Dr. Marilyn Carlson’s Rationale for Developing PreCalculus Materials

As per email to Andrew Tonge and Bev Reed on March 9, 2015

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My first research project after completing my dissertation examined calculus students’ understandings of key ideas of calculus—the primary finding was that calculus students’ weak understanding of ideas of function, variable, rate of change and other foundational ideas made it impossible for them to make sense of applied problems and understand ideas of limit, derivative, the chain rule, and the Fundamental Theorem of Calculus. Even though the Pathways Precalculus materials appear to be more effective (than traditional approaches and other approaches we’ve tried) in building these foundational understandings, students would be much better off if high school courses were more mathematically engaging, and had a greater focus on understanding ideas. It is a challenging to reverse years of meaningless instruction in one semester.

Regarding your [Andrew’s] questions:

Dr. Tonge: *Can you point me to data on how Pathways students' conceptual knowledge changes compared with students in standard courses? I found*

1. I do not have a published paper on the impact of Pathways Precalculus; however my research group and other colleagues have been collecting data over the past 4 years aimed at investigating the impact of Pathways at various sites. Our initial data was collected at ASU by Fabio Milner, our director of STEM education. His study found that Pathways students (as compared to non-Pathways students at ASU) had significantly higher PCA scores over 5 semesters. The data he collected also revealed that a significantly higher percentage of students from Pathways courses completed beginning calculus, as compared to the non-Pathways sections. Iowa State University and Middle Tennessee State University have been using Pathways over the past 2.5 years. Their data has also consistently shown higher gains on PCA and greater continuation onto calculus (see recent data below). I and my colleagues are currently compiling all data we’ve gathered in the context of Pathways to include in a manuscript we’re submitting for publication and will have more data to share in a few months.

Dr. Tonge: *In all our courses, there is an enormous variation across sections in mean student outcomes as measured by grades. In courses where we have common finals, this is less dramatic, but still true, for final exam scores. When you compare Pathways and non-Pathways students how do you control for the instructor variable? Instructors will usually be biased in favor of one approach or another.*

1. The wide variation in grades across courses is a phenomena that needs to be studied. My experience (as Director of First Year Math at the University of Kansas and then at Arizona State University) also supports that with no coordination and individual exams, there is a wide variation in student success from one section of the same course to another. Our examination of this phenomena revealed that some faculty provide little support for student learning and believe good teachers are ones who weed out the weak students, while other instructors believe that good teachers are ones who motivate students to attend class; make class engaging and interesting so that students value coming to class; make demands on students that support them in engaging in “meaning making” toward understanding and using the course’s key concepts to solve novel problems. The Pathways Professional Development supports instructors in reflecting on their role in helping students become independent and powerful mathematical thinkers, in contrast to viewing teaching as showing students methods for getting answers to specific problem types.

Dr. Tonge: *How do you preserve the integrity of the concept inventory without changing the questions you ask the students? It is very easy to take a photo with a cell phone*

1. In validating the PCA we have conducted hundreds of interviews with students and have found that it is extremely rare for student to select the correct answer without possessing the understandings needed to respond to the question. After the instrument had been developed, we tried to teach students how to get the answers to the questions in three different sections of precalculus, and found that showing them how to work the problems the day before the exam resulted in the same mean score as other classes. Lastly, students have no motivation to preform well on the PCA. When we give it as a pre-test students are told to do their best so that the data can be used to determine where we need to start instruction. At the end of the semester we tell students that they receive one point for showing their work and making a strong effort to get the right answer, and expect everyone to get a 25/25. (The post-test exam is then counted as a homework or quiz score.) One other point—if students were cheating by taking pictures of the exam, one would think that students from both Pathways and non-Pathways sections would be exhibiting the same behavior.

Since the focus of Pathways is on understanding concepts, one could argue that Pathways is biased towards Pathways students. When people make this argument I really don’t know how to respond. Shouldn’t it be a goal of all courses to help students understand key ideas of a course, and be able to access facts and procedures as needed to solve novel problems? One last point, we continue to collect data to assure that Pathways students are performing just as well on procedural types of problems and skills they may need—our data to this point suggests that Pathways students are doing just as well as none-Pathways students. (We include a moderate amount of procedural questions in homework assignments.)