Mathematics Teachers’ Beliefs about Teaching and Learning Mathematics

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The purpose of this study is to investigate the extent to which:

a) mathematics teachers’ educational beliefs about mathematics change as they participate in professional development

b) teachers’ educational background and teaching experience in mathematics contribute to their educational beliefs and to changes in these beliefs
Outline of Background

• Three types of educational beliefs:
  – Self-efficacy beliefs
  – Internal locus of control
  – Epistemic beliefs

• Definition

• Outcomes

• Antecedents
Self-efficacy Beliefs

- Defined as the extent to which teachers believe they can successfully execute teaching-related tasks. (Tschannen-Moran & Hoy, 2001)
- Linked to instructional approaches, students’ motivation and achievement. (e.g., Stipek et al., 2001)
- Four sources (Bandura, 1986):
  1. personal mastery experiences
  2. vicarious experiences (observation of models)
  3. affective indicators
  4. social persuasion
Internal Locus of Control

• Defined as how much teachers attribute student outcomes (i.e., achievement) to themselves or external factors. (Rose & Medway, 1981)

• Positively predicts teacher effectiveness and adaptive classroom behavior among students. (Jeloudar & Lotfi-Goodarzi, 2012)

• Examined in teacher efficacy research using the same antecedents as those for self-efficacy. (Swackhamer, Koellner, Basile, & Kimbrough, 2009)
Epistemic Beliefs

- Defined as an individual’s belief about knowledge. Where does it come from? What is the essence of it? How does one come to know and justify beliefs? (Hofer & Pintrich, 1997)

- Conceptualized on a continuum from *non-availing* to *availing*. (Muis, 2004)

knowledge is fixed, simple, certain, objective, comes from an authority

knowledge is evolving, complex, uncertain, subjective, stems from one’s own construction of knowledge
• Availing epistemic beliefs in mathematics have been thought to promote reform-based teaching. (Gill et al., 2004)

• Higher levels of education are associated with more availing epistemic beliefs. (King, Wood, & Mines, 1990)

• Advanced mathematical background may be related to more availing epistemic beliefs about mathematics.
Research Questions

• Did mathematics teachers’ educational beliefs about mathematics change after participating in a professional development program?

• What is the predictive value of background variables such as teaching experience, college mathematics hours, and teacher preparation route on teachers’ beliefs about teaching and learning mathematics?
Professional Development (PD)

- Three-week summer intervention
- To improve teachers’ mathematical knowledge for teaching (MKT), the knowledge that they use “to produce instruction and student growth” (Hill, Ball, & Schilling, 2008, p. 374)
  - knowledge of content and students
- MKT → knowledge of content and teaching knowledge of curriculum
  (Hill et al., 2008)
Participants

- 151 K-12 math teachers (year 1: 80 & year 2: 71) representing several urban school districts in the Greater Houston area.
Demographic Breakdown of Participating Teachers

- White: 25%
- AA: 8%
- Hispanic: 26%
- Asian: 39%
- Other: 2%

Gender of Participating Teachers

- Female: 78%
- Male: 22%
The surveys consisted of:

1. Demographics and professional background (pre)
2. Likert-scaled items adapted from previous scales (pre and post)
   b. Mathematics Beliefs Instrument (Schoenfeld, 1989)

with adequate reliability and validity measuring the main constructs.
How strongly do you agree/disagree with the following statements?

- Self-efficacy: “I know the steps to teach mathematics concepts effectively.”
- Internal locus of control: “Students’ achievement in mathematics is directly related to their teacher’s effectiveness in mathematics teaching.”
- Non-availing epistemic beliefs: “Everything important about mathematics is already known by mathematicians.”
Table 1. *Paired-Samples t-test Results for Change in Measures of Teachers’ Educational Beliefs*

<table>
<thead>
<tr>
<th>Survey</th>
<th>N</th>
<th>Mean gain</th>
<th>S.D.</th>
<th>t-value</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy in teaching math</td>
<td>151</td>
<td>0.22</td>
<td>0.42</td>
<td>6.40*</td>
<td>.52</td>
</tr>
<tr>
<td>Internal locus of control</td>
<td>151</td>
<td>0.21</td>
<td>0.45</td>
<td>5.71*</td>
<td>.47</td>
</tr>
<tr>
<td>Non-availing epistemic beliefs</td>
<td>151</td>
<td>-0.28</td>
<td>0.45</td>
<td>-7.86*</td>
<td>.64</td>
</tr>
</tbody>
</table>

Notes. *p < .01.
Table 2. Independent-Samples t-test Results for Comparing Change in Beliefs between Grade Levels

<table>
<thead>
<tr>
<th>Survey</th>
<th>N</th>
<th>Mean gain</th>
<th>S.D.</th>
<th>t-value</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K-6</td>
<td>7-12</td>
<td>K-6</td>
<td>7-12</td>
<td>K-6</td>
</tr>
<tr>
<td>Δ Self-efficacy in teaching math</td>
<td>77</td>
<td>74</td>
<td>0.33</td>
<td>0.11</td>
<td>0.47</td>
</tr>
<tr>
<td>Δ Internal locus of control</td>
<td>77</td>
<td>74</td>
<td>0.22</td>
<td>0.21</td>
<td>0.42</td>
</tr>
<tr>
<td>Δ Non-availing epistemic beliefs</td>
<td>77</td>
<td>74</td>
<td>-0.34</td>
<td>-0.27</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Notes. *p < .01.
Video clip of teachers showing development of epistemic beliefs through enactive experiences.
### Table 3. Means, Standard Deviations, and Pearson Correlations among the Main Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>S.D.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Years of math teaching</td>
<td>3.52</td>
<td>4.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Math college hours</td>
<td>21.6</td>
<td>15.8</td>
<td>.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trad. teacher prep route</td>
<td>0.42</td>
<td>0.50</td>
<td>-.11</td>
<td>-.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Other prep route</td>
<td>0.08</td>
<td>0.27</td>
<td>.24</td>
<td>.30**</td>
<td>-.25**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. SE in teaching math</td>
<td>4.04</td>
<td>0.49</td>
<td>.21**</td>
<td>.07</td>
<td>.00</td>
<td>.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Internal locus of control</td>
<td>3.51</td>
<td>0.48</td>
<td>.07</td>
<td>-.06</td>
<td>-.15</td>
<td>.12</td>
<td>.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Epist. beliefs (non-avail.)</td>
<td>2.25</td>
<td>0.52</td>
<td>.06</td>
<td>-.04</td>
<td>-.02</td>
<td>.01</td>
<td>-.20**</td>
<td>-.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Δ SE in teaching math</td>
<td>0.22</td>
<td>0.42</td>
<td>-.08</td>
<td>-.19**</td>
<td>-.04</td>
<td>.00</td>
<td>-.56**</td>
<td>.03</td>
<td>.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Δ Internal locus of control</td>
<td>0.22</td>
<td>0.46</td>
<td>.00</td>
<td>.02</td>
<td>-.01</td>
<td>-.05</td>
<td>-.08</td>
<td>-.33**</td>
<td>.09</td>
<td>.21**</td>
<td></td>
</tr>
<tr>
<td>10. Δ Epist. beliefs (non-avail.)</td>
<td>-0.28</td>
<td>0.44</td>
<td>.07</td>
<td>.12</td>
<td>.02</td>
<td>.09</td>
<td>.05</td>
<td>-.12</td>
<td>-.41**</td>
<td>-.11</td>
<td>.01</td>
</tr>
</tbody>
</table>

**Notes.** N = 148; *p < .05. **p < .01.
Table 4. Summary of Hierarchical Regression Analyses Predicting Educational Beliefs among Mathematics Teachers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Self-efficacy in teaching math</th>
<th>Internal locus of control</th>
<th>Non-availing epistemic beliefs</th>
<th>Δ Self-efficacy in teaching math</th>
<th>Δ Internal locus of control</th>
<th>Δ Non-availing epistemic beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>β</td>
<td>β</td>
<td>β</td>
<td>β</td>
<td>β</td>
</tr>
<tr>
<td>Step 1 (math background)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of math teaching</td>
<td>.20*</td>
<td>.03</td>
<td>.06</td>
<td>- .08</td>
<td>.02</td>
<td>.06</td>
</tr>
<tr>
<td>Math college hours</td>
<td>.05</td>
<td>-.10</td>
<td>-.04</td>
<td>-.21*</td>
<td>.04</td>
<td>.11</td>
</tr>
<tr>
<td>Step 2 (teacher prep route)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>.05</td>
<td>-.12</td>
<td>-.01</td>
<td>-.05</td>
<td>-.02</td>
<td>.04</td>
</tr>
<tr>
<td>Other</td>
<td>.07</td>
<td>.11</td>
<td>.00</td>
<td>.08</td>
<td>-.08</td>
<td>.05</td>
</tr>
</tbody>
</table>

Notes. β indicates standardized regression coefficient. N = 148. *p < .05.
• PD aimed at enhancing MKT seemed to promote teachers’ adaptive educational beliefs about mathematics.

• More mathematics teaching experience was associated with higher self-efficacy at the onset of PD.

• Teachers who entered the program with less college mathematics hours experienced greater growth in mathematics teaching self-efficacy compared to their counterparts who had more college mathematics hours.
• The practical implications for PD programs include providing more support and scaffolding for teachers who lack a strong background in the subject matter they teach so that their content knowledge, and in turn, self-efficacy for teaching mathematics grow.
• Aspects of PD enhancing various types of educational beliefs among mathematics teachers
• Sustainability of changes
• Relationship between beliefs and MKT
• The following video clip shows how a teacher changed her beliefs and knowledge by participating in the professional development, specifically, by collaborating with other teachers in the program.
THANK YOU!

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