Radically Changing Binghamton Calculus
Binghamton University (SUNY)

- 17,166 students (13,578 UG, 3,588 Grad)
- First year retention (FR – 91.7%, Transfer – 85.1%)
- Graduation rate: 4-yr – 72%, 5-yr – 81%
- First-generation – 27%, Pell-eligible – 26%
- SAT Math – 665, Verbal – 641
Binghamton’s Calculus Past

- High enrollment (ca. 1,350 students in Calc 1 each year, ca. 800 students in Calc 2 each year)

- Required prerequisite for multiple majors (Chemistry, Physics, Engineering, Economics)

- Students had struggled:
  - 21.8% D/F/W rate in Calc 1 (2009-2014)
  - 34.4% D/F/W rate in Calc 2 (2009-2014)
  - D/F/W rate for Calc 2 as high as 46.9% (2009) and 44.8% (2013)
Consequences

- Study of STEM-intended majors who were leaving STEM (up to 40%)
- Engineering (375 Freshman) with “internal” retention rate of 82-85%
- Engineering faculty finding that students were “afraid of calculus” and showed an inability to apply it in subsequent courses
- Students encouraged to take calculus elsewhere
Provost Decided a Change was Needed

- Consulted outside experts (David Bressoud, Karen Rhea)
- Hiring Committee created (math faculty, Center of Learning and Teaching, heads of STEM departments)
- Director of Calculus hired in June 2014
New Calculus Initiative

- Develop a Plan
  - New Pedagogy
  - Training program for instructors
  - Evaluate curriculum
  - Develop new course structure
  - Establish campus-wide collaboration partners
Phase One

**Pedagogy** -- Active learning emphasis -- “Flipped” classroom -- IBL

- create videos to watch before class
- Instructors engaged with students during the lesson

**Graduate Student Instructor Training**

- Special training program for new and continuing instructors
- Establish culture of student-centered teaching and support
Phase Two

- **Curriculum**—Assess and revise
  - Meet with calculus-reliant programs to collect feedback and understand needs
  - Assess existing curriculum in light of learning objectives

- **Course Structure**—A bold new approach
  - Transform 2 four-credit courses into 5 two-credit courses
New Course: Introduction to Calculus
(pre calculus topics essential for calculus)

- For students who need to take Calculus 1, but scored in the lower 20% of PE exam scores
- Inequalities involving absolute values and quadratics
- Trigonometry functions and equations
- Transcendental functions and equations
- Sketching fundamental equations (polys, trig, transcendental, absolute value, circles)
- Polynomial division and factoring
- Limits and continuity
- Rates of change
Course Transformations

Old pathway: 2 courses, 4 credits each

Calculus 1 (4 credits) → Calculus 2 (4 credits)

New pathway: 5 courses, 2 credits each

Intro to Calc → Calc 1 A → Calc 1 B → Calc 2 A → Calc 2 B
Potential Benefits

- “Rapid Recovery” option -- especially for students in tightly sequenced programs (e.g. Engineering)
- Academic difficulty has smaller impact on GPA, credits earned

Challenges

- Course scheduling: time slots, instructor allocation
- Rapid mid-semester transition: exams, grading, course placement adjustment (if needed)
Student Assessment for Calculus Half-Semester Courses (2-credits)

- Midterm (35%) & Final (35%)
- Basic Skills Test taken on computer (16%)
- Online HW (7%)
- In class work and written HW (2%)
- Weekly Quizzes (5%)
Sample course pathway

The plan: Fall: Calc 1 A & B,

Spring: Calc 2 A&B

Winter session: Calc 1 B
Comparing Calc 1 Results – all students

Grades

- A
- B
- C
- D/F/W

D/F/W

Calc 1 B (2016-2018)
Calc 1 A (2016-2018)
Intro to Calc (2016-2018)
OLD - Calc 1 (2012-14)
Comparing Calc 1 Results – Female students

- Calc 1 B (2016-2018)
- Calc 1 A (2016-2018)
- Intro to Calc (2016-2018)
- OLD - Calc 1 (2012-14)
Comparing Calc 2 Results – all students

Grades

- A
- B
- C
- D/F/W

Calc 2 B
Calc 2 A
OLD - Calc 2

Updated May 2019
Comparing Calc 2 Results – Female students

Grades

- A
- B
- C
- D/F/W

Calc 2 B
Calc 2 A
OLD - Calc 2

Updated May 2019
Students who started with Calc 1 as Freshmen (Fall semester)

- **Old Calc 1 D/F/W rates**
  - URM – 21.2%
  - F – 13.2%
  - ENG – 15.0%

- **New Calc 1 (1A and 1B) D/F/W rates**
  - URM – 14.6%
  - F – 7.4%
  - ENG – 8.7%
Students who started with Calc 1 as Freshmen (Fall semester)

- Old Calc 2 D/F/W rates
  - URM – 42.2%
  - F – 37.8%
  - ENG – 41.7%

- New Calc 2 (2A and 2B) D/F/W rates
  - URM – 21.0%
  - F – 10.3%
  - ENG – 12.7%
## Freshman progression (Fall start)

<table>
<thead>
<tr>
<th></th>
<th>OLD</th>
<th>NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Calc 1 GPA</td>
<td>2.78</td>
<td>3.21</td>
</tr>
<tr>
<td>Calc 1 D/F/W rate</td>
<td>15.7%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Mean Calc 2 GPA</td>
<td>2.07</td>
<td>3.16</td>
</tr>
<tr>
<td>Calc 2 D/F/W rate</td>
<td>36.5%</td>
<td>9.6%</td>
</tr>
<tr>
<td>Retention to sophomore</td>
<td>91.0%</td>
<td>93.2%</td>
</tr>
</tbody>
</table>

Updated May 2019
Comparing Calc 3 Results – all students – Fall 2018

Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>NEW - Calc 3</th>
<th>OLD - Calc 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D/F/W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Updated May 2019
Comparing Calc 3 Results – all students – Spring 2019

Grades

<table>
<thead>
<tr>
<th>Grades</th>
<th>NEW - Calc 3</th>
<th>OLD - Calc 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D/F/W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Updated May 2019
OER Begins (Fall 2018 - Spring 2020)

- Performance Improvement Fund Grant
- Bill Kazmierczak (Director of Calculus)
  Don Loewen (Vice Provost for Undergrad Studies)
  Matt Wolak (Visiting Professor)
- OER sections offered for “Intro to Calculus”,
  “Calculus 1A”, and “Calculus 1B”
Implementation

- Text Book: Openstax Calculus and Precalculus
- Online HW: WeBWork at first, now using Lumen OHM
- Fall 2018: 3 sections, 96 students
- Spring 2019: 4 sections, 128 students
- Fall 2019: 4 sections, 130 students
Challenges

- Basic Skills Test implementation
- Training new instructors
Pre-Calc: OER/Non-OER - all students

Grades

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D/F/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Sections</td>
<td>30%</td>
<td>40%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Non-OER</td>
<td>30%</td>
<td>40%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>OER</td>
<td>30%</td>
<td>40%</td>
<td>20%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Updated March 2020
Calc 1A: OER/Non-OER - all students

Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>OER</th>
<th>Non-OER</th>
<th>All Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D/F/W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Updated March 2020
Calc 1B: OER/Non-OER - all students

Grades

- A
- B
- C
- D/F/W

0% 10% 20% 30% 40% 50%

D/F/W
C
B
A

All Sections
Non-OER
OER
Students who started with Calc 1A as Freshmen (Fall semester)

- Calc 1A Non-OER D/F/W rates
  - URM – 8.1%
  - F – 3.3%
  - ENG – 3.7%

- Calc 1A OER D/F/W rates
  - URM – 5.3%
  - F – 7.4%
  - ENG – 0.0% (n<10)
Students who started with Calc 1A as Freshmen (Fall semester)

- Calc 1B Non-OER D/F/W rates
  - URM – 8.8%
  - F – 7.3%
  - ENG – 7.4%

- Calc 1B OER D/F/W rates
  - URM – 0.0%
  - F – 7.1%
  - ENG – 20.0% (n<10)
Students who started with PreCalc as Freshmen (Fall semester)

- PreCalc Non-OER D/F/W rates
  - URM – 3.3%
  - F – 1.7%
  - ENG - N/A

- PreCalc OER D/F/W rates
  - URM – 0.0% (n<10)
  - F – 0.0%
  - ENG - N/A
Students who started with PreCalc as Freshmen (Fall semester)

- Calc 1A Non-OER D/F/W rates
  - URM – 0.0% (n<10)
  - F – 3.3%
  - ENG - N/A

- Calc 1A OER D/F/W rates
  - URM – 0.0% (n<10)
  - F – 0.0%
  - ENG - N/A
# Freshman progression (Fall start w/ Calc 1A)

<table>
<thead>
<tr>
<th></th>
<th>Non-OER</th>
<th>OER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Calc 1A GPA</td>
<td>3.20</td>
<td>2.97</td>
</tr>
<tr>
<td>Calc 1 D/F/W rate</td>
<td>3.3%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Mean Calc 1B GPA</td>
<td>3.02</td>
<td>3.04</td>
</tr>
<tr>
<td>Calc 1B D/F/W rate</td>
<td>7.7%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Retention to 2\textsuperscript{nd} Semester</td>
<td>98.3%</td>
<td>95.9%</td>
</tr>
<tr>
<td>Retention to 2\textsuperscript{nd} Year</td>
<td>91.8%</td>
<td>86.5%</td>
</tr>
</tbody>
</table>
## Freshman progression (Fall start w/ PreCalc)

<table>
<thead>
<tr>
<th></th>
<th>Non-OER</th>
<th>OER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean PreCalc GPA</td>
<td>3.19</td>
<td>3.16</td>
</tr>
<tr>
<td>PreCalc D/F/W rate</td>
<td>2.1%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Mean Calc 1A GPA</td>
<td>2.99</td>
<td>3.34</td>
</tr>
<tr>
<td>Calc 1A D/F/W rate</td>
<td>7.6%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Mean Calc 1B GPA</td>
<td>2.55</td>
<td>2.70</td>
</tr>
<tr>
<td>Calc 1B D/F/W rate</td>
<td>15.8%</td>
<td>9.5%</td>
</tr>
<tr>
<td>Retention to 2(^{nd}) Semester</td>
<td>98.4%</td>
<td>98.1%</td>
</tr>
<tr>
<td>Retention to 2(^{nd}) Year</td>
<td>93.6%</td>
<td>91.7%</td>
</tr>
</tbody>
</table>

Updated March 2020
Future OER

- Offered to all students where Calculus 1 is a terminal course
- Online Courses for Winter and Summer
Thank you for your time. Questions?

Bill Kazmierczak
kaz@math.binghamton.edu