Blending Inquiry-Based Learning and Computer Assisted Instruction in Algebra

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Greater Birmingham Mathematics Partnership
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The opinions expressed herein are those of the authors, and not necessarily those of the National Science Foundation.

Joint Mathematics Meeting, New Orleans, 2011
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Where to Get More Information

Computer Assisted Instruction

● PROS
  – Actively engaged with material
  – More time spent on task
  – On-demand help in lab
  – High tech and high touch

● CONS
  – Algorithmic learning
  – Emphasis on memorization
  – Computation rather than thought
  – Tenuous connection with Quantitative Literacy
Audience for Basic Algebra (MA 098)

- Developmental Course (Non-Credit)
- General studies students
- Liberal arts students
- Pre-service elementary teachers
  - Take four 3-credit hour courses
  - Sometimes MA 098 first
Comparative Study, Fall 2010
MA 098 Class Formats

● Same computer assisted lab instruction
  – Determines 79% of final grade
● Three different treatment groups
  – \((LL)\) Lecture: Traditional lectures on up-coming material twice weekly
  – \((GG)\) Group: Inquiry-based group work with no prior instruction twice weekly
  – \((GL)\) Blended: One lecture meeting and one inquiry-based meeting weekly
● Quasi-experimental: random assignment of students to class formats
Comparative Study Students

- Students register for one of three time slots (Section)
  - 9 AM - MWF, 10 AM - MWF, 12 Noon - MWF
- Section split into 3 subsections
  - Students randomly assigned to subsection
- Each subsection at same time slot receives different treatment
Comparative Study Design

- Three instructor/teaching assistant pairs
- Each pair teaches three time slots
- Each pair implements each treatment
Comparative Study Measurements

- Content pre-test and post-test
  - Part I: Three open-ended questions, rated blind according to rubric on
    - Conceptual understanding 0-1-2
    - Problem-solving 0-1-2
    - Explanation 0-1-2
    - Accuracy 0-1-2
  - Part II: Objective Test (25 questions)

- Course assessments (grades)
  - Sum of first four of five tests
  - Maximum value 520
## Conceptual Understanding:

*Interpreting the concepts of the task and translating them into mathematics*

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Evidence Of Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2</strong></td>
<td>The translation of the task into adequate mathematical concepts using relevant information is completed</td>
<td>Choosing strategies that can work, and then carrying out the strategies chosen.</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>The translation of the major concepts of the task is partially completed and/or partially displayed</td>
<td>Pictures, models, diagrams, symbols, and/or words used to solve the task may be only partially useful and/or partially recorded.</td>
</tr>
<tr>
<td><strong>0</strong></td>
<td>Does not achieve minimal requirements for 1 point</td>
<td>Does not achieve minimal requirements for 1 point</td>
</tr>
</tbody>
</table>
# UAB - Math Scoring Guide

<table>
<thead>
<tr>
<th>Explanation:</th>
<th>Accuracy:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Using pictures, symbols, and/or vocabulary to convey the path to the identified solution</em></td>
<td><em>Providing a complete and accurate solution appropriate for the given problem</em></td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Explanation is clear and complete</td>
</tr>
<tr>
<td>1</td>
<td>The explanation is partially complete and/or partially developed with gaps that have to be inferred</td>
</tr>
<tr>
<td>0</td>
<td>Does not achieve minimal requirements for 1 point</td>
</tr>
</tbody>
</table>

Adapted from the Oregon Department of Education’s 1995-2003 statewide assessments

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Comparative Study  
Hypotheses

- **Hypothesis 1**: Grades will be similar regardless of treatment (as measured by computerized test sum)
- **Hypothesis 2**: Group work treatments will have differentially improved problem-solving and communication skills (as measured by Rubric-Graded Part I, Pre/Post-Test)
- **Hypothesis 3**: Group work treatments will have differentially improved accuracy (as measured by Objective Part II, Pre/Post-Test)
Summary of Results

- Hypothesis 1 supported: no significant difference in test grades
- Hypotheses 2 supported: significant differences in favor of group treatments on pre-test to post-test gains
- Hypothesis 3 not supported: no significant difference in accuracy

Statistical details to follow ---->
Data Supporting Hypothesis 1

- All treatments had similar grades for sum of first four (of five) tests

![Bar chart showing comparison of test sums for GG, GL, and LL treatments.]

N=315
GG=100
GL=106
LL=109
No significant differences on sum of tests, nor any single test.
Pre-Test and Post-Test

Part I

- Three questions
  - Constructed response
- Scored with same rubric used to score individual reports on group work
  - Conceptual understanding 0-1-2
  - Problem-solving 0-1-2
  - Explanation 0-1-2
  - Accuracy 0-1-2
- Maximum value 24

Part II

- Objective test
- 25 questions
- Multiple choice, yes/no, and always/sometimes/never.
- Maximum value 25
- Expected value 10.38

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Support for Hypothesis 2

N=272
GG =85
GL =93
LL =94
Significant difference (p<0.05) in favor of both Group treatments.
Wilks Lambda
Time: $\lambda=0.690$
Time*Treatment: $\lambda=0.921$
Objective Accuracy Analysis

- Part II of Pre/Post-test
  - Objective test
  - Maximum value 25
  - Expected value 10.38

- Significant effect pre- to post- for all treatments taken together and for each treatment individually

- No significant difference among treatments
Objective Accuracy Analysis

N=273
GG =88
GL =91
LL =94
Significant Time effect (p<0.05) for all treatments:
Wilks Lambda $\lambda=0.690$. No significant Time*Treatment effect.
## Objective Accuracy Analysis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Standard Deviation Pre</th>
<th>Standard Deviation Post</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>GG</td>
<td>9.22</td>
<td>11.39</td>
<td>3.02</td>
<td>2.98</td>
<td>0.72</td>
</tr>
<tr>
<td>GL</td>
<td>9.86</td>
<td>11.33</td>
<td>3.44</td>
<td>3.38</td>
<td>0.43</td>
</tr>
<tr>
<td>LL</td>
<td>9.57</td>
<td>12.11</td>
<td>3.00</td>
<td>3.32</td>
<td>0.84</td>
</tr>
</tbody>
</table>
Limitations

- Rater training on rubric
  - Only moderate --- 8 raters working in pairs
- Accuracy gain on post-test low
  - Less than one standard deviation from expected value
- Unit of significance
  - Student versus class
  - Correlation of variance because of a common experience
  - Theory versus practice --- suppression of differences
Conclusions

- The inclusion of group work class meetings in lieu of lecture does not appear to affect adversely student success as measured by grades.

- Inquiry-based group work does have a positive effect on problem-solving and communications abilities.

- Inquiry-based group work does not appear to affect accuracy.

- Two group work sessions do not appear to be significantly better than one per week.
Where to Get More Information about GBMP


Contributors

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