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

Lorraine Males
*University of Nebraska-Lincoln*, lmales2@unl.edu

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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.

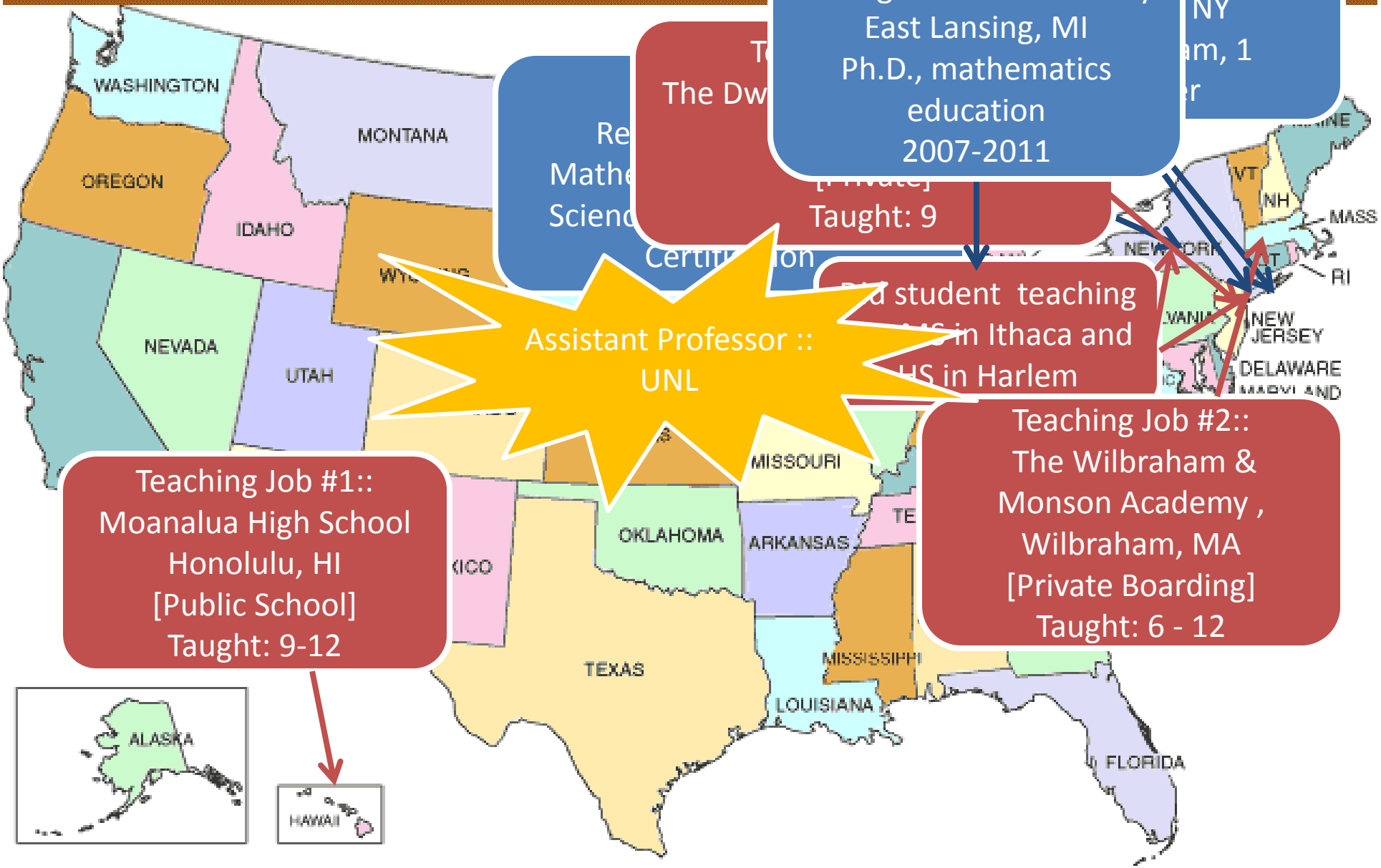
# Educative Supports for Teachers in Middle School Mathematics Curriculum Materials: What is Offered and How is it Expressed?


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



# MOTIVATION & BACKGROUND

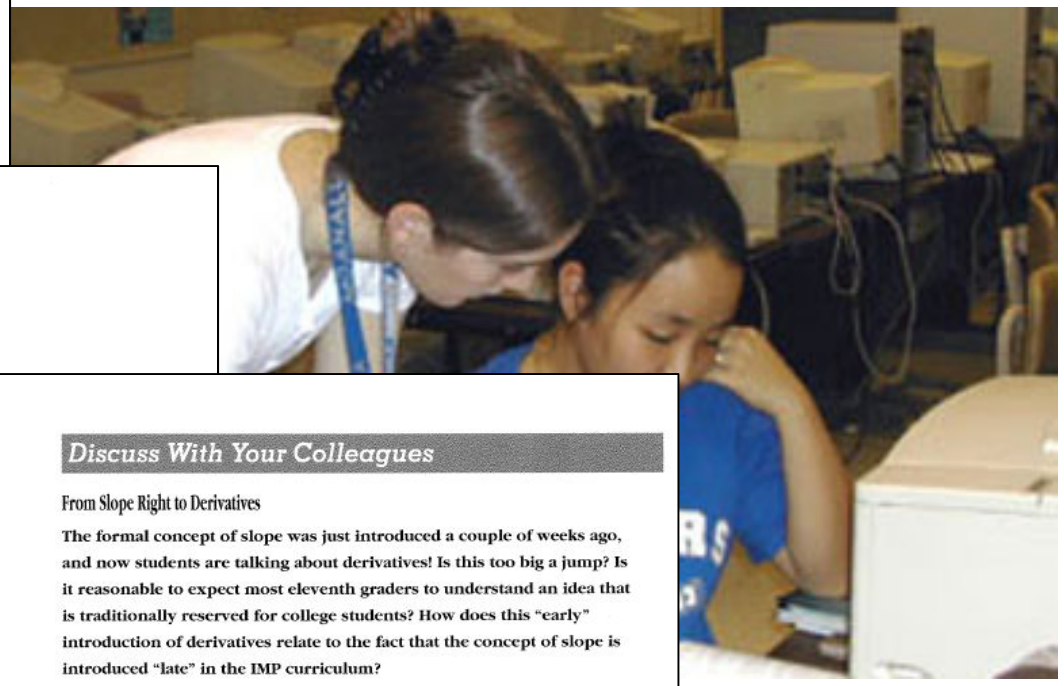
# Why I wanted to so this study

CLASSWORK

## Small World, Isn't It?

Everyone knows that the world's population is increasing.

| Year | Estimated Population |
|---|---|
| 1650 | 470,000,000 |
| 1750 | 694,000,000 |
| 1850 | 1,091,000,000 |
| 1900 | 1,570,000,000 |
| 1950 | 2,510,000,000 |
| 1960 | 3,030,000,000 |
| 1970 | 3,680,000,000 |
| 1980 | 4,480,000,000 |
| 1985 | 4,870,000,000 |
| 1990 | 5,290,000,000 |
| 1995 | 5,730,000,000 |



DAY 14

## The Derivative

Mathemat

- Applying the
- Defining the
- Defining the

Students are introduced to the concept of the derivative of a function at a point.

Special Materials Needed

- A transparency of the graph of the oil slick function (see Appendix B)

In Class

1. Discuss *Homewor* *Growth of the Oil*
2. Discuss *ZOOOOO*
   - Introduce the id line to the graph
   - See that the slop tangent line repr instantaneous ra
3. Define the derivat function at a point
   - Bring out the co among several re and introduce th **derivative** to re common idea
   - Introduce the te describe the pro smaller and smal

Day 14

### Discuss With Your Colleagues

**From Slope Right to Derivatives**

**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?**

### 1. 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.)

# Why the field needs this study

Teacher learning is critical to success (Cohen, Raudenbush, & Ball, 2002; Putnam & Borko, 2000), especially with the implementation of

2010;

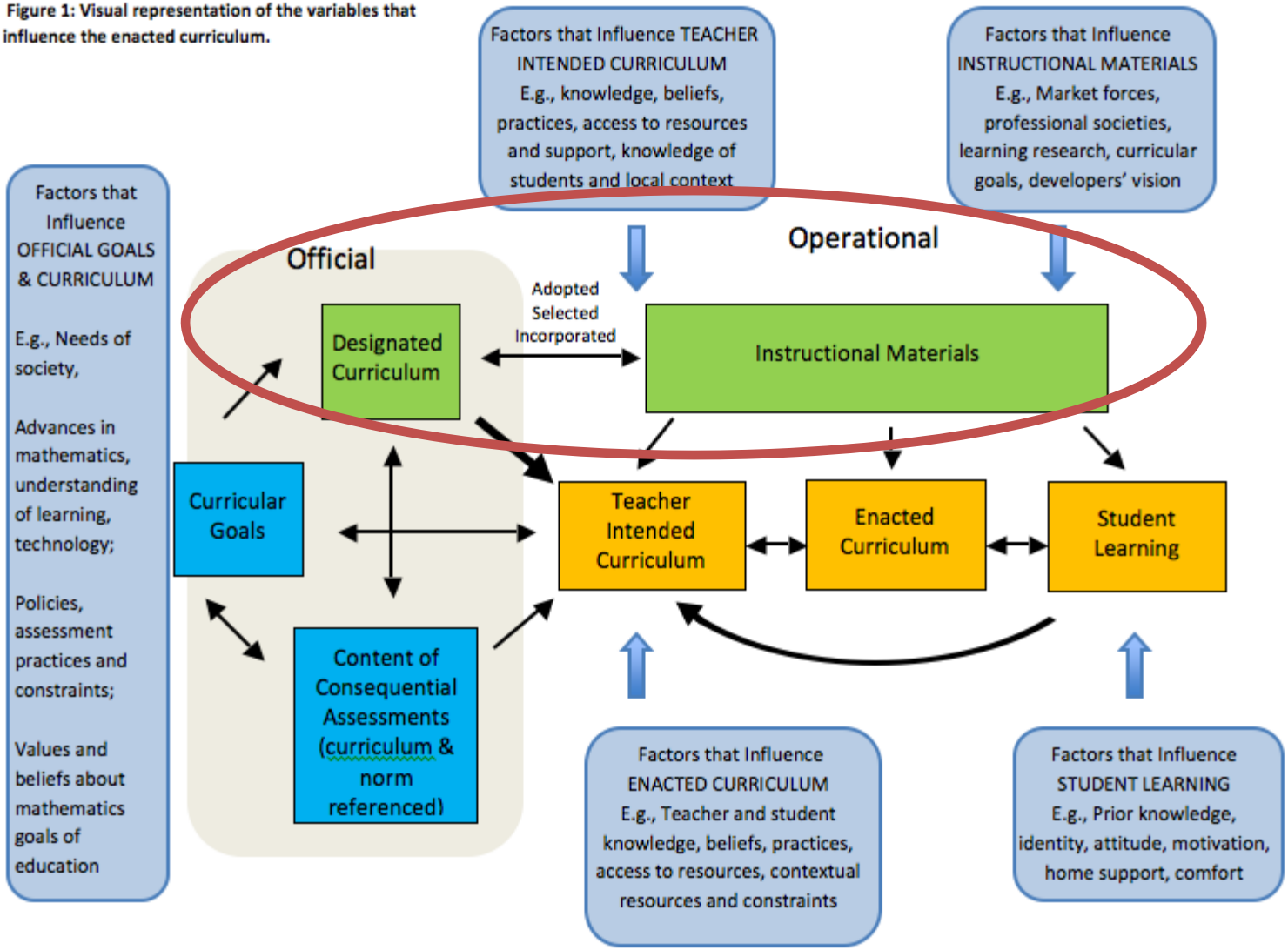
Curric
learni
are so
1996)

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

teachers 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)

# Background – Curriculum and Teachers

**Figure 1: Visual representation of the variables that influence the enacted curriculum.**



# The Roles of Teachers and Curriculum

The **teacher** plays an active role in enacting the curriculum

"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)."

"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

# Educative Curriculum Materials

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

→ be more than just a textbook f

Content must include

→ *Enactment* Guidance

→ *Rationale* Guidance

Expression must

→ allow for the text to speak *t*
teachers

(Ball & Cohen, 1996; Beyer et al., 1
Li, 2004; Remillard, Watanabe, 2005

**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

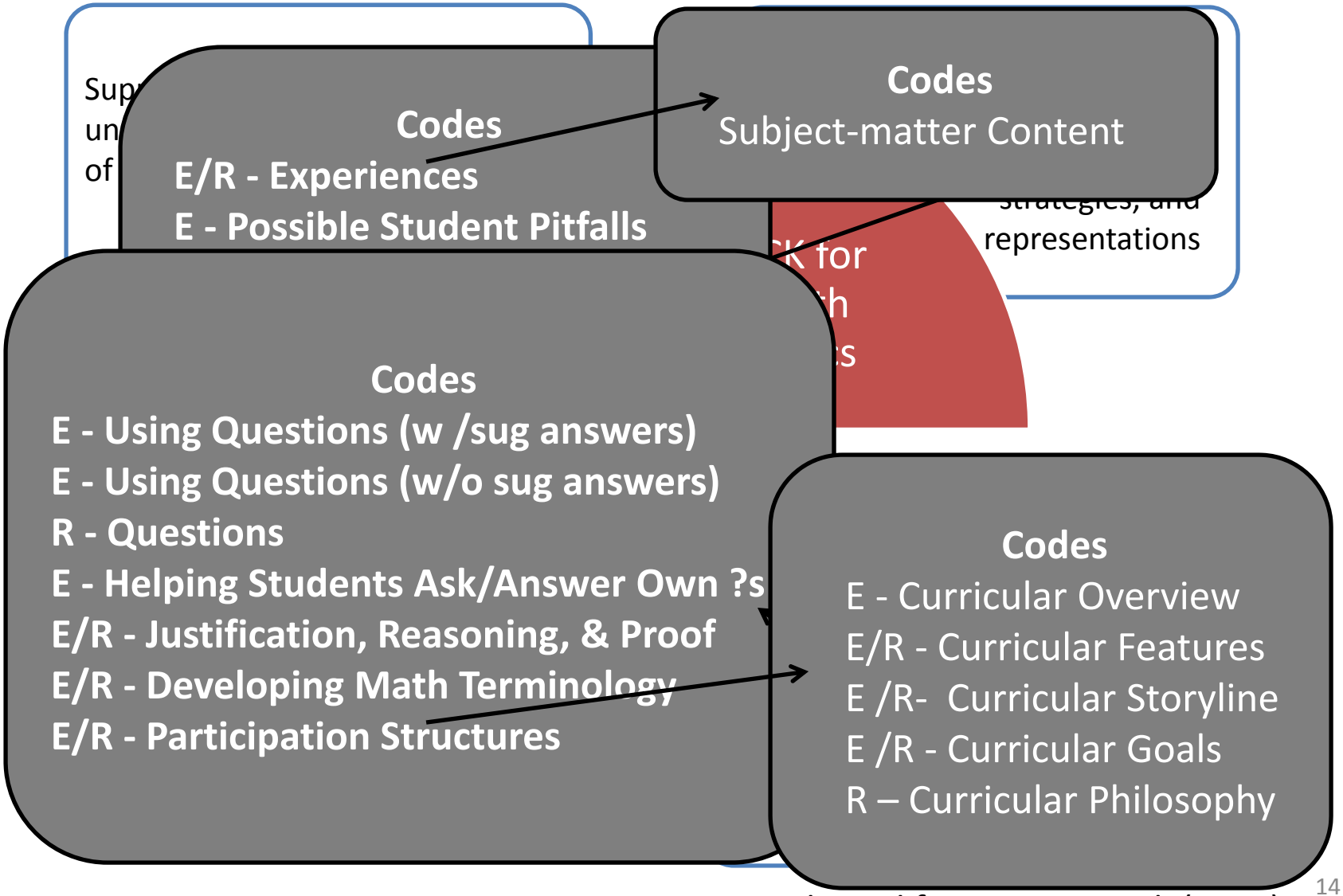
Curricular Series

- 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




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)

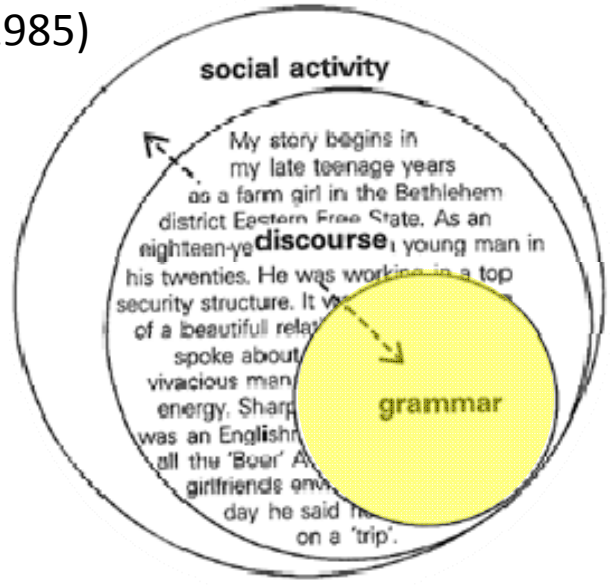
→ Strata & Realizations

→ Metafunctions

→ interpersonal

→ ideational

→ textual




Martin & Rose, 2007, p. 5

# Analytic Framework – Capturing Expression

Personal Pronouns

→ first person – **"I"** and **"we"**

→second person – **"you"**

**Explain that the function rule describes the relationship between.... (Glencoe, Algebra: Functions, p. 47)**

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

"You"-forms

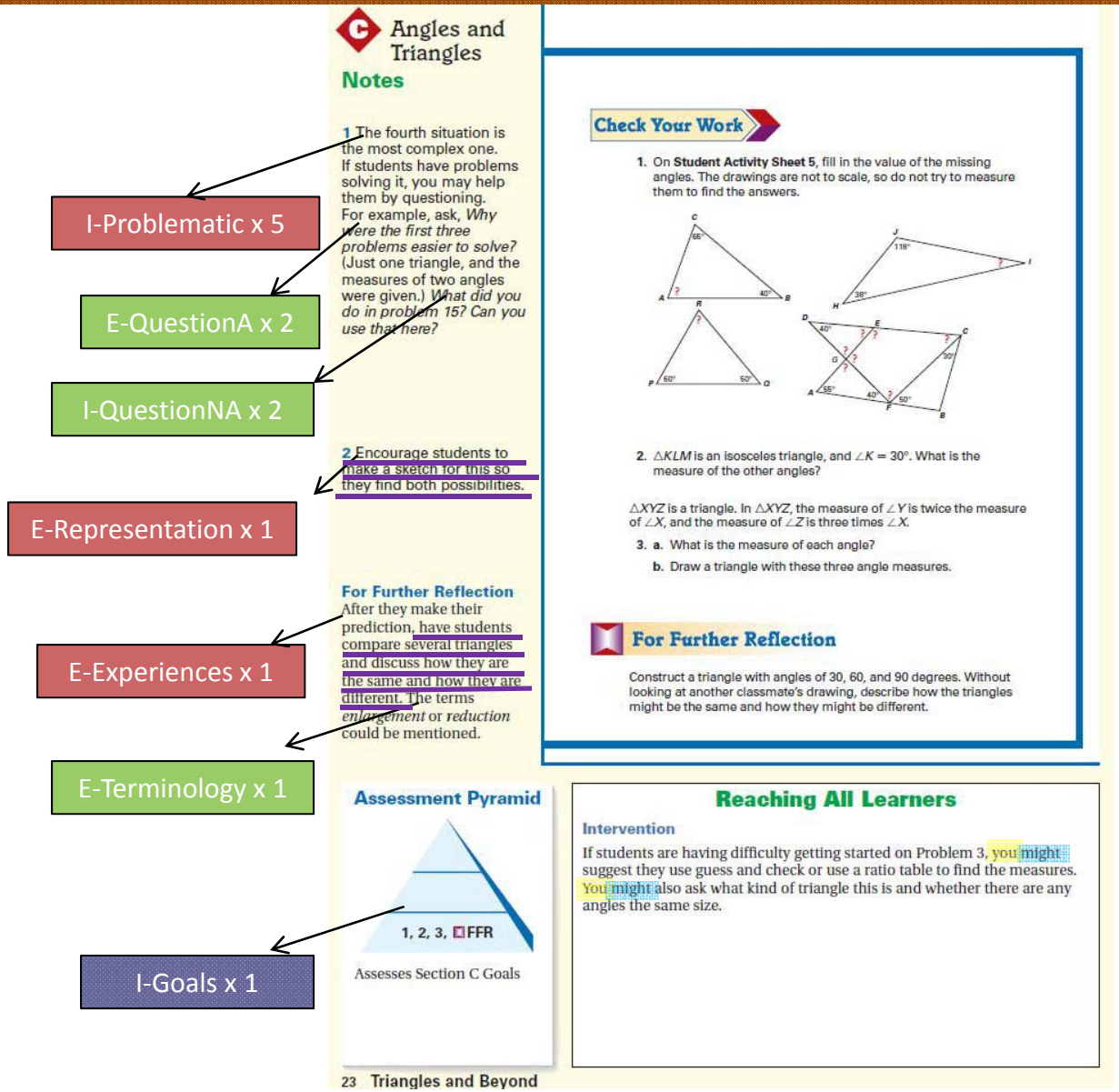
→ implicit - **imperatives**

→explicit - **"you"+ modal verbs**

**You <u>might</u> suggest that they imagine a point leaving a trail (CMP, KHM, p. 53)**

"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

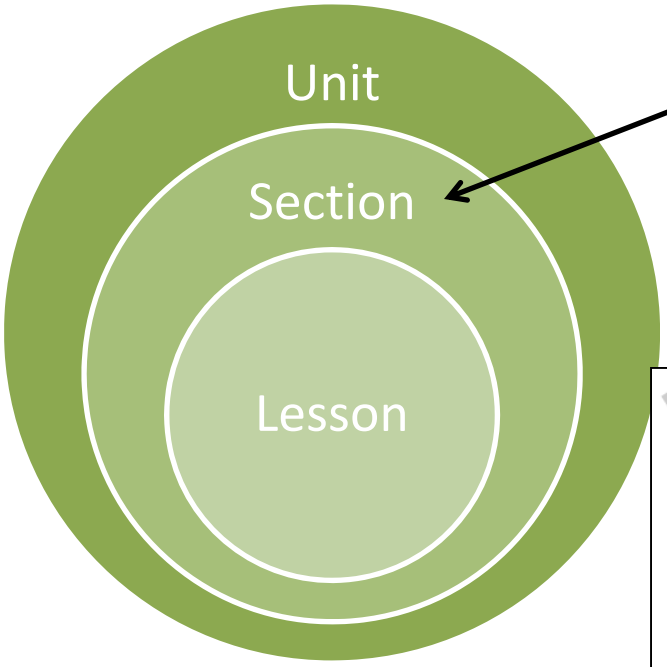
| | Variable | Transformations |
|---|---|---|
| CMP | 85 | 86 |
| Glencoe | 88 | 91 |
| MiC | 85 | 85 |
| UCSMP | 91 | 95 |

# Inter-rater Reliability - Expression

| | Variable | | | Transformations | | |
|---|---|---|---|---|---|---|
| | Personal Pronouns | Imperatives | Modal Verbs | Personal Pronouns | Imperatives | Modal Verbs |
| CMP | 98 | 99 | 100 | 98 | 97 | 100 |
| Glencoe | 100 | 98 | 100 | 100 | 97 | 100 |
| MiC | 100 | 99 | 100 | 99 | 96 | 100 |
| UCSMP | 99 | 96 | 100 | 100 | 96 | 100 |

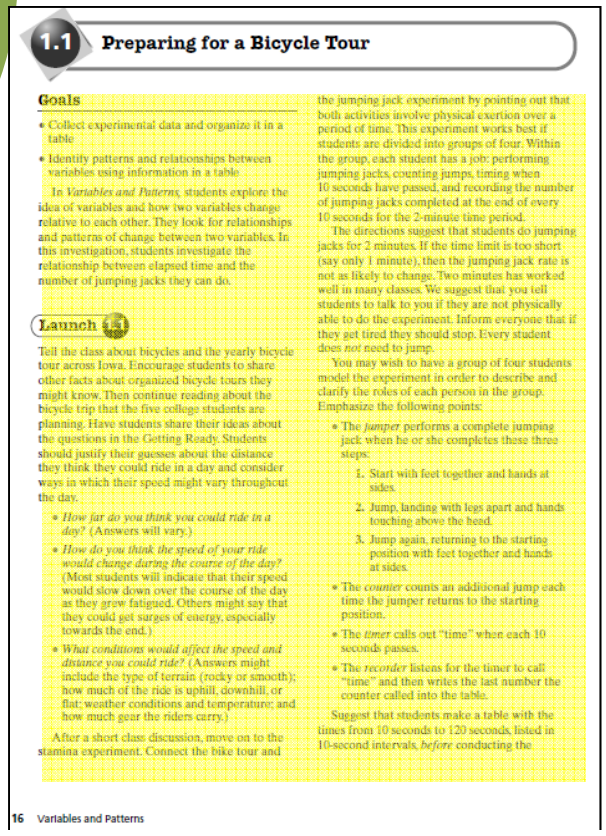
# TOP LEVEL RESULTS

# Structure of the Teachers' Guides




Did not exist in Glencoe and UCSMP

Embedded vs. Non-embedded



1.1 Preparing for a Bicycle Tour

**Goals**

- Collect experimental data and organize it in a table
- Identify patterns and relationships between variables using information in a table

In *Variables and Patterns*, students explore the idea of variables and how two variables change relative to each other. They look for relationships and patterns of change between two variables. In this investigation, students investigate the relationship between elapsed time and the number of jumping jacks they can do.

**Launch** 1.1

Tell the class about bicycles and the yearly bicycle tour across Iowa. Encourage students to share other facts about organized bicycle tours they might know. Then continue reading about the bicycle trip that the five college students are planning. Have students share their ideas about the questions in the Getting Ready. Students should justify their guesses about the distance they think they could ride in a day and consider ways in which their speed might vary throughout the day.

- *How far do you think you could ride in a day?* (Answers will vary.)
- *How do you think the speed of your ride would change during the course of the day?* (Most students will indicate that their speed would slow down over the course of the day as they grow fatigued. Others might say that they could get surges of energy, especially towards the end.)
- *What conditions would affect the speed and distance you could ride?* (Answers might include the type of terrain (rocky or smooth); how much of the ride is uphill, downhill, or flat; weather conditions and temperature; and how much gear the riders carry.)

After a short class discussion, move on to the stamina experiment. Connect the bike tour and the jumping jack experiment by pointing out that both activities involve physical exertion over a period of time. This experiment works best if students are divided into groups of four. Within the group, each student has a job: performing jumping jacks, counting jumps, timing when 10 seconds have passed, and recording the number of jumping jacks completed at the end of every 10 seconds for the 2-minute time period.

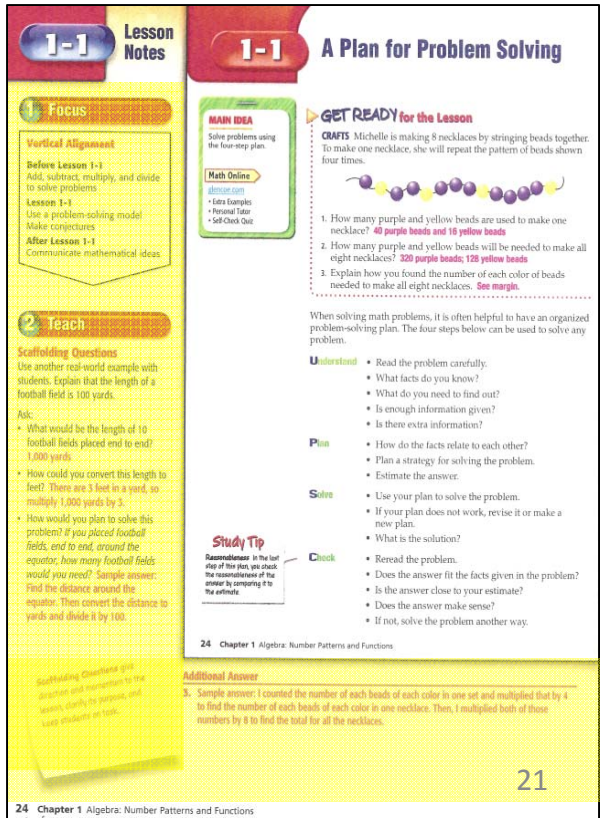
The directions suggest that students do jumping jacks for 2 minutes. If the time limit is too short (say only 1 minute), then the jumping jack rate is not as likely to change. Two minutes has worked well in many classes. We suggest that you tell students to talk to you if they are not physically able to do the experiment. Inform everyone that if they get tired they should stop. Every student does *not* need to jump.

You may wish to have a group of four students model the experiment in order to describe and clarify the roles of each person in the group. Emphasize the following points:

- The *jumper* performs a complete jumping jack when he or she completes these three steps:
  1. Start with feet together and hands at sides.
  2. Jump, landing with legs apart and hands touching above the head.
  3. Jump again, returning to the starting position with feet together and hands at sides.
- The *counter* counts an additional jump each time the jumper returns to the starting position.
- The *timer* calls out "time" when each 10 seconds passes.
- The *recorder* listens for the timer to call "time" and then writes the last number the counter called into the table.

Suggest that students make a table with the times from 10 seconds to 120 seconds, listed in 10-second intervals, *before* conducting the

16 Variables and Patterns



1-1 Lesson Notes

1-1 A Plan for Problem Solving

Focus

Vertical Alignment

Before Lesson 1-1
Add, subtract, multiply, and divide to solve problems

Lesson 1-1
Use a problem-solving model
Make conjectures

After Lesson 1-1
Communicate mathematical ideas

Teach

Scaffolding Questions
Use another real-world example with students. Explain that the length of a football field is 100 yards.

Ask:

- What would be the length of 10 football fields placed end to end? 1,000 yards
- How could you convert this length to feet? There are 3 feet in a yard, so multiply 1,000 yards by 3.
- How would you plan to solve this problem? *If you placed football fields, end to end, around the equator, how many football fields would you need?* Sample answer: Find the distance around the equator. Then convert the distance to yards and divide it by 100.

MAIN IDEA
Solve problems using the four-step plan.

Math Online
glencoe.com
• Extra Examples
• Personal Tutor
• Self-Check Quiz

GET READY for the Lesson

CRAFTS Michelle is making 8 necklaces by stringing beads together. To make one necklace, she will repeat the pattern of beads shown four times.

1. How many purple and yellow beads are used to make one necklace? 40 purple beads and 16 yellow beads
2. How many purple and yellow beads will be needed to make all eight necklaces? 320 purple beads; 128 yellow beads
3. Explain how you found the number of each color of beads needed to make all eight necklaces. See margin.

When solving math problems, it is often helpful to have an organized problem-solving plan. The four steps below can be used to solve any problem.

**Understand**
- Read the problem carefully.
- What facts do you know?
- What do you need to find out?
- Is enough information given?
- Is there extra information?

**Plan**
- How do the facts relate to each other?
- Plan a strategy for solving the problem.
- Estimate the answer.

**Solve**
- Use your plan to solve the problem.
- If your plan does not work, revise it or make a new plan.
- What is the solution?

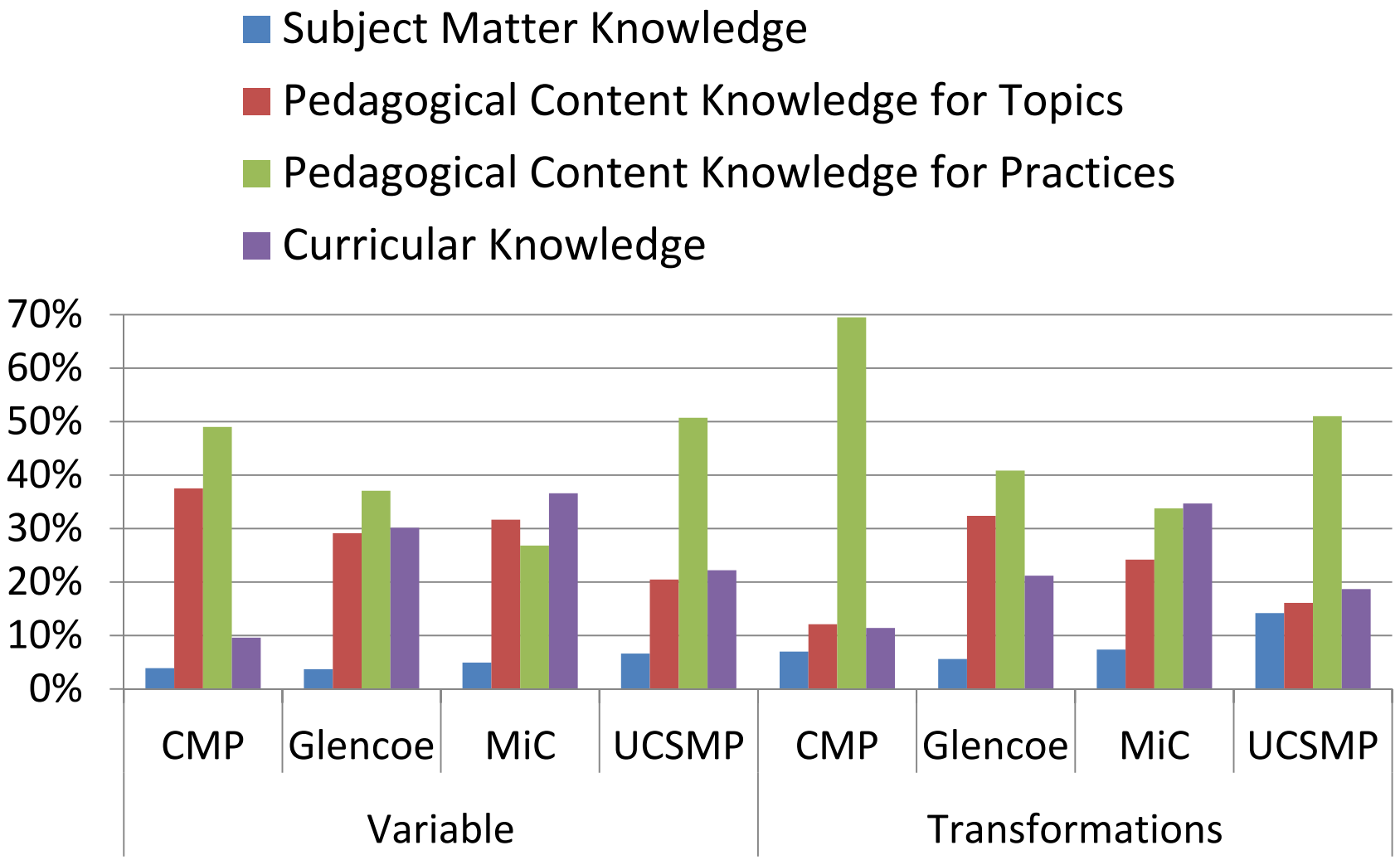
**Check**
- Reread the problem.
- Does the answer fit the facts given in the problem?
- Is the answer close to your estimate?
- Does the answer make sense?
- If not, solve the problem another way.

Study Tip
Reasonableness In the last step of the plan, you check the reasonableness of the answer by comparing it to the estimate.

Additional Answer
3. Sample answer: I counted the number of each beads of each color in one set and multiplied that by 4 to find the number of each beads of each color in one necklace. Then, I multiplied both of those numbers by 8 to find the total for all the necklaces.

24 Chapter 1 Algebra: Number Patterns and Functions

# Content – Knowledge by Category



# Content – Type of Support (Enactment & Rationale)

| | Variable | | Transformations | |
|---|---|---|---|---|
| | Enactment Guidance | Rationale Guidance | Enactment Guidance | Rationale Guidance |
| **CMP** | 97% | 3% | 97% | 3% |
| **Glencoe** | 99% | 1% | 99% | 1% |
| **MiC** | 94% | 6% | 98% | 2% |
| **UCSMP** | 94% | 6% | 97% | 3% |

# Content - Location of Support

| | Variable | | | Transformations | | |
|---|---|---|---|---|---|---|
| | Unit | Section | Lesson | Unit | Section | Lesson |
| **CMP** | 14% | 28% | 58% | 48% | 5% | 47% |
| **Glencoe** | 15% | N/A | 85% | 12% | N/A | 88% |
| **MiC** | 24% | 14% | 62% | 16% | 11% | 72% |
| **UCSMP** | 19% | N/A | 81% | 18% | N/A | 82% |

# Expression – Frequencies of Pronouns

| | Variable | | Transformations | |
|---|---|---|---|---|
| | we | you | we | you |
| CMP | 38 | 52 | 102 | 42 |
| Glencoe | 0 | 19 | 0 | 25 |
| MiC | 0 | 61 | 3 | 129 |
| UCSMP | 20 | 33 | 17 | 38 |

# Expression – Use of “we”

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 $\overline{W'X'}$ parallel to $\overline{W''X''}$. The angle in the gap triangle marked X‴ must be congruent to X′ (alternate interior angles). We already know that $\overline{W'''X'''}$ is congruent to $\overline{W''X''}$ since translations preserve length. Thus we know that the gap triangle is congruent to the original triangle, by Side-Angle-Side using $\overline{V''X''}$ as the other side.

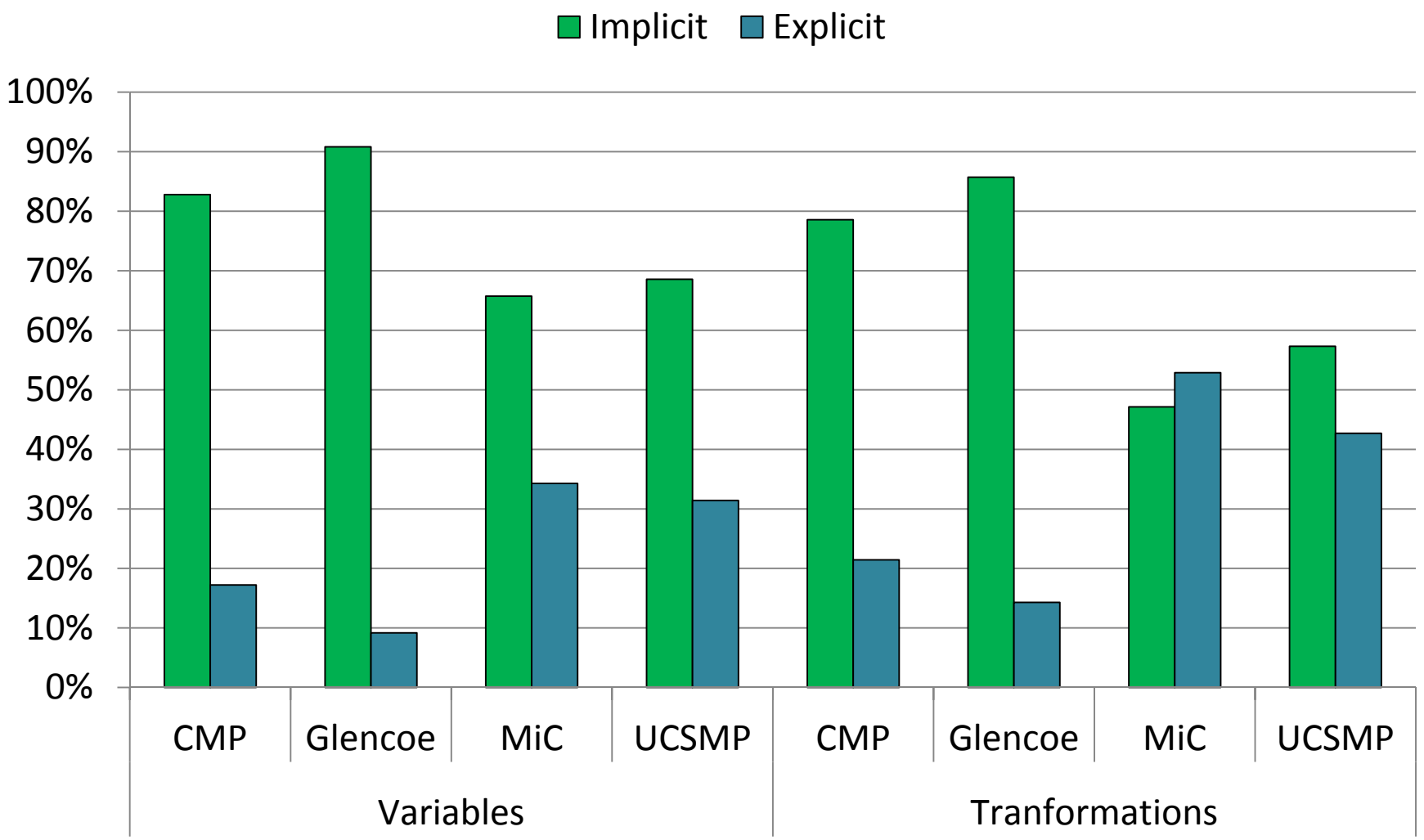
**Method 2:**

- Rotate △1 to △2.
- Translate △2 to △3.
- Translate △1 the distance of $\overline{WX}$ to fill the *gap*.

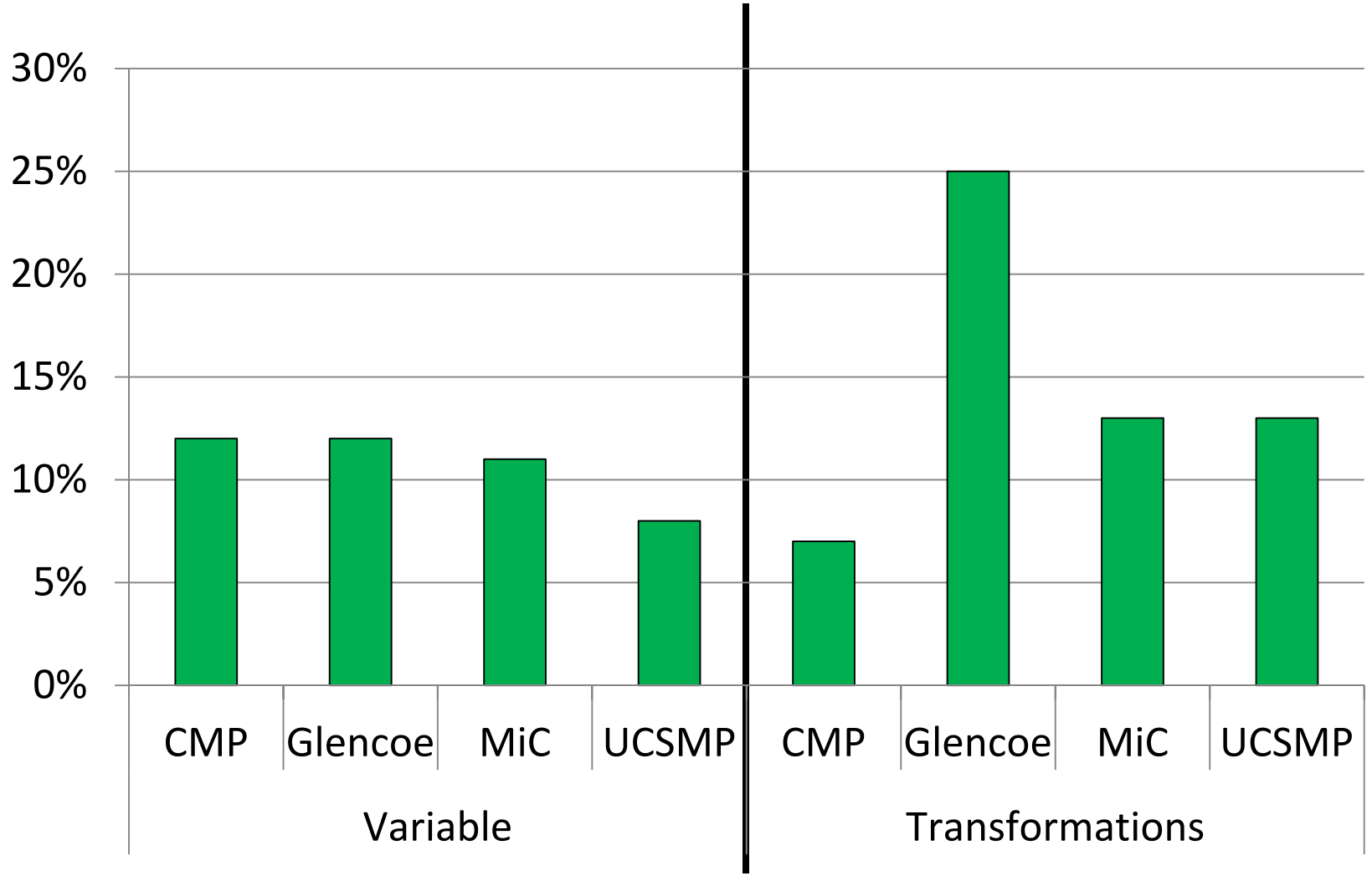
The question is now, "Can we be sure that the last transformation will exactly fill the *gap*?" Here are brief sketches of two ways we might reason about this.

**A.** When △2 is translated to △3 by a distance of $\overline{WV}$, point $X'$ is moved to $X''$. So this distance is congruent to $\overline{WV}$. 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



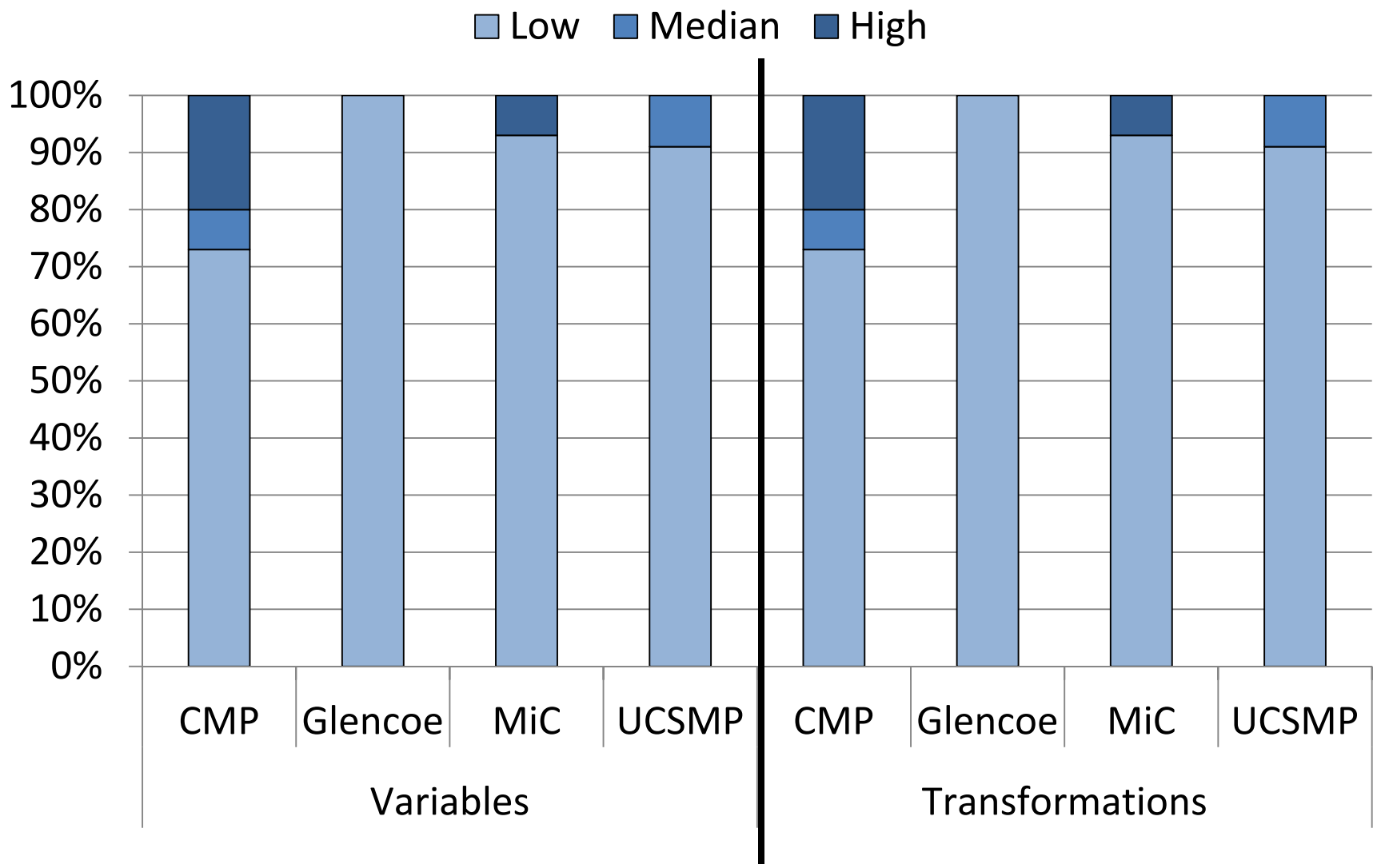
# Expression – Types of Imperatives



# Expression – Types of Imperatives

| | Variable | | Transformations | |
|---|---|---|---|---|
| | inclusive | exclusive | inclusive | exclusive |
| **CMP** | 28% | 72% | 27% | 73% |
| **Glencoe** | 31% | 69% | 17% | 83% |
| **MiC** | 43% | 57% | 48% | 52% |
| **UCSMP** | 0% | 100% | 0% | 100% |

# Expression – Modal Verbs



# 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

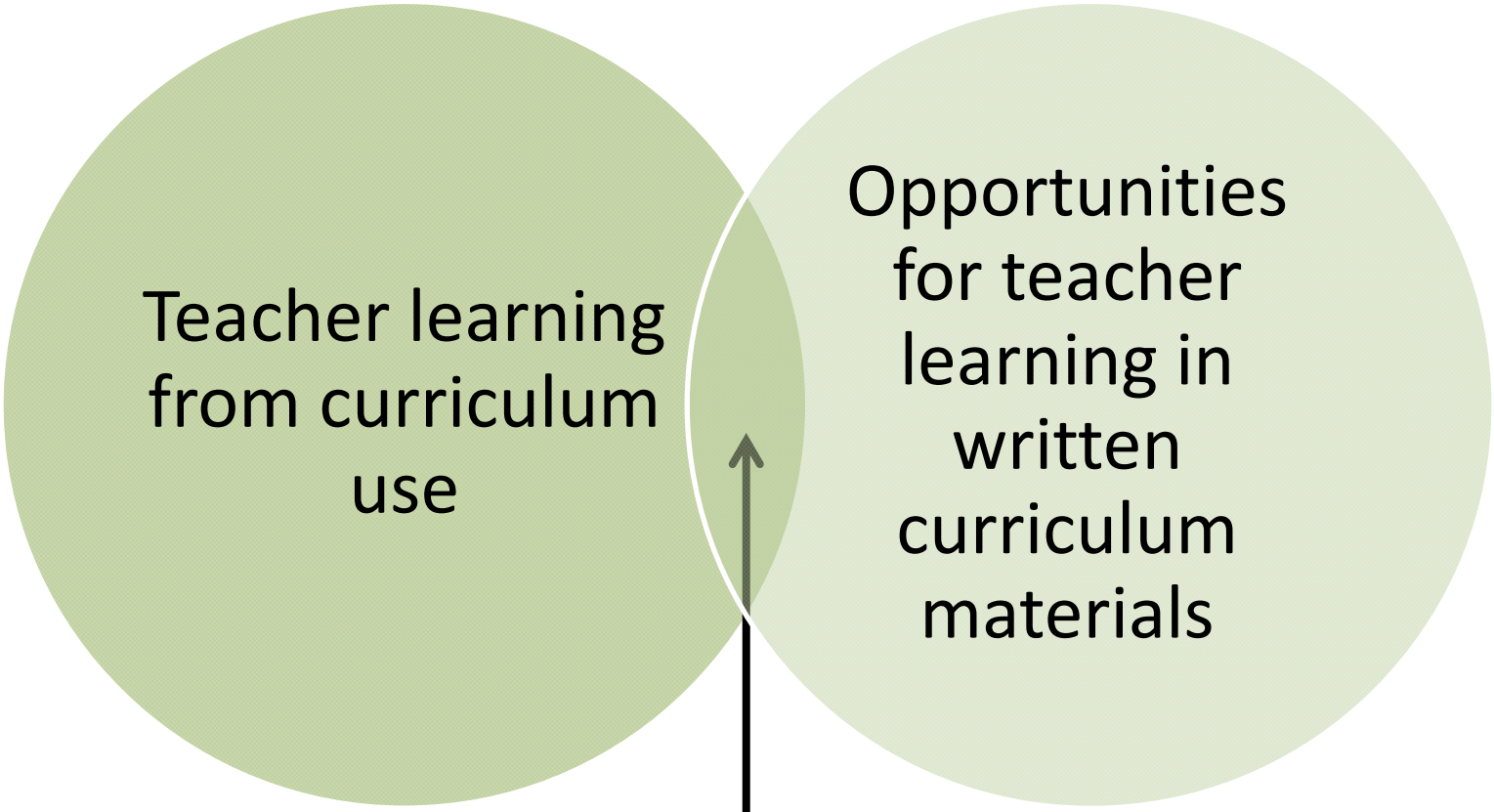
Recognize the importance of expression in curriculum materials, not just the content

- 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




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

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 Phillhower, & 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?

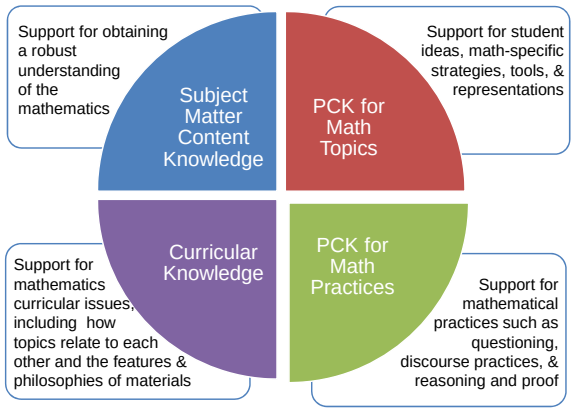
## Data Sources

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]
- Glencoe *Math Connects* (Day, Frey, Howard, Hutchens, Luchin, McClain, et al., 2009) [Glencoe]
- *Mathematics in Context* (Wisconsin Center for Education & the Freudenthal Institute, 2010) [MiC]
- UCSMP's *Transition Mathematics* (Viktora, Cheung, Highstone, Capuzzi, Heeres, Metcalf, et al., 2008) [UCSMP].

## Framework & Analysis

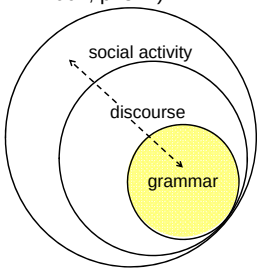
### Educative Supports




| Subject Matter | PCK-Topics | PCK-Practices | Curricular |
|---|---|---|---|
| Subject Matter Content | **Enactment Guidance** | | |
| | • Experiences<br>• Possible Pitfalls<br>• Engage Students in Prob. Exp<br>• Act. Sequences<br>• Representations<br>• Tools<br>• Anticipating Student Ideas | • Use Questions (w/and w/o answers)<br>• Help Students Ask/Ans Own ?s<br>• Reasoning & Proof<br>• Developing Math Terminology | • Overview<br>• Features<br>• Storyline<br>• Goals |
| | **Rationale Guidance** | | |
| | • Experiences<br>• Act. Sequences<br>• Representations<br>• Tools | • Questions<br>• Reasoning & Proof<br>• Math Terminology | • Features<br>• Storyline<br>• Goals<br>• Philosophy |

### 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).




Martin & Rose, 2007, p. 5

Systemic Functional Linguistics (Halliday, 1985)

Metafunctions
→interpersonal
→ideational
→textual

Personal Pronouns
→ first person – **"I"** and **"we"**
→second person – **"you"**

"You"-forms
→ implicit - **imperatives**
→explicit - **"you"+ modal verbs**

**Explain that the function rule describes the relationship between.... (Glencoe, Algebra: Functions, p. 47)**

"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)

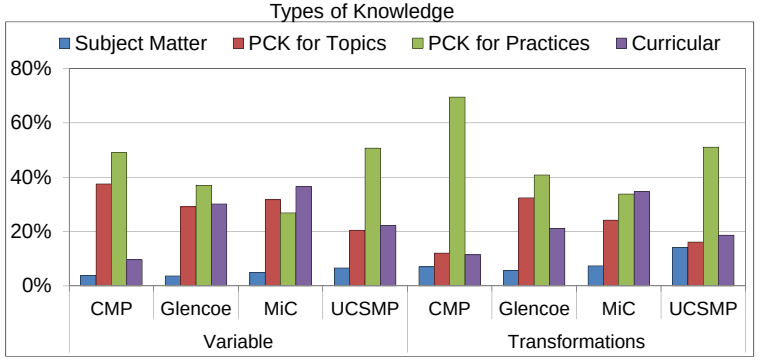
**You might suggest that they imagine a point leaving a trail (CMP, KHM, p. 53)**

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

## Results

### Content Supports

Types of Knowledge




Types of Guidance

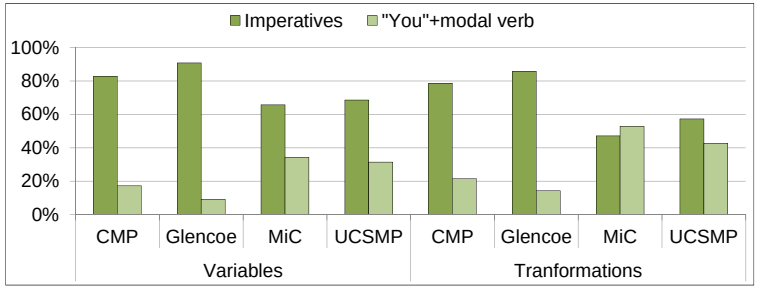
| | Variable | | Transformations | |
|---|---|---|---|---|
| | Enactment | Rationale | Enactment | Rationale |
| CMP | 97 | 3 | 97 | 3 |
| Glencoe | 99 | 1 | 99 | 1 |
| MiC | 94 | 6 | 98 | 2 |
| UCSMP | 94 | 6 | 97 | 3 |

### Expression

Personal Pronouns

| | **Variable** | | **Transformations** | |
|---|---|---|---|---|
| | **we** | **you** | **we** | **you** |
| **CMP** | **38** | **52** | **102** | **42** |
| **Glencoe** | **0** | **19** | **0** | **25** |
| **MiC** | **0** | **61** | **3** | **129** |
| **UCSMP** | **20** | **33** | **17** | **38** |

Distribution of "You"-forms




lmales2@unl.edu