Effects of Student-Centered, Inquiry-Based Teaching on Performance, Attitudes, and Efficacy

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Effects of Student-Centered, Inquiry-Based Teaching on Performance, Attitudes, and Efficacy

Brad Bailey, Karen Briggs, & Tom Cooper

March 9, 2011
Talk Outline

• What is the Moore Method or a Modified Moore Method?

• Our Study
  • Methodology
  • Results
Moore Method

- Graduate-level math courses during the early 1900s.
- Students were selected by Moore to participate.
- Moore used no textbook.
- Students worked individually.
- Students presented their proofs in class.
- Moore would give little to no feedback.
- Grades were determined by the proofs that were provided.
Modified Moore Method

• A textbook was not used for the MMM PreCalculus.
  
  • The control group used Stewart, Redlin, and Watson’s Precalculus (2007) text.

• The instructor did not lecture. Approximately 95% of the content of the course was presented by the students themselves.

• Students worked individually or in groups of size 2 or 3.

• Students were not allowed to seek assistance from friends, family, tutors, other instructors, or by reading a Precalculus textbook.

• One-third of their final grade depended upon their class participation/presentations.
Inquiry-Based Problem Sequence

Two parts:

- Advanced Algebra topics:
  - authored by K. Briggs during the Spring 2010 semester.

- Trigonometry topics:
  - used a modification of W. Ted Mahavier’s “Trigonometry”
    (see Journal of Inquiry-Based Learning in Mathematics, No. 1, March 2007)
Example from Problem Sequence

EXPONENTIAL FUNCTIONS

• **Problem 33.** Suppose that $3500 is invested into an account that earns 5% annual interest, compounded continuously.
  
  • a. Find the value of the account after 4 years.
  
  • b. Set up the equation to determine after how many years the account will be worth $5000? Are you able to solve this problem?

LOGARITHMIC FUNCTIONS

• **Definition 9.** The inverse of the exponential function $y = b^x$ is called the **logarithmic function with base $b$** and is denoted by $y = \log_b x$, for $x > 0$ and $0 < b \neq 1$. This means that $y = \log_b x$ is “the power of $b$ which yields $x$”.

• **Problem 34.** Reflect the graph of $y = b^x$ about the line $y = x$. The reflection is the graph of what function?
Day-to-Day Routine

- Students were assigned a set of problems to complete on their own outside of class.

- Instructor began class by calling upon students to present a solution at the board. Students who had the least number of presentations to date were given the first opportunity.

- After each solution was presented, the remainder of the class evaluated the accuracy of the given solution and discussing any differences that appeared in their own solution.

- A new set of problems were assigned for the next class.
Our Study

- A quasi-experimental study on the effects of a Modified Moore Method (MMM) on students in PreCalculus.

- Three instructors teaching using either a MMM (treatment) or traditional methods (control) during two semesters.

- Instructors switched roles for second semester of study.
Research Questions

• Do students using a MMM have lower self-efficacy early in the semester?
  • Do students who probably have not seen a Moore method before lose confidence due to the “new” teaching method?

• Do students using a MMM (still) have lower self-efficacy at the end of the semester?
  • If “Yes” before, do they gain their confidence back after they’ve become comfortable with the Moore method?

• What effect might the Moore method have on students' Attitudes & Beliefs about mathematics & teaching?
Research Questions

• Are there any specific topics that the different sections perform differently on?
  • Is the Moore method better for trig, but not for exponential and logarithmic functions, or vice versa?

• Which group will score higher on a common final exam?

• Which group will do better in Calculus?
Methodology

• Developed a survey to assess the students Grade efficacy, task-specific efficacy and attitudes about the mathematics and how mathematics should be taught (ABSE survey).

• The ABSE survey was administered once about 5 class meetings into the semester and again just before the last exam.

• The professors involved also co-wrote a common final exam.

• Will “track” students who continue into Calculus.
The Survey

• Includes a set of questions on grade-efficacy, GE1-GE4.
  • The sum of these form the Grade Efficacy scale.
  • This scale has a Cronbach’s alpha of 0.937 (n= 101).

• Includes questions on task-specific self-efficacy, TE25-TE33.
  • The sum of these form the Task Efficacy Scale.
  • This scale has a Cronbach’s alpha of 0.924 (n= 101).
The Survey

• Questions AB5-AB24 were about students attitudes and beliefs regarding mathematics.
  • Many were reverse coded.
  • When coding was reversed, these had a Cronbach’s alpha of 0.754 (n = 101).

• Intend to examine each of these questions individually; especially the differences between beginning of semester and the end in the two groups.
The Common Final

• Used same final exam both semesters which allowed for across semester comparisons.

• We developed a very specific rubric.

• In addition, we divided the exam into three (roughly) equal parts; each professor graded the same part on the final for all three sections.
Early Semester Survey

• Administered after about a week & a half of classes.

• There was not a statistically significant difference between the overall attitudes and beliefs of the students in the different sections.

• There was however a statistically significant difference in the students' self-efficacy.
PRE-ABSE RESULTS
• When comparing total Control versus total Treatment using the Mann-Whitney $U$-Test, only CALC35 was significantly different ($p = 0.000$) with the Treatment students less likely to agree that the course had prepared them for Calculus.

• When split by instructor, one Control Group had significantly higher Grade Efficacy ($p = 0.013$), and another Control Group had significantly higher Task Efficacy ($p = 0.004$).

• When split by gender, three items had significantly different responses given:
  - AB21 (Math problems can be done correctly in only one way.) Males agreed more ($p = 0.044$).
  - TE25 (I am confident that I can correctly use the laws of logarithms to solve a logarithmic equations.) Females agreed more ($p = 0.045$).
  - CALC34 (I will take Calculus within the next three semesters.) Males agreed more ($p = 0.008$).
POST-ABSE Results
• At the end of the semester, Treatment Females were significantly more likely to agree that they expected to pass the course with a C or better (GE2, \( p = 0.025 \)) and with an A (GE4, \( p = 0.014 \)) than the Treatment Males.

• There were no other significant differences in grade efficacy.

• There were only a few significant differences in attitudes:
  
  Males agreed more with AB8 –
  
  You have to remember the right answers…

  Control students agreed more with AB12-
  Wrong answers are absolutely wrong …
There was a definite trend of higher task efficacy in the control sections.

For 5 of the 9 task efficacy items and total task efficacy, the control group gave higher responses than the treatment group for all three instructors.

When comparing Total Treatment versus Total Control, the control students reported significantly higher responses for 7 of the 9 task efficacy items.

The Total Control group also reported feeling better prepared for Calculus (CALC35, $p = 0.000$).
• The Treatment and Control Groups did not have significantly different SATM scores
  • Treatment Mean = 553.2,
  • Control Mean 552.8,
  • \( t = -0.0515, \ p\text{-value} = 0.959 \).

• We used ANCOVA with SATM as a covariate to control for variations in prior mathematics aptitude.
The total Treatment Group did marginally significantly better than the total Control Group.

Control Group:

\[ n = 101, \text{ Mean } = 117.7^*, \text{ SD } = 35.31 \]

Treatment Group:

\[ n = 92, \text{ Mean } = 124.8^*, \text{ SD } = 34.44 \]

\[ F = 3.09, p = 0.081 \]

*The final exam was out of 200 possible points.
• There were differences across the three instructors.

• For each instructor, the Control and Treatment groups had similar SATM scores, so ANCOVA could be used in each case.

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Control Sample Size, Mean</th>
<th>Treatment Sample Size, Mean</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29, 121.7</td>
<td>31, 111.8</td>
<td>1.25</td>
<td>0.268</td>
</tr>
<tr>
<td>2</td>
<td>31, 119.7</td>
<td>29, 139.7</td>
<td>8.97</td>
<td>0.004</td>
</tr>
<tr>
<td>3</td>
<td>31, 115.5</td>
<td>28, 128.1</td>
<td>1.72</td>
<td>0.196</td>
</tr>
</tbody>
</table>
• There were also interesting differences by gender.

• Overall, the Males had higher SATM scores than Females (559 vs. 548), but not significantly so ($t = -1.339, p = 0.182$).

• But the females did significantly better on the final exam ($t = 2.09, p = 0.038$).

• This result held when controlling for SATM as well ($F = 6.28, p = 0.013$).
The MMM was more beneficial for females than males

- For each instructor, the females in the Treatment class outscored the females in the Control class.

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Control Sample Size, Mean</th>
<th>Treatment Sample Size, Mean</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19, 112.1</td>
<td>14, 119.4</td>
<td>1.34</td>
<td>0.256</td>
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<tr>
<td>2</td>
<td>19, 123.0</td>
<td>21, 144.6</td>
<td>9.78</td>
<td>0.003</td>
</tr>
<tr>
<td>3</td>
<td>19, 113.0</td>
<td>14, 146.8</td>
<td>12.12</td>
<td>0.002</td>
</tr>
<tr>
<td>All</td>
<td>57, 116.0</td>
<td>49, 138.0</td>
<td>21.49</td>
<td>0.000</td>
</tr>
</tbody>
</table>
• For males SATM was not a strong predictor of Final Exam scores, so ANCOVA should not be used.

• Instead, we used $t$-tests

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Control Sample Size, Mean</th>
<th>Treatment Sample Size, Mean</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14, 124.4</td>
<td>17, 105.6</td>
<td>1.29</td>
<td>0.211</td>
</tr>
<tr>
<td>2</td>
<td>12, 114.5</td>
<td>9, 125.9</td>
<td>-0.87</td>
<td>0.396</td>
</tr>
<tr>
<td>3</td>
<td>12, 119.3</td>
<td>15, 106.3</td>
<td>1.06</td>
<td>0.303</td>
</tr>
<tr>
<td>All</td>
<td>38, 119.7</td>
<td>41, 110.3</td>
<td>1.19</td>
<td>0.239</td>
</tr>
</tbody>
</table>
Struggles

• At the beginning of the semester, we moved through the problem sequence at a snail’s pace.
  • Many students did not complete the assigned problems before class.
  • Students feared going to the board and making a mistake in front of their peers.
• Students frequently requested to see worked examples like those found in a textbook.
• Getting students to understand the grading policy.
• Student attitudes and lack of maturity.
Activity

• Pick a skill your students should master.

  • Break that skill into small components or sub-skills.

  • For each component, consider a way to “guide” your students to discover it.

  • Assimilate these sub-skills into larger skill.
The End

Thank you for coming!