CAPR | CENTER FOR THE ANALYSIS OF POSTSECONDARY READINESS

Implementation and Outcomes Findings From the Adoption of the Technology-Centered Instruction in Developmental Math

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Emporium-Style Instruction

- Replaces traditional lectures with interactive instructional software
- Self-paced
- Faculty serve more as tutors who deliver individualized instruction, as opposed to lecturers
- Content divided into modules taught using tutorials, practice exercises, and online quizzes and tests
- Offered by third-party providers such as Pearson or McGraw-Hill

Research Questions

- Does the use of technology-centered instruction in developmental math courses result in higher course pass rates and persistence rates for students than the traditional version of these courses?
  - Do these results differ by student subgroup?
- How does technology-driven developmental math instruction support student learning?
- How do faculty respond to mandated, technology-driven instructional change in developmental math?

Hypotheses: Potential Positive Effects

- Consistency across sections may result in more even levels of academic preparation for college-level courses
- Greater on-demand assistance for students
- Faculty can give more individualized instruction, as little time is spent directing the class as a whole
- Clear expectations for progress, including deadlines for exams
- Students work at their own pace, which allows some to move more quickly into their college-level courses, creates efficiencies in course delivery

Hypotheses: Potential Negative Effects

- Not all students comfortable using technology as an instructional tool, particularly at a self-driven pace
- Assumes students have the ability to self-pace
- Students may choose to “game” the online quizzes

Limited Prior Research: K-12

- Negative effects of taking an online course compared with face-to-face on scores on standardized test and passing the next course in the sequence (Hart et al., 2019; Heinrich et al., 2019; Heppen et al., 2017)
- Positive effects of hybrid courses, but many have small sample sizes, no control groups, or were sponsored by an organization with an interest in the outcome (Tamin et al., 2011; Waxman, Lin, & Michko, 2003)
- Mixed experimental and quasi-experimental results of hybrid courses (Barrow, Markman, & Rouse, 2009; Cavalluzzo et al., 2012; Dynarski et al., 2007; Pane et al., 2013)

Limited Prior Research: Higher Education

- In 4-year colleges, students using a hybrid model perform worse in the course and, in some cases, subsequent courses (Cosgrove & Olitsky, 2015; Goode et al., 2018; Kwak, Menezes, & Sherwood, 2015; Powers, Brooks, Galazyn, & Donnelly, 2016)
- In community colleges, descriptive results are usually positive (Ryan et al., 2016; Twigg, 2013; Vallade, 2013) or report no differences (Spradlin & Ackerman, 2010; Ashby, Sadera, McNary, 2011)

Data

Tennessee Board of Regents: Student by term 2005–06 to 2015–16

- Demographics
- HS information, ACT scores
- Course numbers, grades, mode of instruction
- Degree completion

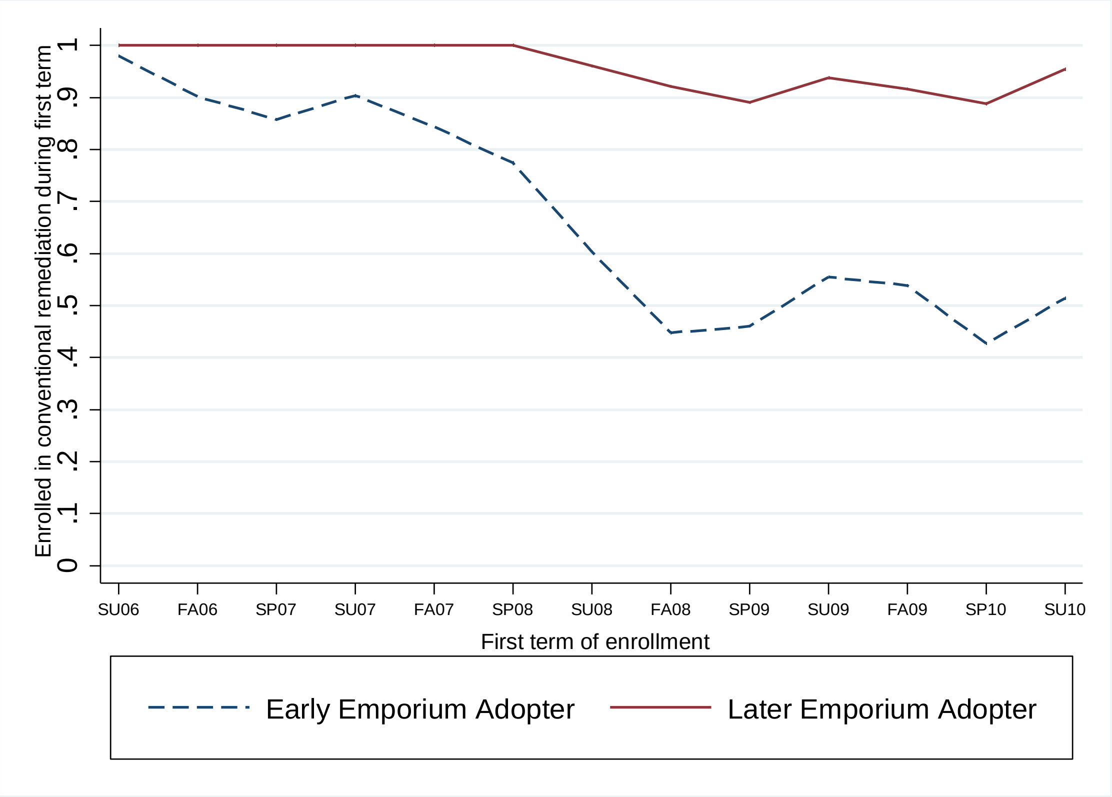
Collected qualitative data

- Surveys to 19 TBR public colleges
- Site visits: Purposive sampling (maximum variation)
- Classroom observations, faculty/admin and student focus groups
  - Four community colleges and two 4-year colleges
  - Areas of focus: classroom instructional, logistical, and social experience; perceived benefits and challenges of various aspects of instruction and assessment

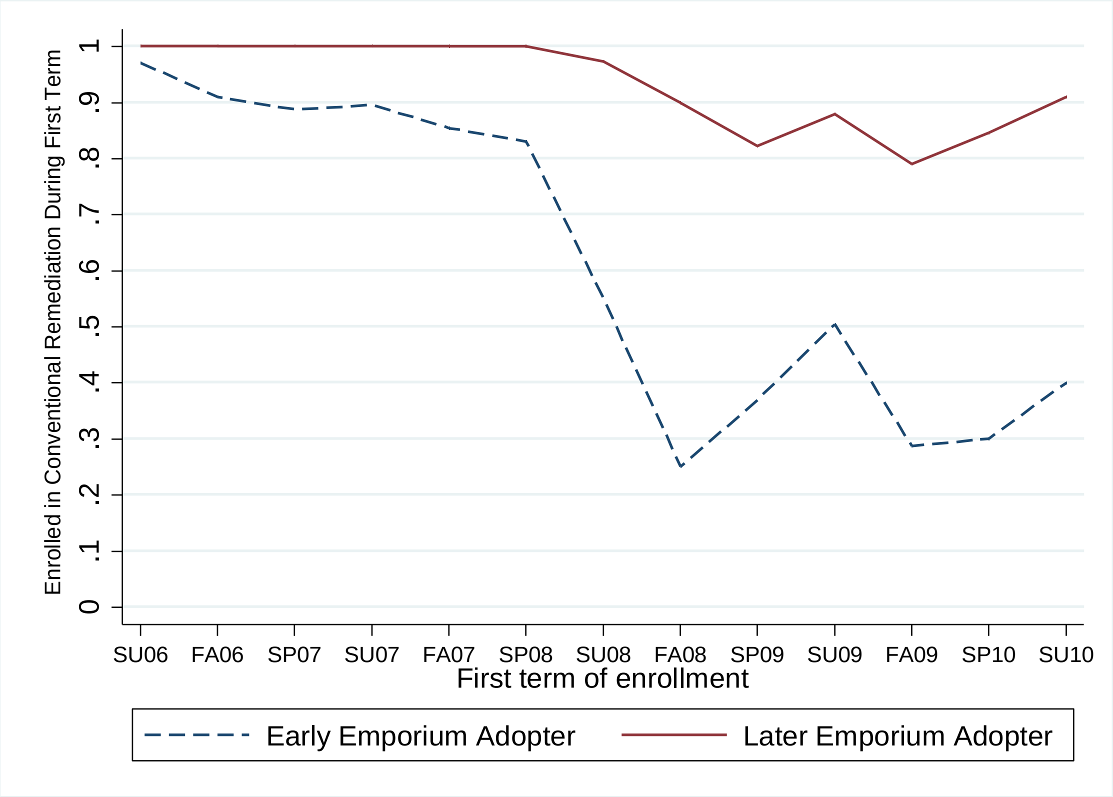
Moving to Technology-Centered Instruction in TN

- 2008–09: Early adopters
- 2011: Increase the adoption of this model to all public institutions (developmental math, reading, and writing)
- 2013: Full implementation
  - Colleges varied in the degree to which they “fully” implemented the model
  - Stricter in their compliance in math
- (2012: Eliminated developmental education from 4-year colleges)

Community Colleges: % Enrolled in a Conventional Developmental Math Course



Four-Year Colleges: % Enrolled in Conventional Learning Support Course



Impact Analysis

- 2005–06 to 2010–11 cohorts followed through 2015–16 at 19 public colleges
- Difference-in-differences design
  - Diff #1: Students assigned to dev math at the early-adopter institutions before and after adoption
  - Diff #2: Students assigned to dev math at the later-adopter institutions
    - Controls: gender, age, ACT math score, HS GPA, lottery status
    - Year and college-by-course fixed effects
    - Sensitivity analyses: Event study, covariate balancing, falsification tests

	2-Year Colleges		4-Year Colleges	
	DD	Comparison Mean	DD	Comparison Mean
Passed first dev math	-0.010 (0.028)	0.64	0.054** (0.026)	0.78
# of terms in dev math	-0.140 (0.112)	2.14	-0.292** (0.122)	2.02
Passed college math, if took	-0.057*** (0.022)	0.61	-0.054*** (0.015)	0.69

	2-Year Colleges		4-Year Colleges	
	DD	Comparison Mean	DD	Comparison Mean
Cum. credits within 3 terms	-0.702* (0.379)	16.3	0.801 (0.497)	23.1
Cum. credits within 6 terms	-1.556*** (0.575)	23.5	-1.059 (0.940)	40.8
Persisted to 2nd year	-0.065*** (0.015)	0.65	0.006 (0.018)	0.88
Earned AA within 3 years	-0.012 (0.011)	0.06	0.003 (0.002)	0.01
Earned AA within 6 years	-0.035** (0.014)	0.13	0.001 (0.010)	0.02
Earned any degree within 6 years	-0.037** (0.015)	0.21	0.056 (0.032)	0.46

Community Colleges

- Lower pass rates in college-level math driven by female students. Male students experienced greater reductions in the likelihood of earning an associate degree or any credential within six years. No statistically significant effect for female students on the number of credits completed over time or degree completion.
- Largely driven by traditional-aged students, those 22 years and younger, compared with older students.
- Negative student outcomes associated with the Emporium Model are largely concentrated among those with ACT Math scores above 16.
- Findings are largely consistent with Kozakowski (2019), examining community colleges in Kentucky.

Four-Year Colleges

- Few differences by sex.
- Older students report higher pass rates in their developmental math courses under the Emporium Model. They also spend fewer terms in developmental math compared with students 22 and younger.
- At the four-year colleges, there are fewer substantial differences by ACT score.

How does technology-driven developmental math instruction support student learning?

- Site visits: Classroom observations, faculty/admin and student focus groups at four community colleges and two 4-year institutions
- Analysis
  - Transcription
  - Two-stage, line-by-line coding to identify emergent categories and themes

Cognitive and Social Accessibility

- **Cognitive accessibility:** Facilitating the acquisition of specific math skills by:
  - Increasing access to material
  - Affording abundant opportunities for practice
  - Providing immediate feedback
- **Social accessibility:** Contributing to feelings or beliefs that the course and material are within reach through:
  - Multiple avenues for relationships with instructors
  - Deepening connections between students and instructors

Psychosocial Response to Accessibility

1. Breaking down barriers to math

   I enjoy the fact that we were kind of forced into the math lab, because otherwise I would have been way too intimidated to go into it. Kind of like a girl going to the gym to lift weights: Like, we want to do it, but we're afraid we're going to look stupid … Because I hear math lab, and I think, "There's a bunch of geeky people in there," and that I'm just … like, I'm going to stick out like a sore thumb because I don't, you know, know what pi is, you know? And so being in there for my math support class kind of helped to make that a less intimidating environment.

Psychosocial Response to Accessibility

2. Empowering student agency

It's like a blessing and a curse ...You can get behind a lot easier. Whereas if it was just a specific math class ... everybody's done ... at that point in time, and you just turn it in or whatever. But this one is like specific lessons that you have to do, which you could get them all done a week in advance or you could fall behind on one lesson and it makes the other lessons harder on you.

Faculty Interviews

- Initially skeptical of instructional redesign
  - Lack of direct instruction, loss of academic freedom, and the ability of students to "mimic" their understanding vs. deep learning.
  - Concerns that students in developmental mathematics, who most need support with skills development, are not being well-served by this model.
  - Worry that students do not take their technology-driven math course seriously and do not take advantage of the additional resources that technology offers.
- Want evidence of how it affects student learning.
- Take advantage of the flexibility they perceive with regard to their teaching and interim assignments.
  - Staffing and scheduling changes required hiring math lab coordinators and reassigning existing faculty.

Discussion

- Hybrid emporium model increased student access to instructional material and support, provided abundant opportunities for practice, and connected them with immediate feedback.
  - These features contribute to their ability to utilize and feel empowered by the curriculum.
- Positive student experience, but outcomes suggest unaddressed barriers at community colleges
  - Are negative mid- and long-term relationships between the emporium model and student outcomes due to differences in the quality of instruction, supports, and relationships in subsequent (math) classes? Or in the alignment of instructional methods in developmental versus college-level courses?

Description of Site Visit Sample

			Student Focus Group Characteristics				
Sector	**Urbanicity**	**Size**	**Total**	**Race/Ethnicity**	**Gender**	**Age**	**Professional Participants**
Public, 2-year	Suburb: Large	10,000 - 19,999	2	Black/African-American (2)	Female (2)	Traditional (2)	Faculty, Department Chair, Developmental Math Coordinator
Public, 2-year	Rural: Fringe	5,000 - 9,999	3	Black/African-American (2); Hispanic (1)	Female (1); Male (2)	Traditional (2); Nontraditional (1)	Faculty, Curriculum Chair, Math Lab Coordinator
Public, 2-year	City: Small	1,000 - 4,999	4	Black/African-American (1); Hispanic (1); White (2)	Female (3); Male (1)	Traditional (4)	Faculty, Former and Current Department Chairs
Public, 2-year	City: Midsize	5,000 - 9,999	6	White (6)	Female (3); Male (3)	Traditional (4); Nontraditional (2)	Faculty, Math Lab Coordinator
Public, 4-year or above	Town: Remote	10,000 - 19,999	5	Black/African-American (2); White (3)	Female (3); Male (2)	Traditional (4); Nontraditional (1)	Faculty, Department Chair, Math Lab Coordinator
Public, 4-year or above	City: Large	5,000 - 9,999	7	Black/African-American (6); White (1)	Female (4); Male (3)	Traditional (6); Nontraditional (1)	Faculty, Department Chair, Math Lab Coordinator

Description of Survey Sample

Sector	Urbanicity	Size	Remediation Rate	Survey Completer
Public, 2-year	Town: Distant	1,000 - 4,999	61-70	Developmental Math Coordinator
Public, 2-year	Town: Distant	5,000 - 9,999	51-60	Director of Institutional Effectiveness and Planning
Public, 2-year	Town: Distant	5,000 - 9,999	51-60	Developmental Math Coordinator
Public, 2-year	Suburb: Large	10,000 - 19,999	41-50	Department Chair and Developmental Math Coordinator
Public, 2-year	Suburb: Large	5,000 - 9,999	61-70	Developmental Math Coordinator
Public, 2-year	Rural: Fringe	5,000 - 9,999	61-70	Curriculum Chair and Math Lab Coordinator
Public, 2-year	Rural: Fringe	5,000 - 9,999	41-50	Department Chair
Public, 2-year	City: Small	1,000 - 4,999	61-70	Dean, Math & Science
Public, 2-year	City: Small	1,000 - 4,999	61-70	Department Chair
Public, 2-year	City: Small	5,000 - 9,999		Developmental Math Coordinator
Public, 2-year	City: Midsize	5,000 - 9,999	51-60	Department Chair
Public, 2-year	City: Large	5,000 - 9,999	71-80	Dean, Division of Math and Natural Sciences
Public, 2-year	City: Large	5,000 - 9,999	71-80	Department Chair
Public, 4-year or above	Town: Remote	10,000 - 19,999	41-50	Faculty Member and Math Lab Coordinator
Public, 4-year or above	City: Small	10,000 - 19,999		Faculty Member and Math Lab Coordinator
Public, 4-year or above	City: Midsize	10,000 - 19,999		Developmental Math Coordinator
Public, 4-year or above	City: Midsize	20,000 and above		Faculty Member
Public, 4-year or above	City: Large	20,000 and above		Faculty Member
Public, 4-year or above	City: Large	5,000 - 9,999	71-80	Faculty Member and Math Lab Coordinator

Example of Raw Interview Data	*Codes*	*Explanation of Codes*	*Theme*
"They will tell you what you did wrong and where did you mess up wrong, and [you can choose] 'Help Me Solve This', and 'Have You Solve This', 'Ask Instructor', 'See an Example'…"	Increasing Access to Material and Support	Students find greater opportunities to engage with instructional material and to find help in understanding concepts.	Cognitive Accessibility
"…you get to solve questions and if you need more practice you get to repeat it until you get it, and you're certified to know if you're really good at it before you take the test."	Affording Abundant Opportunities for Practice	Students find model structure and platform contents provide plentiful problems to practice their skills.	
"You get instant gratification from it. As soon as you get done with the test, you don't have to wait [for feedback]."	Providing Immediate Feedback	Students immediately informed of incorrect answers and errors are explained.	
"So he's always there [in class and the math lab] to help out and answer any questions you've got, and he's always open for emails, too."	Multiple Avenues for Relationships between Students and Instructors	Students have more opportunities to interact with faculty.	Social Accessibility
"I can see how passionate and how interested she is…She's sweet. I like her. She seems like a grandma to me, like but give me mom speeches."	Deepening Relationships between Students and Instructors	Students and faculty have substantive interactions and form deeper relationships.	
"It like challenges you to work by yourself instead of asking the [instructor or tutor]. You can figure out how to do it yourself…You don't rely on a person."	Empowering Student Agency	Students have ownership, responsibility for learning and resources to meet that responsibility.	Breaking down barriers to math

Cognitive Accessibility

1. Increasing access to material

   Everything done in class is online for us to look and go back and review for when we do our homework. So like, you know, if we have one problem we're stuck on, we can go back and do that, so that's something I noticed. The technology is a pretty big plus.

Cognitive Accessibility

2. Affording abundant opportunities for practice

In high school they gave you your homework in class and you'd finish it, and then you wouldn't have anything else to do. I mean, yeah, that's okay, but I'd rather go more in depth with it than I did in high school. When we do math homework [on the technology-driven platform] and we got these options to, like, "Get another question" or "Do it again." It's like we're learning from our mistakes.

Cognitive Accessibility

3. Providing immediate feedback

I think ... having that immediate feedback, like, "Hey, you got this answer wrong," it's easier to go back and look and see where your mistake was and find holes in your understanding of the material.

Social Accessibility

1. Multiple avenues for relationships with instructors

   He sends us more e-mails than ... all my teachers combined. Like, I at least get like two a day from him just about, like, "If you want to come [to the lab]..." Like, "If you need any help..." or "If you need anything..." Stuff like that.

Social Accessibility

2. Deepening connections between students and instructors

   She's kind of like a mom sometimes. She really is! I swear. I get mom looks just from her when I miss school.