4-3-2013

Educative Supports for Teachers in Middle School Mathematics Curriculum Materials: What is Offered and How is It Expressed?

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Abstract for DBER Group Discussion on 2013-04-04

Presenter, Department(s):
Lorraine Males
Department of Teaching, Learning, and Teacher Education
University of Nebraska-Lincoln

Title:
Educative Supports for Teachers in Middle School Mathematics Curriculum Materials: What is Offered and How is It Expressed?

Abstract:
In this talk I will present the findings from my study of the educative nature of four middle school mathematics curriculum materials. Educative curriculum materials are materials for Grades K-12 that are “intended to promote teacher learning in addition to students” (Davis & Krajcik, 2005, p. 3). I particularly investigated the opportunities for teacher learning embedded within four middle school curricular series in the areas of introduction to variable and geometric transformations. Drawing on the work on educative curriculum materials from science education (Davis & Krajcik, 2005) and Systemic Functional Linguistics (Halliday, 1985), I investigated opportunities to learn by examining the content presented (i.e., subject-matter, pedagogical content, curricula) and certain aspects of the voice (i.e., use of personal pronouns, modality) of teachers’ guides. Results indicated that although all four curricular series included content supports, these supports may be insufficient. In addition, the ways in which authors spoke to teachers in the written text may further hinder teachers’ opportunities to learn. Implications for curriculum development, teacher education, and research will be discussed.
Educative Supports for Teachers in Middle School Mathematics Curriculum Materials: What is Offered and How is it Expressed?

Lorraine M. Males
Mathematics Education
Teaching, Learning, and Teacher Education
Presentation Agenda

• A Bit About Me
• Motivation & Background
• Methods
• Results
• Discussion & Next Steps
• Questions
A Bit About Me

Bay Shore, NY:
Where I grew up and attended K-12

Ithaca, NY:
Received my B.S. in Mathematics & Computer Science with 7-12 Teacher Certification
Did student teaching in MS in Ithaca and HS in Harlem

Moanalua High School, Honolulu, HI [Public School]
Teaching Job #1::
Taught: 9-12

Teaching Job #2::
The Wilbraham & Monson Academy, Wilbraham, MA [Private Boarding]
Taught: 6 - 12

The Dwight Englewood School, Englewood, NJ [Private]
Teaching Job #3::
Taught: 9

Graduate Work ::
Michigan State University
East Lansing, MI
Ph.D., mathematics education
2007-2011

Assistant Professor ::
UNL

Graduate Work ::
Teachers College New York, NY
Ed.D. Program, 1 semester

Michigan State University
East Lansing, MI
Ph.D., mathematics education
2007-2011

Assistant Professor ::
UNL
MOTIVATION & BACKGROUND
Why I wanted to do this study

Small World, Isn't It?

Everyone knows that the world's population is increasing.

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1650</td>
<td>470,000,000</td>
</tr>
<tr>
<td>1750</td>
<td>601,000,000</td>
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<tr>
<td>1850</td>
<td>1,901,000,000</td>
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<tr>
<td>1900</td>
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<td>3,680,000,000</td>
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<td>1980</td>
<td>4,480,000,000</td>
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<td>1985</td>
<td>4,870,000,000</td>
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<tr>
<td>1990</td>
<td>5,200,000,000</td>
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<tr>
<td>1995</td>
<td>5,730,000,000</td>
</tr>
</tbody>
</table>

The Derivative

Mathematics

1. Applying the definition
2. Defining the derivative of a function at a point
3. Defining the derivative of a function at certain values

Discuss With Your Colleagues

The formal concept of slope was just introduced a couple of weeks ago, and now students are talking about derivatives! Is this too big a jump? Is it reasonable to expect most eleventh graders to understand an idea that is traditionally reserved for college students? How does this "early" introduction of derivatives relate to the fact that the concept of slope is introduced "late" in the IMP curriculum?

In Class

1. Discussion of Homework
2. Discuss Zeros of Polynomials
3. Introduce the idea of the derivative
4. Introduce the idea of the instantaneous rate of change
5. Introduce the idea of the derivative of a function at a point
6. Introduce the idea of the derivative of a function at certain values

Discussion of Homework 13: The Growth of the Oil Slick

Have spade card students present their work on different parts of the assignment. The concept of an instantaneous rate of change may be harder for students to visualize in this context than it was in the context of speed (for instance, in The Instant of Impact).

Have students sketch (by hand) a graph of the area as a function of time in order to get an intuitive sense of the instantaneous growth rate. Have them mark line segments on the graph to show the relevant values. For instance, the graph here indicates the segments needed to find the rate of change in the area for the time interval from \( t = 0 \) to \( t = 2 \). (A larger version of this graph, without the line segments, is included in Appendix B.)
Teacher learning is critical to success (Cohen, Raudenbush, & Ball, 2002; Putnam & Borko, 2000), especially with the implementation of the Common Core Standards (Confrey, 2010; McCallum, Lappan, Kepner, & 2010).

We know little about the features of written curriculum materials, let alone how these materials may impact teacher learning (Stein, Remillard, & Smith, 2007).

Curriculum materials can and do learn from using curriculum materials (Choppin, 2008; Collopy, 2003; Drake & Sherin, 2009; Lloyd, 2008; Remillard, 2000; Remillard & Bryans, 2004; Schneider, Krajcik, & Blumenfeld, 2005; Schneider & Krajcik, 2002; Schneider, 2006; Van Zoest & Bohl, 2002).
The **teacher** plays an active role in enacting the curriculum.

“If it (new curriculum) cannot change, move, perturb, inform teachers, it will have no effect on those they teach. It must first and foremost be a curriculum for teachers. If it has any effect on pupils, it will have it by virtue of having an effect on teachers” (Bruner, 1977, p. xv).

“The **curriculum** plays a role in teacher learning.

“Its [the curriculum’s] primary value, its primary indication, is for the teacher, not for the child. It says to the teacher: Such and such are the capacities, the fulfillments, in truth and beauty and behavior, open to these children. Now see to it that day by day the conditions are such that their own activities move inevitably in this direction, toward such culmination of themselves. (Dewey, 1902, p. 39).”
Educative Curriculum Materials

To be educative (serve as a source of learning for teachers), curriculum materials must:

→ be more than just a textbook for students

Content must include

→ *Enactment* Guidance

→ *Rationale* Guidance

Expression must

→ allow for the text to speak through teachers

(Ball & Cohen, 1996; Beyer et al., 2010; Li, 2004; Remillard, Watanabe, 2003)

**Enactment Guidance Example**

“In the case of tables, one has to decide which values of the independent variable should be represented in the table to give most informative results” (CMP, Variables & Patterns, p. 3).

**Rationale Guidance Example**

"Unlike the combination chart, notebook notation can be used to solve problems involving combinations of more than two kinds of items. In addition, notebook notation can be used to record the new combinations. Students should come to appreciate the advantages of notebook notation over guess-and-check strategies and combination charts" (MiC, Comparing Quantities, p. 22B).
Focus of Study - Research Questions

1. What is the relative frequency of educative supports in middle school mathematics curriculum materials for teachers’ subject matter content knowledge, pedagogical content knowledge for mathematics topics and practices, and curricular knowledge?

2. How do middle school mathematics curriculum materials speak to teachers (i.e., what language choices do they make) through the written text in the teachers’ guides?

3. How does opportunity to learn (content and expression) differ for introduction to variable and geometric transformations?
A Note about my Purpose

Curriculum Development is difficult

All of what authors intend does not always make it to the final printed page

My purpose is **NOT** to name the curriculum with the best teacher support, but to **describe opportunities to learn** and to **raise awareness** of how content and expression may influence these opportunities.
METHOD
Sample- Choice of Curricular Series & Content

Curricular Series
• Connected Mathematics Project (CMP)
• Math Connects (Glencoe)
• Mathematics in Context (MiC)
• Transition Mathematics (UCSMP)

Mathematical Content
• Introduction to Variable
• Geometric Transformations
Analytic Framework – Capturing Content

Support for understanding the mathematics curriculum, including how topics relate to each other and the features and philosophies of materials.

Support for obtaining a robust understanding of the mathematics.

Support for understanding student ideas, math-specific strategies, and representations.

Support for understanding and using mathematical practices such as questioning, problem solving, and reasoning and proof.

Adapted from Beyer et al. (2009)
Analytic Framework – Capturing Expression

“Voice” (Herbel-Eisenmann, 2007; Morgan, 1996)
→ helps to identify “how speakers shift positions, identities, and alignments toward the words they speak as well as toward one another” (Herbel-Eisenmann, p. 347).

Systemic Functional Linguistics (Halliday, 1985)
→ Strata & Realizations

→ Metafunctions
  → interpersonal
→ ideational
→ textual

Martin & Rose, 2007, p. 5
Analytic Framework – Capturing Expression

Personal Pronouns

→ first person – “I” and “we”
→ second person – “you”

“You”-forms

→ implicit - imperatives
→ explicit - “you” + modal verbs

"the degree of likelihood, probability, weight, or authority a speaker attaches to the utterance" (Hodge & Kress, 1993) and can be negotiated on a scale that describes "how obliged" you are to act (Martin & Rose, 2007)
Example of coded page (MiC)

Content
→ SMK
→ PCK-Topics
→ PCK-Practices
→ CK

Expression
→ imperatives
→ “you”+modal verbs
# Inter-rater Reliability - Content

<table>
<thead>
<tr>
<th>Variable</th>
<th>Transformations</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP</td>
<td>85</td>
</tr>
<tr>
<td>Glencoe</td>
<td>88</td>
</tr>
<tr>
<td>MiC</td>
<td>85</td>
</tr>
<tr>
<td>UCSMP</td>
<td>91</td>
</tr>
</tbody>
</table>
## Inter-rater Reliability - Expression

<table>
<thead>
<tr>
<th></th>
<th>Variable</th>
<th>Transformations</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Personal Pronouns</td>
<td>Imperatives</td>
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<tr>
<td>CMP</td>
<td>98</td>
<td>99</td>
</tr>
<tr>
<td>Glencoe</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>MiC</td>
<td>100</td>
<td>99</td>
</tr>
<tr>
<td>UCSMP</td>
<td>99</td>
<td>96</td>
</tr>
</tbody>
</table>
Structure of the Teachers’ Guides

Did not exist in Glencoe and UCSMP

Embedded vs. Non-embedded
Content – Knowledge by Category

- Subject Matter Knowledge
- Pedagogical Content Knowledge for Topics
- Pedagogical Content Knowledge for Practices
- Curricular Knowledge

Bar chart showing the percentage distribution of knowledge categories for different programs: CMP, Glencoe, MiC, and UCSMP. The categories are Variable and Transformations.
## Content – Type of Support (Enactment & Rationale)

<table>
<thead>
<tr>
<th></th>
<th>Variable</th>
<th></th>
<th>Transformations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enactment Guidance</td>
<td>Rationale Guidance</td>
<td>Enactment Guidance</td>
<td>Rationale Guidance</td>
</tr>
<tr>
<td>CMP</td>
<td>97%</td>
<td>3%</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>Glencoe</td>
<td>99%</td>
<td>1%</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>MiC</td>
<td>94%</td>
<td>6%</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>UCSMP</td>
<td>94%</td>
<td>6%</td>
<td>97%</td>
<td>3%</td>
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</table>
## Content - Location of Support

<table>
<thead>
<tr>
<th>Content</th>
<th>Location of Support</th>
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</thead>
<tbody>
<tr>
<td>CMP</td>
<td>14% 28% 58%</td>
</tr>
<tr>
<td>Glencoe</td>
<td>15% N/A 85%</td>
</tr>
<tr>
<td>MiC</td>
<td>24% 14% 62%</td>
</tr>
<tr>
<td>UCSMP</td>
<td>19% N/A 81%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Transformations</th>
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</thead>
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<tr>
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<td>Unit</td>
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<tr>
<td>Section</td>
<td>Section</td>
</tr>
<tr>
<td>Lesson</td>
<td>Lesson</td>
</tr>
<tr>
<td>CMP</td>
<td>14% 28% 58%</td>
</tr>
<tr>
<td></td>
<td>48% 5% 47%</td>
</tr>
<tr>
<td>Glencoe</td>
<td>15% N/A 85%</td>
</tr>
<tr>
<td></td>
<td>12% N/A 88%</td>
</tr>
<tr>
<td>MiC</td>
<td>24% 14% 62%</td>
</tr>
<tr>
<td></td>
<td>16% 11% 72%</td>
</tr>
<tr>
<td>UCSMP</td>
<td>19% N/A 81%</td>
</tr>
<tr>
<td></td>
<td>18% N/A 82%</td>
</tr>
</tbody>
</table>
Expression – Frequencies of Pronouns

<table>
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<th>Transformations</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>we</td>
<td>you</td>
<td>we</td>
</tr>
<tr>
<td>CMP</td>
<td></td>
<td>38</td>
<td>52</td>
<td>102</td>
</tr>
<tr>
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<td>19</td>
<td>0</td>
</tr>
<tr>
<td>MiC</td>
<td></td>
<td>0</td>
<td>61</td>
<td>3</td>
</tr>
<tr>
<td>UCSMP</td>
<td></td>
<td>20</td>
<td>33</td>
<td>17</td>
</tr>
</tbody>
</table>
Clear referents for “we”

“we” refers to curriculum authors

Functions:
1. Make suggestions or recommendations for teachers
   (e.g., "We recommend that...," "We encourage...")
2. State assumptions/choices without rationale
   (e.g., "We introduce...," "We ask students...," "We assume...")
3. State assumptions/choices with rationale (e.g., "We start with tables because...," "We have purposely chosen...because")
Expression – Use of “we”

Unclear referent for “we”

“we” is used in questions or statements, particularly when outlining solutions or procedures

Some possible functions:
→ Bring authors into the community of the discipline of mathematics
→ Bring authors into the mathematical classroom community

B. When ∆2 is translated angles are preserved, so ∠W' = ∠W. This makes WX' parallel to WW"X". The angle in the gap triangle marked X" must be congruent to X' (alternate interior angles). We already know that W"X" is congruent to W'X" since translations preserve length. Thus we know that the gap triangle is congruent to the original triangle, by Side-Angle-Side using WX" as the other side.

Method 2:
• Rotate ∆1 to ∆2.
• Translate ∆2 to ∆3.
• Translate ∆1 the distance of WX to fill the gap.

The question is now, “Can we be sure that the last transformation will exactly fill the gap?” Here are brief sketches of two ways we might reason about this.

A. When ∆2 is translated to ∆3 by a distance of WW', point X' is moved to X". So this distance is congruent to WW. This gives us the three sides of the gap triangle congruent to the three sides of the original triangle. So ∆1 will fit the gap.
Expression – “You”-Forms

The chart compares Implicit and Explicit variables and transformations across the following programs:

- CMP
- Glencoe
- MiC
- UCSMP

The y-axis represents the percentage ranging from 0% to 100%, while the x-axis lists the programs.

- CMP and Glencoe show a higher percentage of Implicit variables.
- MiC and UCSMP have a higher percentage of Explicit transformations.

The chart indicates a general trend where Implicit variables are more prevalent in the first section (Variables) and Explicit transformations are more prevalent in the second section (Transformations).
Expression – Types of Imperatives

![Bar chart showing the distribution of variables and transformations across CMP, Glencoe, MiC, and UCSMP.](chart.png)
Expression – Types of Imperatives

<table>
<thead>
<tr>
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<th>Transformations</th>
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<td>exclusive</td>
<td>inclusive</td>
<td>exclusive</td>
</tr>
<tr>
<td>CMP</td>
<td>28%</td>
<td>72%</td>
<td>27%</td>
<td>73%</td>
</tr>
<tr>
<td>Glencoe</td>
<td>31%</td>
<td>69%</td>
<td>17%</td>
<td>83%</td>
</tr>
<tr>
<td>MiC</td>
<td>43%</td>
<td>57%</td>
<td>48%</td>
<td>52%</td>
</tr>
<tr>
<td>UCSMP</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Expression – Modal Verbs

- CMP
- Glencoe
- MiC
- UCSMP

Variables

Transformations
DISCUSSION & NEXT STEPS
Opportunity to Learn?

In general, insufficient opportunities

→ Over 15 of 31 content supports were unobserved or infrequent

→ Absent supports were often Rationale Guidance supports (accounted for no more than 6% of support)

→ Language often positioned teachers as agents doing the bidding of the “more knowledgable” curriculum authors
Implications – Curriculum Development

1. Raise awareness about possible impacts of content and expression

2. Speak more “to” rather than “through” teachers
   - Expression – Choose to use less imperatives and more modals verbs
   - Content – Include more rationale

3. Be more strategic about location of support
   - more (particularly SMK) at lesson level
Implications – Teacher Education

1. Recognize the important role of curriculum materials in teacher education

2. Create opportunities for teachers to work with curriculum materials
   - help with “reading” curriculum materials (including pointing out where to find support)
   - compare and critique various curriculum materials
   - plan and enact lessons from materials

3. “Teaching with rationales” – Think about being more explicit in teacher education courses
Implications – Research

1. Recognize the importance of expression in curriculum materials, not just the content
   - Seeking out new frameworks and combining them to get a more nuanced description of opportunity to learn

2. Consider how the philosophy and structure of the curriculum materials impacts analysis
Future Directions for Research and Development

Teacher learning from curriculum use

Opportunities for teacher learning in written curriculum materials

Examining how teachers learn from the opportunities in written mathematics curriculum
Future Directions for Research and Development

Design and research teachers use of electronic curriculum materials

→ more support is possible
→ customizable
→ adaptable
Thank you all for attending this talk and thank you to

I’d like to acknowledge:
Jack Smith, Glenda Lappan, Beth Herbel-Eisenmann, Kristen Bieda, Aladar Horvath, Jillian Cavana, Joanne Philipsower, & The Division of Science and Mathematics Education at Michigan State University
Questions

Lorraine M. Males
Teaching, Learning, & Teacher Education
lmales2@unl.edu
Educative Supports for Teachers in Middle School Mathematics Curriculum Materials: What is Offered and How is it Expressed?

Lorraine M. Males
Mathematics Education, Department of Teaching Learning, and Teacher Education

Focus of Study and Research Questions
To describe opportunities for teacher learning embedded in written middle school mathematics curriculum materials by investigating the content of the teachers’ guides and how this content was expressed. Specifically, I address the following research questions:
1. What is the relative frequency of educative supports in middle school mathematics teachers’ guides for teachers’ subject matter content knowledge, pedagogical content knowledge for mathematics topics and practices, and curricular knowledge?
2. How are supports expressed to teachers in middle school mathematics teachers’ guides?

Data Sources
Teachers’ Guides for the Introduction to Variable and Geometric Transformations units from each of the following:
- Connected Mathematics Project 2 (Lappan, Fey, Fitzgerald, Friel, Phillips, 2006) [CMP]
- Mathematics in Context (Wisconsin Center for Education & the Freudenthal Institute, 2010) [MiC]
- UCSMP’s Transition Mathematics (Viktora, Cheung, Highstone, Capuzzi, Heeres, Metcalfe, et al., 2008) [UCSMP].

Results

<table>
<thead>
<tr>
<th>Content Supports</th>
<th>Types of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Matter</td>
<td>Enactment</td>
</tr>
<tr>
<td>Variable</td>
<td>Enactment</td>
</tr>
<tr>
<td>Transformations</td>
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<td>MiC</td>
<td>94</td>
</tr>
<tr>
<td>UCSMP</td>
<td>94</td>
</tr>
</tbody>
</table>

Expression

Aspects of “Voice” (Herbel-Eisenmann, 2007) helps to identify “how speakers shift positions, identities, and alignments toward the words they speak as well as toward one another” (Herbel-Eisenmann, 2007, p. 347).

Systemic Functional Linguistics (Halliday, 1985)

- Metafunctions → interpersonal → ideational → textual
- Other aspects include social activity, discourse, and grammar

Personal Pronouns

- “You”-forms → first person – “I” and “we” → second person – “you”
- “You”-forms influence how speakers shift positions, identities, and alignments toward the words they speak as well as toward one another

Subject Matter | PCK for Topics | PCK for Practices | Curricular

<table>
<thead>
<tr>
<th>Subject Matter Content</th>
<th>PCK for Topics</th>
<th>PCK for Practices</th>
<th>Curricular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Matter Content</td>
<td>Enactment Guidance</td>
<td></td>
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<tr>
<td>Enactment Guidance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subject Matter Content</td>
<td>Rationale Guidance</td>
<td></td>
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</tr>
<tr>
<td>Rationale Guidance</td>
<td></td>
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</tr>
</tbody>
</table>

Subject Matter Topics
- Experiences
- Possible Pitfalls
- Engage Students in Prob. Exp.
- Act. Sequences
- Representations
- Tools
- Anticipating Student Ideas

Subject Matter Practices
- Use Questions (w/and w/o answers)
- Help Students Ask/Ans Own 7s
- Reasoning & Proof
- Developing Math Terminology

Curricular Knowledge
- Overview
- Features
- Storyline
- Goals

You should emphasize that the value could be found by solving an equation (UCSMP, Some Imp Geom Ideas, p. 397)

You might suggest that they imagine a point leaving a trail (CMP, KHM, p. 53)