, and allowing wrong answers to be considered. Students take ownership for what they are discovering and become active participants in their education.

Course Support

The *Concepts of Numbers for Arithmetic and Prealgebra* textbook, published by Pearson Learning Solutions, has a number of features to facilitate this approach to teaching and learning. For example, the text has minimal narrative and explanation to facilitate the teacher's use of the discovery approach. Having less prescription allows the lesson to evolve according to the needs and knowledge of the students in the class. The number of homework problems is radically reduced as compared to a traditional textbook. Homework problems are intended to help students assess their own understandings, not to drill procedures. Faculty that use *Concepts* report an increase in completed assignments and attendance compared to students in traditional mathematics courses. They attribute this change in students' academic behavior partially to the smaller homework sets and the need to be present as lessons evolve. For students or instructors who believe that additional practice is needed, supplemental problems are available in the workbook format and via an online resource aligned with the text.

Moving from Pilot to Scale

Over the span of four years, *Concepts* has gone from a single section pilot to the only mathematics course offered at Montgomery County Community College (MCCC). Positive pass rates during the pilot in 2008 prompted the math department to add 20 sections in 2010. In 2011, the department voted to replace the traditional mathematics/pre-algebra course with *Concepts*.

The Aftermath

Concepts course pass rates indicate that this new curricular and pedagogical approach has been effective for many students referred to the lowest level of developmental mathematics at MCCC. In 2011, the college was awarded a two-year William and Flora Foundation grant through the Community College Research Center to replicate the course at two colleges. It is presently being taught at Reading Area Community College (PA) and Berkshire Community College (MA). Ten other colleges in Pennsylvania, Ohio, Massachusetts, Illinois, California, and Alaska are using *Concepts,* ranging from a pilot phase to full-scale implementation.

Lessons Learned

As *Concepts* expanded, the orientation of new faculty was critical to implementing the curriculum as designed. The course's reorganization of subject matter and the change in teaching methods required faculty to move away from a lecture-drill-practice approach. Changing from a lecture-based mode of instruction to a discovery/facilitation format requires time, practice, and support. Replicating colleges have reported success with faculty orientations and continuing professional development sessions.

Conclusion

It is an exciting time to be a developmental math educator. The field is currently flooded with practitioners and researchers trying to find answers to the math barrier that impedes degree completion and transfer goals of so many community college students. *Concepts* represents a tiny piece of the puzzle within the developmental math sequence that has worked for MCCC and our replicating partners. It has equipped students with a basic understanding of numbers and a new confidence to continue their academic paths. Institutions must examine multiple factors, including data collection and long-range goals, to determine whether *Concepts* is a good fit for their campus.

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Data Table

MAT010 *Concepts of Numbers* versus MAT010 Traditional Course

	Fall 2008	Spring 2009	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013	Fall 2013
Concepts of Numbers	74% N=19	63% N=19	68% N=19	60%* N=255	58%** N=380	57% N=289	58% N=704	61% N=316	60% N=545	62% N=327	62% N=523
Traditional Mathematics	45% N=664	34% N=429	41% N=567	40% N=236	40% N=284	38% N=150					

* The top 13% of Mathematics Accuplacer scorers were accelerated into the next course (a 4 credit beginning algebra class)

** An additional top 12% of Mathematics Accuplacer scorers were accelerated into the next course (a 4 credit beginning algebra class)

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