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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, \( p = 0.000 \)).
Final Exam
• 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:

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

Treatment Group:

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

\[ F = 3.09, \ p = 0.081 \]

*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>
</tr>
<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