Adapting Active Learning in Precalculus and Calculus Courses to Changing Conditions

March 22, 2022
OLSUME

Adapting Your Vision to Changing Circumstances

Martina Bode, University of Illinois at Chicago
<table>
<thead>
<tr>
<th>Percentage</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>54%</td>
<td>54% of freshmen state that diversity was important in their decision to attend UIC.*</td>
</tr>
<tr>
<td>52%</td>
<td>52% of undergraduates are women.</td>
</tr>
<tr>
<td>38%</td>
<td>38% of students are first-generation college students.</td>
</tr>
<tr>
<td>36%</td>
<td>36% of freshmen report a first language other than English.*</td>
</tr>
<tr>
<td>60%</td>
<td>60% of undergraduates are Pell grant eligible.</td>
</tr>
<tr>
<td>70%</td>
<td>70% of undergraduates receive financial aid.**</td>
</tr>
<tr>
<td>80%</td>
<td>80% of students are commuters.</td>
</tr>
<tr>
<td>25%</td>
<td>25% of undergraduates are STEM majors.</td>
</tr>
<tr>
<td>40%</td>
<td>40% of students come from CPS high schools.</td>
</tr>
<tr>
<td>72%</td>
<td>72% of freshmen expect opportunities to interact with students from different backgrounds.*</td>
</tr>
<tr>
<td>8.6%</td>
<td>8.6% of UIC students are non-traditional (aged 25 and up).</td>
</tr>
<tr>
<td>3%</td>
<td>3% are Out of State students.</td>
</tr>
</tbody>
</table>
Demographics at UIC

About 20,000 undergrad students
Fall 2019 Demographics

PreCalculus

Fall 2019

- 20% Asian
- 44% Hispanic or Latinx
- 18% White

Compare to UIC:

Calculus I

- 38% Asian
- 28% Hispanic or Latinx
- 20% White

Asian 21.4
Hispanic 32.6
White 29.6

Calculus II

Fall 2019

- 38% Asian
- 24% Hispanic or Latinx
- 25% White
Low Pass Rates in Precalculus and Calculus courses

2014
Beginnings of Course Coordination & Active Learning

Creation of two new positions:
- Director of Precalculus
- Director of Calculus
Typical Format for Math Courses at UIC

**Lecture component**
- 120 students per class/600-1200 in a course
- 3 times per week (50 minutes each)

**Discussion**
- 20 students
- Taught by Teaching Assistants
- Two times per week (50 minutes each)
- Students work through worksheet problems in groups
Active Learning

- Students engage with the material
- Students work collaboratively
- Utilize what the space offers
- Build a communal environment
- Integrate Learning Assistants

Instructors and TAs use student ideas
Learning Assistants (LA)

- Undergraduate students who assist in the classroom.
- Started with a pilot of 2 LAs in 2015
2.6 Continuity
3.1 Introducing the Derivative
3.2 Working with Derivatives

Watch the Panopto Video on Introduction to Continuous Functions

2.6 Continuity In words, a function $f$ is continuous at a number $a$ if the graph can be sketched without lifting a pencil at and near the point $a$.

**Question 1** Sketch two graphs, one that is continuous everywhere, another that is not continuous at a point.

**Definition:** A function $f$ is **continuous** at a number $a$ if $\lim_{x \to a} f(x) = f(a)$.

Compare the definition with your two graphs above, does the continuous function satisfy $\lim_{x \to a} f(x) = f(a)$ for all $a$? and what condition does your example of a non continuous function not satisfy?

Most familiar functions are continuous on their domain. Every polynomial function is continuous, as are the sine, cosine, and exponential functions. The restriction for rational functions, tangent, secant, logarithms are that they are only continuous on their domain.
Institutional Support

- Opening of a Math & Science Learning Center 2017-
- TLC (Teaching and Learning Communities) 2015-2017
- Center for the Advancement of Teaching Excellence (CATE) 2020-
Lecture Halls at UIC
Opening of Active Learning Classrooms in 2019

Spring 2019
New Classrooms
Fall 2019
Precalculus: One instructor taught one section in the new active learning classroom, and another section in a traditional lecture hall.

Calculus I: All sections were taught in the new active learning classroom. Instructor used active learning in both rooms and had Learning Assistants in both rooms. All materials were the same for the course.

Calculus II: One instructor taught one section in the new active learning classroom, all other sections were taught in traditional lecture halls.
<table>
<thead>
<tr>
<th>Precalculus</th>
<th>Lecture Hall</th>
<th>New Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20 %</td>
<td>32 %</td>
</tr>
<tr>
<td>B</td>
<td>31 %</td>
<td>32 %</td>
</tr>
<tr>
<td>C</td>
<td>25 %</td>
<td>20 %</td>
</tr>
<tr>
<td>DFW</td>
<td>25 %</td>
<td>16 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LatinX Students</th>
<th>Lecture Hall</th>
<th>New Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>19.1 %</td>
<td>28.6 %</td>
</tr>
<tr>
<td>B</td>
<td>23.5 %</td>
<td>33.9 %</td>
</tr>
<tr>
<td>C</td>
<td>29.4 %</td>
<td>25 %</td>
</tr>
<tr>
<td>DFW</td>
<td>27.9 %</td>
<td><strong>12.5 %</strong></td>
</tr>
<tr>
<td>LatinX Students</td>
<td>DFW</td>
<td>LatinX Students</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>(Lecture Hall)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring 2015</td>
<td>57.2%</td>
<td>(New Classroom Pilot with one section)</td>
</tr>
<tr>
<td>Spring 2016</td>
<td>30.8%</td>
<td></td>
</tr>
<tr>
<td>Spring 2017</td>
<td>33.8%</td>
<td></td>
</tr>
<tr>
<td>Spring 2018</td>
<td>24.4%</td>
<td></td>
</tr>
<tr>
<td>Spring 2019</td>
<td>30.4%</td>
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</table>
### Calculus II: One section of Calculus II was taught in the new classroom

<table>
<thead>
<tr>
<th></th>
<th>Lecture Hall</th>
<th>New Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28 %</td>
<td>33 %</td>
</tr>
<tr>
<td>B</td>
<td>28 %</td>
<td>40 %</td>
</tr>
<tr>
<td>C</td>
<td>25 %</td>
<td>15 %</td>
</tr>
<tr>
<td>DFW</td>
<td>19 %</td>
<td>11 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LatinX Students</th>
<th>Lecture Hall</th>
<th>New Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFW</td>
<td>24.4 %</td>
<td>15.2 %</td>
</tr>
</tbody>
</table>
### Spring 2019

#### Calculus I: All sections of Calculus I were taught in the new classroom

<table>
<thead>
<tr>
<th></th>
<th>Calculus I</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Spring 2017</td>
<td>Spring 2018</td>
<td>Spring 2019</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>5.2 %</td>
<td>17.6 %</td>
<td>20.1 %</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>23.4 %</td>
<td>23.8 %</td>
<td>32.8 %</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>30.2 %</td>
<td>27.2 %</td>
<td>22.3 %</td>
</tr>
<tr>
<td>DFW</td>
<td></td>
<td>41.2 %</td>
<td>31.4 %</td>
<td>24.8 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>LatinX Students</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spring 2017</td>
<td>Spring 2018</td>
<td>Spring 2019</td>
<td></td>
</tr>
<tr>
<td>DFW</td>
<td>47.3 %</td>
<td>35.4 %</td>
<td>27.0%</td>
<td></td>
</tr>
</tbody>
</table>
Fall 2019

Calculus I: All sections of Calculus I were taught in the new classroom

<table>
<thead>
<tr>
<th></th>
<th>Fall 2016</th>
<th>Fall 2017</th>
<th>Fall 2018</th>
<th>Fall 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculus I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFW</td>
<td>26.4 %</td>
<td>21.6 %</td>
<td>20.4 %</td>
<td>17.7 %</td>
</tr>
<tr>
<td>Latinx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFW</td>
<td>33.6 %</td>
<td>26.9 %</td>
<td>31.9 %</td>
<td>24.6 %</td>
</tr>
</tbody>
</table>
Everything was starting to look GREAT!

And then…

- Pass Rates
- Retention
- Performance of LatinX students
March 2020...

Week 1: Content Meeting 1

Question 1: Find the family of antiderivatives for the following functions.

(a) \( f(x) = x^2 + 3x + 5 \)

\[ F(x) = \frac{x^3}{3} + \frac{3x^2}{2} + 5x \]

(b) \( g(x) = \frac{1}{x^3} + 3e^{2x} \)

(c) \( h(x) = 3 \cos x + \frac{5}{1 + x^2} \)
New Challenges

- 75% lack of personal motivation
- 66% trying to balance school and family demands
- 60% worry about not having a quiet place to study
- 33% access to reliable internet/service
- 12% access to reliable digital devices
- 7% not having enough food
- 3% not having a place to stay

UIC Student Survey
A survey to all enrolled UIC students with 3,704 students (12.3% response rate) showed the challenges students face!
Building of a Community of Practice

- Pre-pandemic monthly in person happy hours for lecturers
- Instructors from a variety of courses started to meet virtually weekly to exchange ideas
- New virtual formats were piloted in the summer
- Conversion of in person to virtual materials
- Creation of self guided content sheets and videos for initial asynchronous teaching
The changing roles of Learning Assistants (LAs)

Pre-covid LAs helped during MWF lectures

During covid, they helped the TAs to facilitate TuTh discussion & ran online exam reviews

Transitioning back to in-person, all discussions have a TA and LA; and some LAs are helping in the lecture classes and run online exam reviews
Growth of the Learning Assistant program

**Fall 2015**
- 2 LAs in one section

**Fall 2016**
- 7 LAs in 2 courses

**Fall 2017**
- 26 LAs in 4 courses

**Fall 2018**
- 38 LAs in 4 courses

**Fall 2019**
- 48 LAs in 4 courses

**Fall 2020**
- 37 LAs in 6 courses

**Fall 2021**
- 57 LAs in 7 courses
Adjusted Format for Math Courses at UIC Fall 2020

Asynchronous guided materials
- 120 students per lecture/600-1200 in a course
- Taught by lecturers
- Optional meeting in online rooms to work through sample problems. Two to three times per week (50 minutes each)

Synchronous Discussion
- 20 students
- Taught by Teaching Assistants with the help of a Learning Assistant.
- Two times per week (50 minutes each)
- Student presentations once a week
Assessments

Before Covid

Homework (30%)
- Online and written

High Stake Exams (70%)
- 2 midterms
- final

During Covid

Homework (20%)
- Online
- Asynchronous Content (videos and worksheets)

Discussions (16%)
- Live presentations

Low Stake Exams (64%)
- 4-7 modules & final
How did we do?

- Pass rates for virtual classes with online assessments
- Increasing numbers of reports of academic dishonesty cases
- General exhaustion...

Small print: Ds were converted to passing grades Spring & Fall 2020…
Fall 2021

Transitioning back to in person

Lectures online

Discussions in person

Testing in person

- Pass Rates down for all students
- DFW rates for Latinx students almost twice as high as for white students
Performance gap (DFW Fall semesters) - Latinx versus white students

* Ds were converted to passing grades Spring & Fall 2020...
Performance gap (DFW Spring semesters) latinx versus white students

* Ds were converted to passing grades Spring & Fall 2020…
# Student Surveys

<table>
<thead>
<tr>
<th>Semester</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2019</td>
<td>1842</td>
</tr>
<tr>
<td>Spring 2020</td>
<td>500</td>
</tr>
<tr>
<td>Fall 2020</td>
<td>628</td>
</tr>
<tr>
<td>Spring 2021</td>
<td>924</td>
</tr>
<tr>
<td>Fall 2021</td>
<td>1080</td>
</tr>
</tbody>
</table>

IRB exemption UIC  
Protocol Number 2019-1291
Active Learning – Student Perception
In this class, I am more actively involved than in traditional lecture classes.

Calculus I

2 strongly agree...
1 agree
0 neither agree nor disagree
-1 disagree
-2 strongly disagree

* This question was not asked Spring 2020
Active Learning – Student Confidence Gains by active learning
My confidence in my math skills since this math class has:

Calculus I

2 strongly increased...
1 increased
0 neither increased nor decreased
-1 decreased
-2 strongly decreased

I am more actively involved than in traditional lecture classes.

Fall 2019, 2020, and 2021 data combined
Student Confidence Gains by expected final grade. My confidence in my math skills since this math class has:

**Calculus I**

2 strongly increased...
1 increased
0 neither increased nor decreased
-1 decreased
-2 strongly decreased
Student Confidence Gains by gender. My confidence in my math skills since this math class has:

Calculus I

2 strongly increased...
1 increased
0 neither increased nor decreased
-1 decreased
-2 strongly decreased

![Bar chart showing confidence gains by gender across different semesters.](chart.png)
Spring 2020
Change in confidence gains in Calculus I

Wording of the questions
Before question:
*My confidence in my math skills BEFORE the change to distance learning was*

After question:
*My confidence in my math skills AFTER the change to distance learning was*

2 strongly increasing...
1 increasing
0 neither increasing nor decreasing
-1 decreasing
-2 strongly decreasing
New Initiatives

Inclusive Syllabus Project

Diversity and Inclusion workshops for Faculty & Graduate students in Math
https://padlet.com/bodem/9n8jy7wzbknzo3g

What does active learning look like at your school?

What was the impact of the pandemic on student success at your school?

What are some positive outcomes?

What adjustments did you make?

What does your LA program look like?

And where do we go from here?
Thank You! Martina Bode, bodem@uic.edu

- Special thanks to:
  - Brooke Shipley, Department Head, UIC
  - Jenny Ross, Director of Precalculus, UIC
  - Shavila Devi, Lecturer, UIC
  - Asma El Sabbagh, Honor Student, UIC
  - Kiley Pooler, Former UIC Student, Chicago Public Highschool Teacher
  - Matt Lee, Professor, Oakton Community College