A Hybrid Approach to Calculus

Dr. Joseph Brennan

SUNY Binghamton

5/30/2014
Partial Support:
CIT SUNY Innovative Instruction Technology Grants

Dr. Laura Anderson

Dr. James Pitarresi
In the Fall of 2013, Binghamton ran 33 sections of Calculus 1 with all sections capped at or below 35 students. 30 sections are taught by graduate students.

**Student Population of Study:**

Mostly Beginning Freshman Engineering Students

All sections meet MWF 8-9:30am.

**Division of Students:**

- **Flipped Sections**
  - 3 Stronger Students
  - 2 Weaker Students

- **Controlled Sections**
  - 5 Stronger Students
  - 1 Weaker Students
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<tr>
<th></th>
<th>Calculus</th>
<th>Precalculus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>85.2%</td>
<td>83.6%</td>
</tr>
<tr>
<td>Control</td>
<td>71.7%</td>
<td>95.2%</td>
</tr>
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</table>
Non-Traditional Components

- Precalculus Review Modules
- Basic Skills Tests
- "Flipped" Classroom Format
Precalculus Review Modules

A substantial amount of a traditional Calculus lecture is devoted to reviewing Precalculus material.
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Daniel McKinney

Each module is constructed with the weekly schedule of Calculus in mind and provides a "just-in-time" review of specific Precalculus topics just as they become relevant in calculus.
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Each module consists of three parts:

- Short First Assignment.
  (3-5 questions)
- List of Review Resources.
  (Including select 3rd party videos such as Patrick JMT)
- Long Second Assignment.
  (Students scoring below 80% on first assignment)
Basic Skills Tests

An automated exam meant to ensure that a calculus student can be expected to complete a set of questions with a minimum degree of accuracy. Administered through WebAssign.

Lack of appropriate skills is a major reason for many poor grades. A good skills test should encourage students to either sharpen their skills or get out of the course, as they are unable/unwilling to improve.
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- There are 4 skills tests. There is NO partial credit awarded.
- For each test, students have three attempts over three weeks to pass a skills test with a 70% or higher.
- Any skills test which is not passed after three attempts results in an automatic **failure**.
- Students need clear guidance on what is considered a ”basic” skill.
Basic Skills Tests

"A student who passes calculus at some point should demonstrate that they can compute a limit, a derivative, and a basic integral calculation with nearly 100% accuracy."

Compared to the five previous years
- the percentage of D/F went from 16% to 8%,
- the percentage of W went from 8% to 11%,
- the percentage of A went from 22% to 28%.
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<td><strong>A</strong></td>
<td>72</td>
<td>59</td>
<td>47</td>
<td>66</td>
</tr>
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<td><strong>B</strong></td>
<td>23</td>
<td>23</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>6</td>
<td>16</td>
<td>33</td>
<td>16</td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>0</td>
<td>2.3</td>
<td>1.6</td>
<td>0.8</td>
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<table>
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</thead>
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<td><strong>A</strong></td>
<td>71</td>
<td>54</td>
<td>54</td>
<td>68</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>19</td>
<td>27</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>9.7</td>
<td>16</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>0.4</td>
<td>3.2</td>
<td>2.4</td>
<td>1.5</td>
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</table>
”Flipped” Classroom Format

- **Before Class:**
  - Visit Blackboard for Preparation Instructions.
  - Watch Short Videos.
  - Complete WebAssign Warm-Up.

- **Class:**
  - Classroom Activities.

- **After Class:**
  - WebAssign Practice and Suggested Homework Assignments.
Blackboard acts as a course homepage.

- Weekly to-do list and semester schedule.
- Solutions to assignments and review materials.
- Links to WebWork and WebAssign.
- Link to Skills Test reservation page.
Videos

- The videos are a **short** introduction to the material which will be covered in class.

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- Videos are a maximum of 10 minutes and have averaged about 7 minutes in length.
- The intent of the videos is to free up class time to allow for more interactive work. Students are required to come prepared!
- The intent of a short video lecture is the ability to stop and digest information. Additionally, the library of videos are useful to students as review material.
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- The intent of a short video lecture is the ability to stop and digest information. Additionally, the library of videos are useful to students as review material.
- The drawback of videos is the inability to ask questions.
Pencasts with Camtasia

\[
\lim_{\theta \to 0} \frac{\sin(\theta)}{\theta} = 1
\]

\[
\cos(\theta) \leq \frac{\sin(\theta)}{\theta} \leq 1
\]

A Hybrid Approach to Calculus

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Classroom Activities

Activities draw heavily from Good Questions at Cornell and betterfilingcabinet.com
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- Video Review Questions
- Conceptual Multiple Choice
- Computation (easy to hard)
- Conceptual Free Response

Student work is graded in class.
Peeling an orange changes its volume $V$. What does $\Delta V$ represent?

a) the volume of the rind.

b) the surface area of the orange.

c) the volume of the "edible part" of the orange.

d) $-1 \times (\text{the volume of the rind})$. 

You are traveling with velocity \( v(t) \) that varies continuously over the interval \([a, b]\) and your position at time \( t \) is given by \( s(t) \). Which of the following represent your average velocity for that time interval:

(I) \[ \frac{1}{b - a} \int_a^b v(t) \, dt \]

(II) \[ \frac{s(b) - s(a)}{b - a} \]

(III) \( v(c) \) for at least one \( c \) between \( a \) and \( b \).

a) I, II, and III

b) I only

c) I and II only
## Results

### Common Midterm Exams

<table>
<thead>
<tr>
<th></th>
<th>Flipped</th>
<th>Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>64.8</td>
<td>63.2</td>
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<tr>
<td><strong>3 Quartile</strong></td>
<td>77.5</td>
<td>76</td>
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<tr>
<td><strong>Median</strong></td>
<td>67.5</td>
<td>65.5</td>
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<tr>
<td><strong>1 Quartile</strong></td>
<td>54</td>
<td>51.5</td>
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<tr>
<td><strong>SDeviation</strong></td>
<td>17.84</td>
<td>18.4</td>
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# Results

## Common Final Exam

<table>
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<th></th>
<th>Flipped</th>
<th>Controlled</th>
<th>Coursewide</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>68</td>
<td>61</td>
<td>64</td>
</tr>
<tr>
<td><strong>3 Quartile</strong></td>
<td>79.5</td>
<td>74.5</td>
<td>76.5</td>
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<tr>
<td><strong>Median</strong></td>
<td>70.5</td>
<td>62</td>
<td>66.5</td>
</tr>
<tr>
<td><strong>1 Quartile</strong></td>
<td>59</td>
<td>49</td>
<td>53</td>
</tr>
<tr>
<td><strong>SDeviation</strong></td>
<td>16.9</td>
<td>18.2</td>
<td>17.5</td>
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</tbody>
</table>
# Results

## Common Final Exam - Engineers Only

<table>
<thead>
<tr>
<th></th>
<th>Flipped</th>
<th>Controlled</th>
<th>Coursewide</th>
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</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>67.2 (68)</td>
<td>59.3 (61)</td>
<td>64</td>
</tr>
<tr>
<td><strong>3 Quartile</strong></td>
<td>78 (79.5)</td>
<td>74 (74.5)</td>
<td>76.5</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>69 (70.5)</td>
<td>60 (62)</td>
<td>66.5</td>
</tr>
<tr>
<td><strong>1 Quartile</strong></td>
<td>59 (59)</td>
<td>46 (49)</td>
<td>53</td>
</tr>
<tr>
<td><strong>SDeviation</strong></td>
<td>16.6 (16.9)</td>
<td>19.4 (18.2)</td>
<td>17.5</td>
</tr>
</tbody>
</table>
## Results

### Common Final Exam

<table>
<thead>
<tr>
<th></th>
<th>Flipped Strong</th>
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<th>Coursewide</th>
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<tbody>
<tr>
<td><strong>Average</strong></td>
<td>70.5</td>
<td>62</td>
<td>64</td>
</tr>
<tr>
<td><strong>3 Quartile</strong></td>
<td>80.5</td>
<td>75.5</td>
<td>76.5</td>
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<tr>
<td><strong>Median</strong></td>
<td>73</td>
<td>63.5</td>
<td>66.5</td>
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<td>63</td>
<td>50</td>
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<td>16.9</td>
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Calculus 2: Final Exam Averages

- Flipped 63.04
- Controlled 60.12
- Coursewide 63.1
## Evaluating Students

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Percentage of final grade</th>
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<tbody>
<tr>
<td>Skills Tests</td>
<td>4 x 7% each</td>
<td>28%</td>
</tr>
<tr>
<td>Midterm Exams</td>
<td>2 x 15% each</td>
<td>30%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>12 x 0.5% each</td>
<td>6%</td>
</tr>
<tr>
<td>In-class work and homework</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Precalculus Review</td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Final Exam</td>
<td></td>
<td>30%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100%</strong></td>
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## Student Satisfaction:

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<tr>
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<th>Videos</th>
<th>Activities</th>
<th>Overall</th>
<th>WebAssign</th>
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<tbody>
<tr>
<td></td>
<td>3.36</td>
<td>3.18</td>
<td>3</td>
<td>2.64</td>
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</table>
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"I was in a lecture format at the beginning of the semester and this section is definitely preferable. It is nice to get feedback and help on questions and have lots of homework."

"I like how class is for practice, but you learn as you practice. The videos provide basic background info. It has been interesting."
"I don’t want to take a class like this ever again. Next semester I hope to take a more traditional style of teaching calculus."

"I dislike this format completely. I would learn much better if I was taught be an instructor that I could ask questions. It would be better if there were more lectures."
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"They seem to be a good judgment of where you are at material-wise and are very similar to the homework, but the problems are very easy compared to classwork."
Spring 2014

4 Traditional Sections.
- Capped at 35 students.
- Weaker students.

3 Flipped Sections.
- Capped at 70 students.
- Weaker students.
- One instructor and one experienced teaching assistant.
- Two undergraduate teaching assistants.
# Results

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Informal Observations
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Thank you for your attention!