Research and Practice in Undergraduate Mathematics Education
• What does the research tell us about class size?
• Do flipped classrooms work?
• How do I best teach students whose first language is not English?
• Should our department use a placement exam?
• How should we prepare our TAs to teach?
• My students don’t really seem to understand limit, no matter how I try to explain it to them. What can I do?
• How are learning and retention (of content and students!) related?
What does it take to answer questions like these?

- Empirical investigation *
- Building and testing theory *
- Developing and testing interventions *
- Replicating results
- Understanding institutional contexts
- Coordination of research efforts
- Time and money
RUME Research Evolution

- Identifying student difficulties, misconceptions, and “cognitive obstacles”
- Understanding the processes by which students learn particular concepts
- Classroom studies (including curricular/pedagogical innovations)
- Research on teachers’ knowledge, beliefs, and practices
What does research tell us about student learning of limit?

Identifying student difficulties, misconceptions, and “cognitive obstacles”

- Students draw upon ideas and intuitions from personal experience when trying to make sense of limit (Cornu, 1981)
  - Approaching means getting closer (but not necessarily arriving)
  - Limit means a boundary that is not crossed
- Students’ over-reliance on dynamic view of limit (Tall & Vinner, 1981)
  - No term in a convergent sequence can be closer to the limit than the previous term
What does research tell us about student learning of limit?

Identifying student difficulties, misconceptions, and “cognitive obstacles”

Understanding the processes by which students learn particular concepts

• Students’ beliefs about limit (e.g., a limit is a boundary that cannot be crossed) are resilient, even in the face of counter-examples (Williams, 1991; Szydlik 2000)
What does research tell us about student learning of limit?

Identifying student difficulties, misconceptions, and “cognitive obstacles”

Understanding the processes by which students learn particular concepts

Classroom studies (including curricular/pedagogical innovations)

• Students rely on different metaphors for limit throughout calculus – e.g. approximation (Oehrtman, 2009)

• Students can re-invent the formal definition of limit, by explicitly focusing on a “y-first” approach (Swinyard, 2011)
What does research tell us about student learning of limit?

Identifying student difficulties, misconceptions, and “cognitive obstacles”

Understanding the processes by which students learn particular concepts

Classroom studies (including curricular/pedagogical innovations)

Research on teachers’ knowledge, beliefs, and practices
  • Comparison of students’ and teachers’ discourse on limit (Gucler, 2013)
**Gaps**

- What does a students’ understanding of limit predict about her success in calculus?
- How can pre-calculus curriculum be designed to more effectively support the learning of limit in calculus?
- Could approximations be used in place of limit in the calculus curriculum? What would be the effects on student learning of other calculus concepts?
- What is the *pedagogical content knowledge* instructors need to help students navigate the complex idea of limit?
Based on several years of research that developed and tested abstract algebra curriculum

Set of instructional materials (videos, instructor explanations) to support the curriculum

Study of challenges in implementing the curriculum
Characteristics of Successful College Calculus Programs

• Recent large-scale study of successful calculus programs at 2- and 4-year postsecondary institutions
• 5 pedagogical activities significantly related to students’ decisions to continue onto Calculus II after Calculus I
  (1) the instructor showing examples of worked problems;
  (2) the instructor preparing extra material for students;
  (3) holding whole-class discussions;
  (4) requiring explanations of thinking on exams; and
  (5) requiring explanations during class.
Challenges

• Need more empirical results to impact the curriculum (textbooks)
• Incentives for more RUME research to look at larger questions working with larger data sets (Big Questions in RUME?)
• Better avenues to disseminate results (perennial educational research problem)
• Need to better understand what impacts student retention (unique to post-secondary research)