

Computational Thinking and Experiences of Arithmetic Concepts

Online Seminar Series on Programming in Mathematics Education

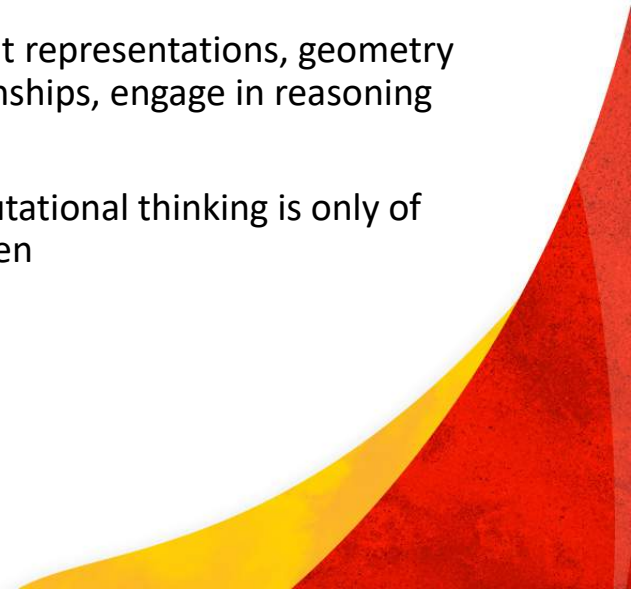


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Brent Davis, University of Calgary

July 3, 2020 11:00 EDT

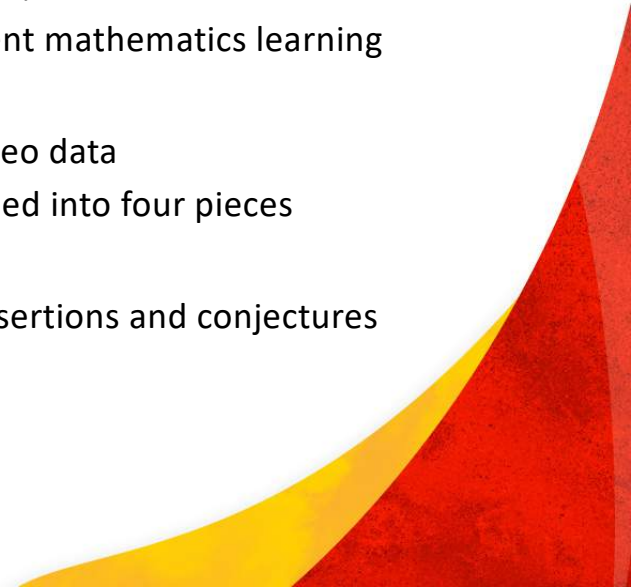
Tying into Hoyles & Ross (2020 June 19)

- ▶ Papert & Constructionism
- ▶ Overlaps between ...
 - ▶ Computational Thinking (abstraction, algorithms, decomposition, pattern recognition) and
 - ▶ Mathematics (different representations, geometry structures and relationships, engage in reasoning and problem solving)
- ▶ Without good design, computational thinking is only of benefit to advantaged children



Overview

1. Situating ourselves conceptually
 - Visiting learningdiscourses.com
 - Brushing past [Conceptual Metaphor Theory](#)
 - Digging into the concept of "number"
2. Introducing the research setting
 - Robotics (coding motion) focus
 - Designed to complement mathematics learning
3. Presenting some analyzed video data
 - 9-minute episode, parsed into four pieces
4. Offering some culminating assertions and conjectures



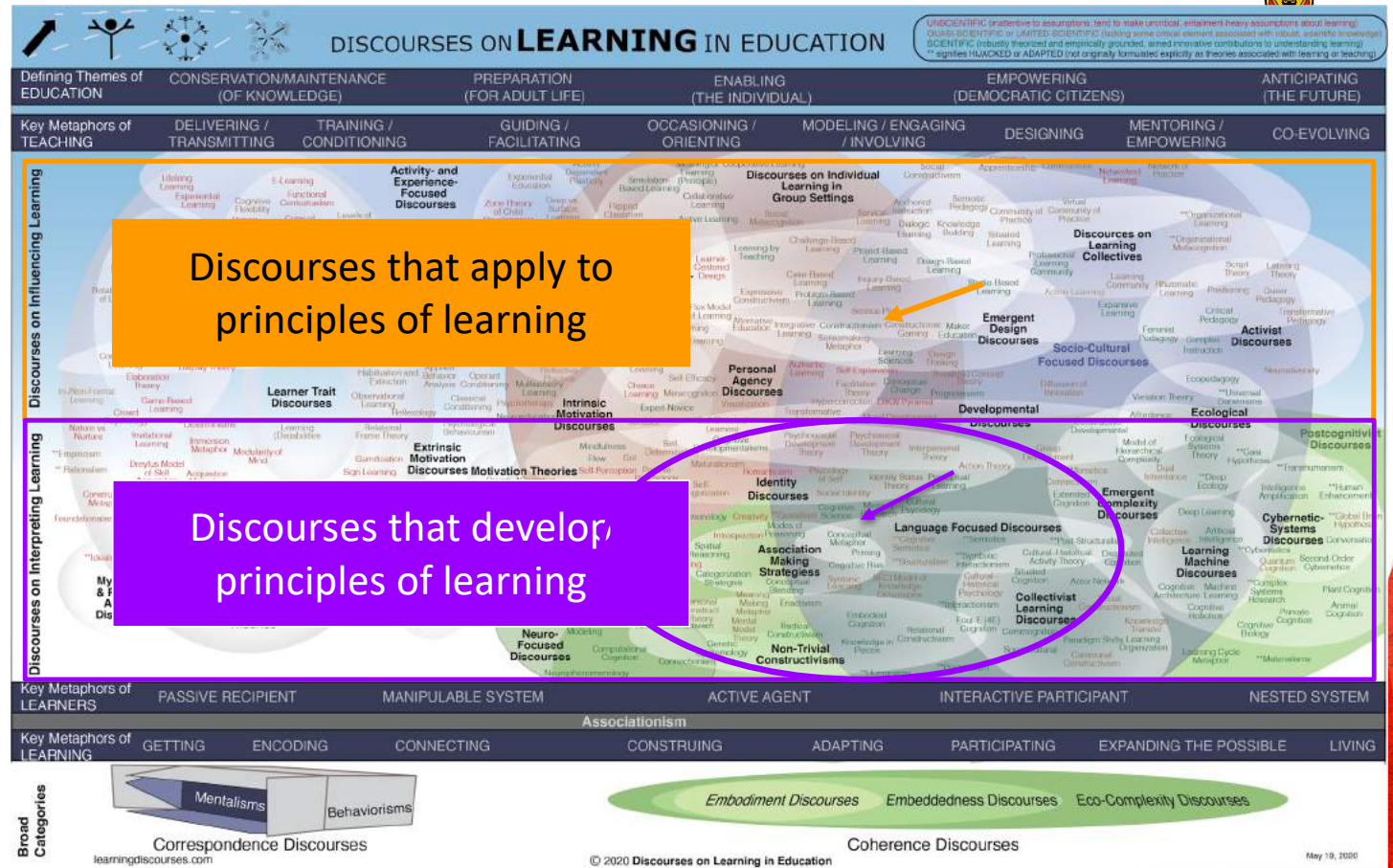
Part 1

Situating
ourselves
conceptually

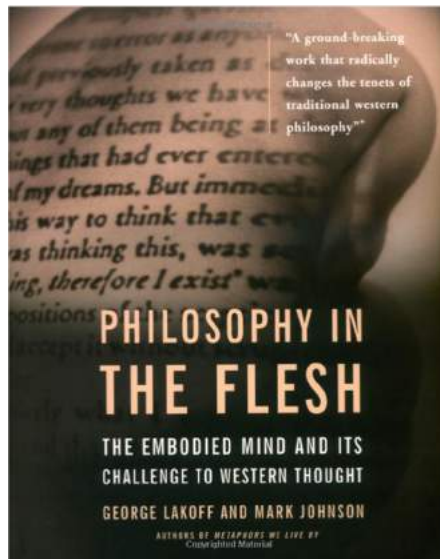


Discourses on Learning in Education

learningdiscourses.com



Conceptual Metaphor Theory

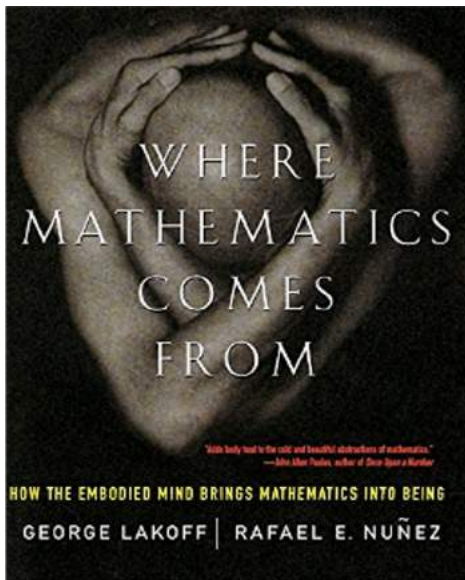


Subdiscourse of cognitive sciences

Associated with embodied cognition

- ▶ Human thought is mainly analogical/associative, rather than logical deductive
- ▶ Metaphor is a core to human thinking ...
- ▶ ... and is especially important for bridging bodily experience and conceptual interpretation.

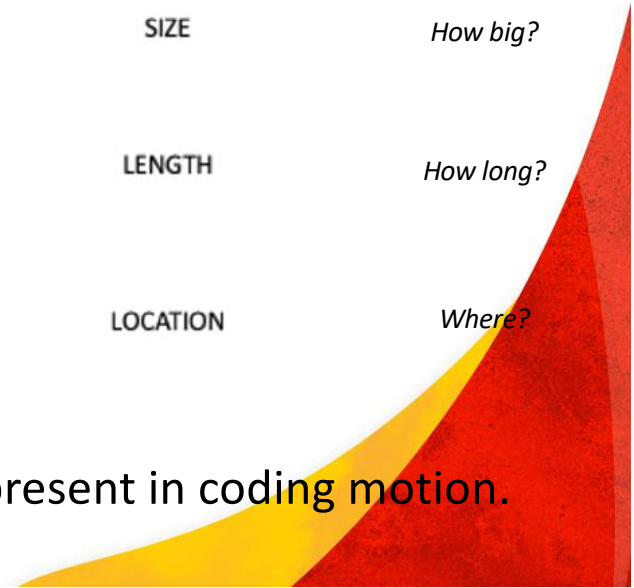
Conceptual Metaphor Theory



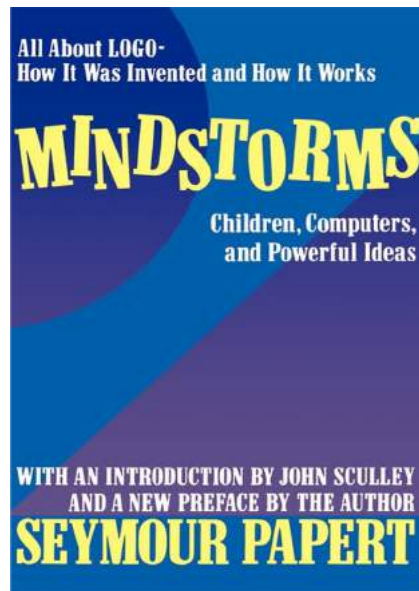
"Grounding Metaphors of Arithmetic"

Four Grounding Metaphor(s) of Arithmetic	An instantiation of "5"	Number as ...	Matter addressed
OBJECT COLLECTION		COUNT	<i>How many?</i>
OBJECT CONSTRUCTION		SIZE	<i>How big?</i>
MEASURING STICK		LENGTH	<i>How long?</i>
MOVING ALONG A PATH		LOCATION	<i>Where?</i>

All of the metaphors are present in coding motion.




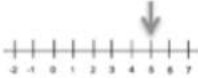


Constructionism (Papert)



"Objects-to-think-with"

- ▶ familiar constructs used to grapple with novel situations
- ▶ Our goal: render the number line an object-to-think-with ...

Four Grounding Metaphor(s) of Arithmetic	An instantiation of "5"	Number as ...	Matter addressed
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MOVING ALONG A PATH		LOCATION	<i>Where?</i>

Hypoth- assertion



Objects-to-
Think-With

- ▶ Coding/computational-thinking environments – **and work with robotic motion in particular** – are superb spaces to develop number sense ...
- ▶ ... partly because multiple instantiations of number are invoked, usually simultaneously ...
- ▶ ... which shouldn't be all that surprising, given that computational thinking is an offspring of mathematics.

Part 2

The research setting



Context

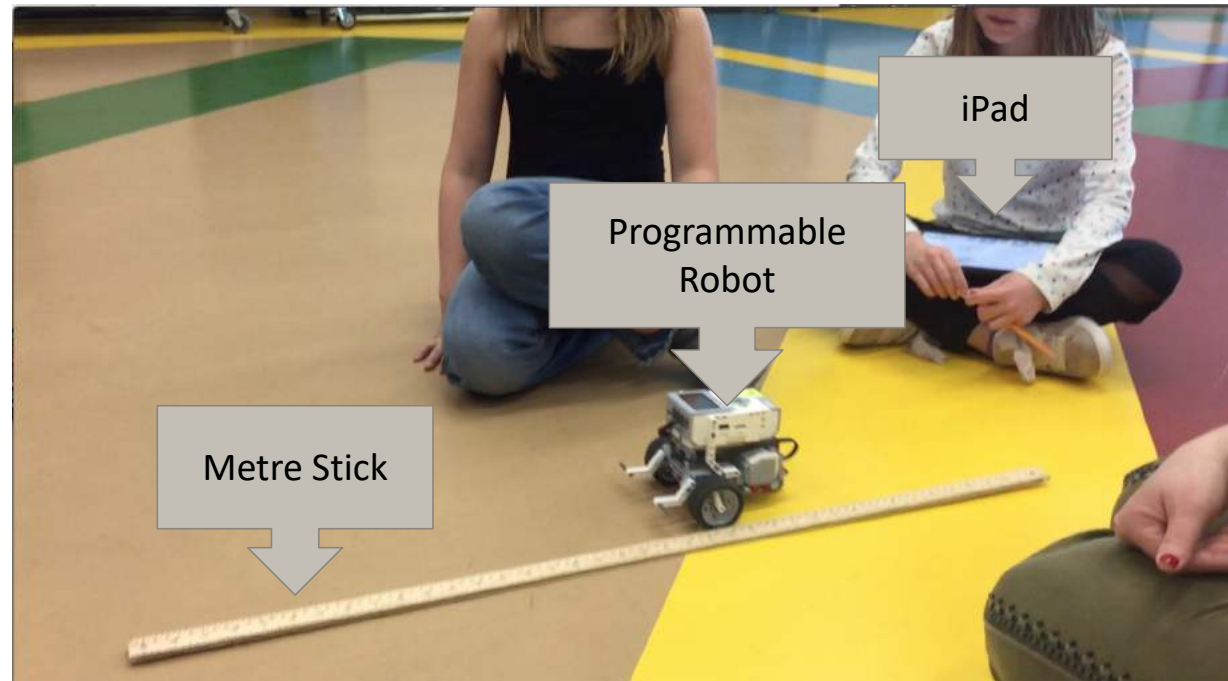


- ▶ Local elementary school
- ▶ Weekly robotics classes
- ▶ Beginning of Grade 4 (haven't yet formally encountered decimals)
- ▶ Learning to move robot



How many wheel rotations are needed for the robot to travel 100 cm?

Task







Join in:

Ranking of Metaphors

Which metaphors of number are most appropriate for this task?

- ▶ To participate go to <https://www.menti.com/f989bjbf6g>
- ▶ Choices are count, size, length, location

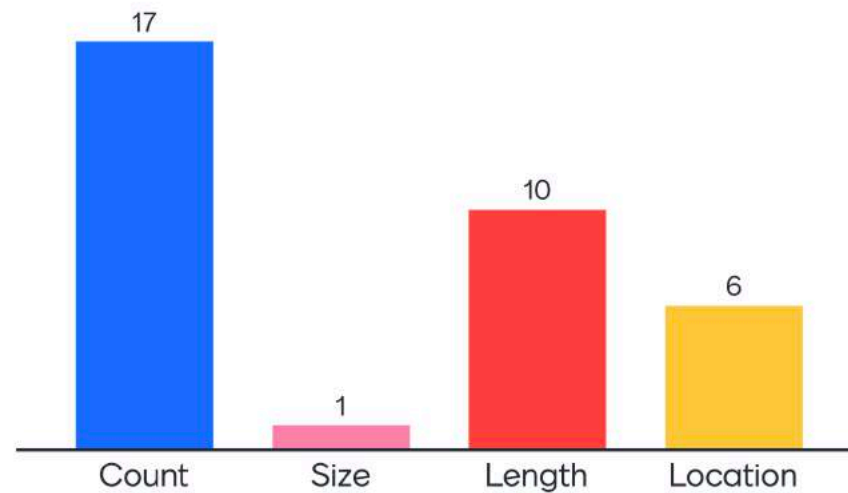
OBJECT COLLECTION		COUNT	<i>How many?</i>
OBJECT CONSTRUCTION		SIZE	<i>How big?</i>
MEASURING STICK		LENGTH	<i>How long?</i>
MOVING ALONG A PATH		LOCATION	<i>Where?</i>

Results of Audience Voting

Go to www.menti.com and use the code 35 81 12

How many wheel rotations to travel 100 cm?

Mentimeter



34
●

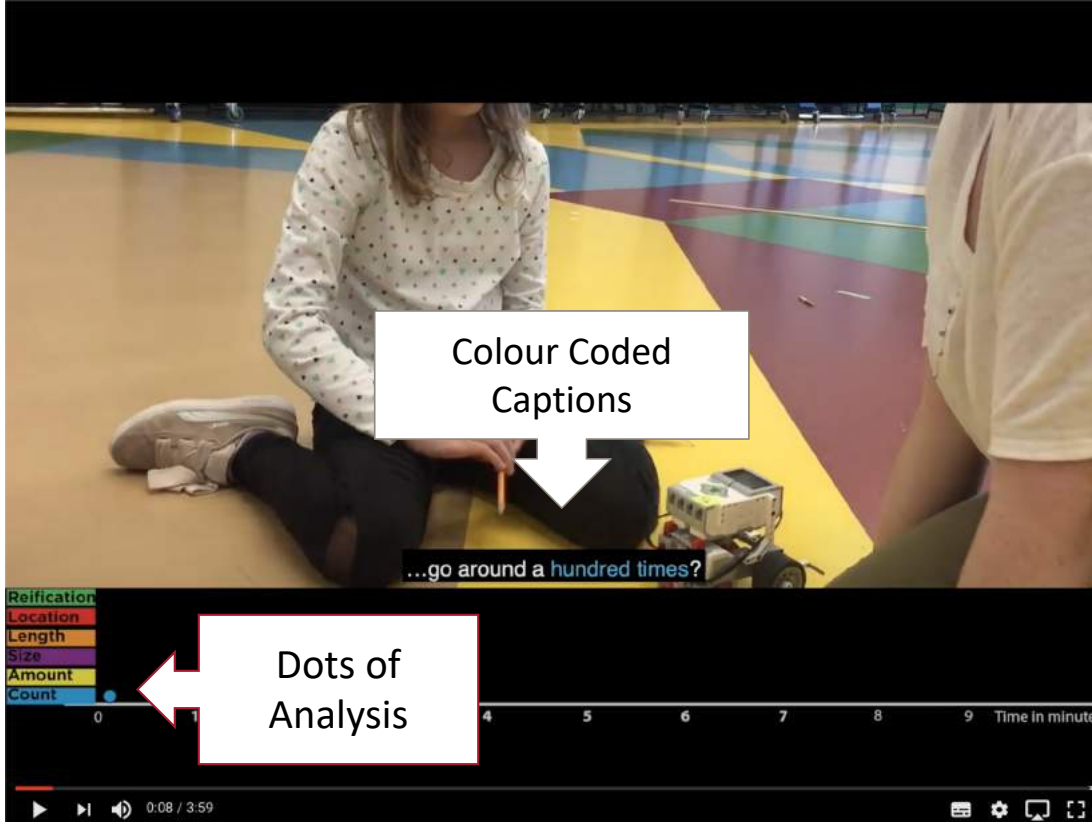
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Part 3

Some analyzed
video data



Watch for...



Colour Coded Captions

...go around a hundred times?

Dots of Analysis

Reification
Location
Length
Size
Amount
Count

0 1 4 5 6 7 8 9 Time In minutes

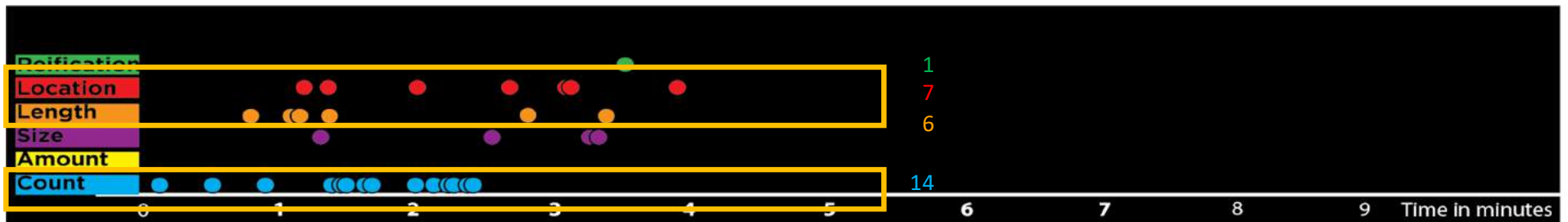
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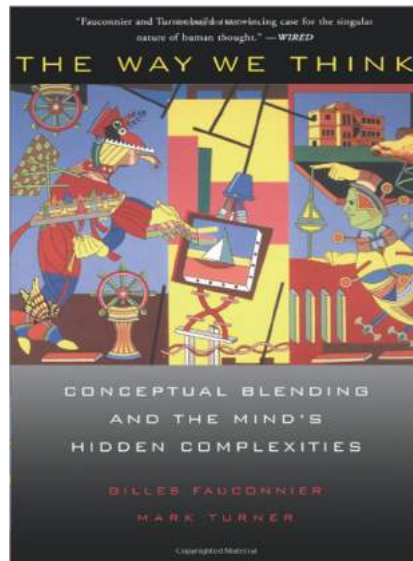
See video at <https://vimeo.com/313928391>



Brief Recap 1



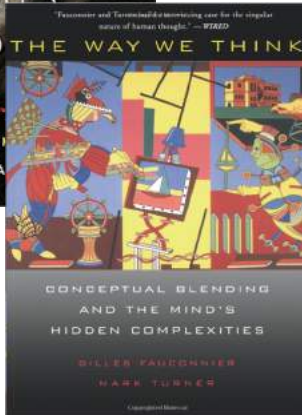
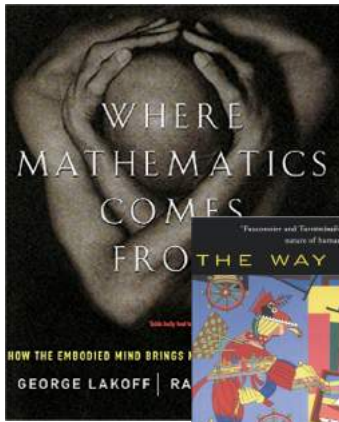
Conceptual Blending Theory



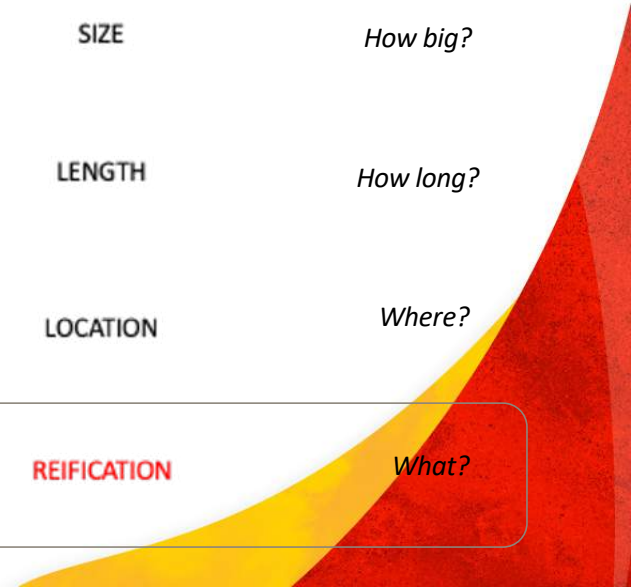
Complement to Conceptual Metaphor

- ▶ Creative leaps and sophisticated concepts involve a blending of metaphors that results in amplifications of interpretative reach.
- ▶ Blending can happen very quickly ... and, we think, is frequently experienced as the spark of insight, the leap of intuition, the Aha!

Conceptual Blending Theory



Four Grounding Metaphor(s) of Arithmetic	An instantiation of "5"	Number as ...	Matter addressed
OBJECT COLLECTION		COUNT	<i>How many?</i>
BLEND →		RANK	<i>Which?</i>
BLEND →		AMOUNT	<i>How much?</i>
OBJECT CONSTRUCTION		SIZE	<i>How big?</i>
MEASURING STICK		LENGTH	<i>How long?</i>
MOVING ALONG A PATH		LOCATION	<i>Where?</i>
BLEND →	5	REIFICATION	<i>What?</i>

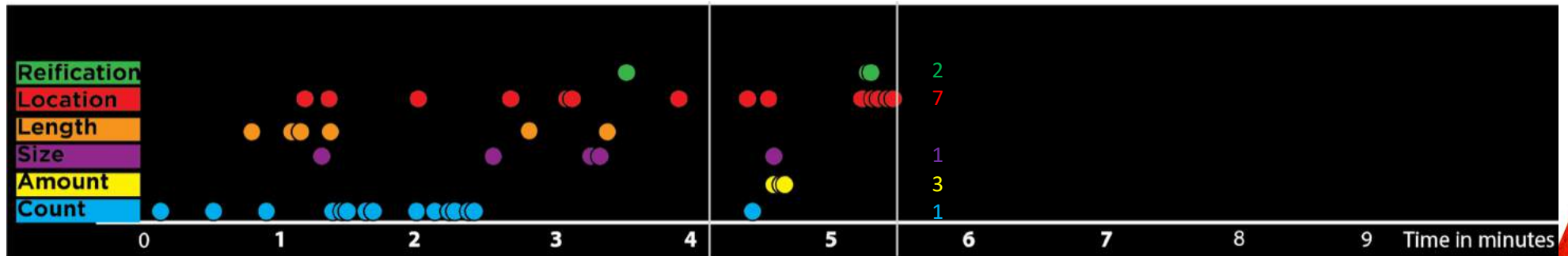




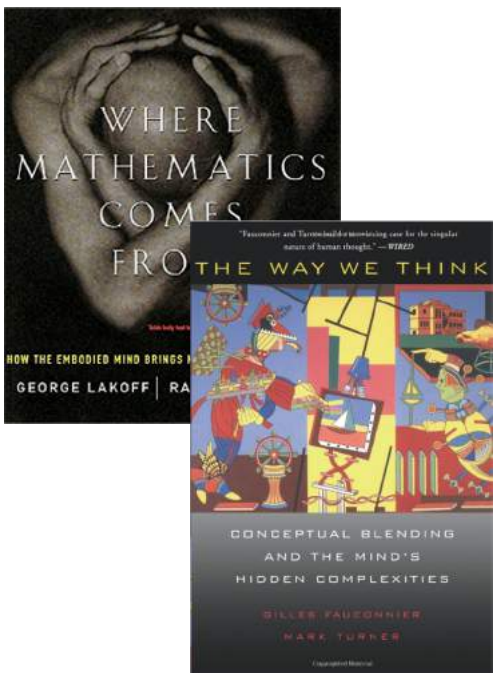
See video 2 at <https://vimeo.com/317354442>



Brief Recap 2



Conceptual Blending Theory



Four Grounding Metaphor(s) of Arithmetic

An instantiation of "5"

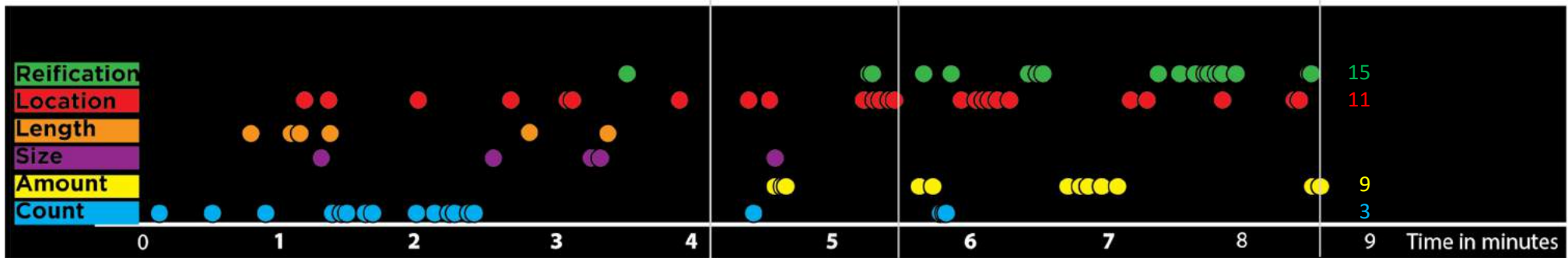
Number as ...

Matter addressed

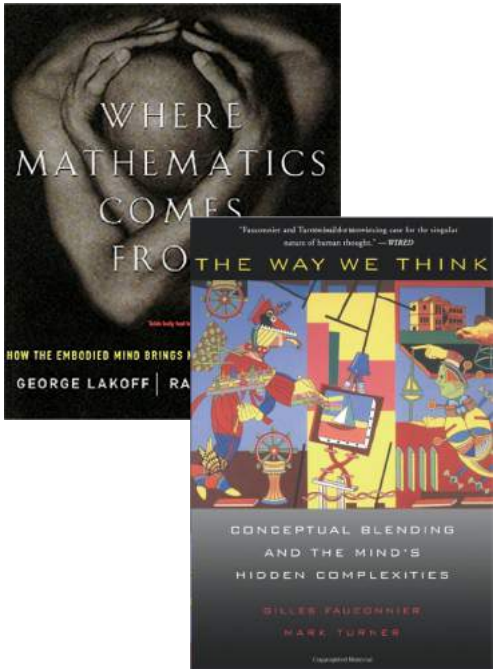
Four Grounding Metaphor(s) of Arithmetic	An instantiation of "5"	Number as ...	Matter addressed
OBJECT COLLECTION		COUNT	How many?
BLEND		RANK	Which?
BLEND		AMOUNT	How much?
OBJECT CONSTRUCTION		SIZE	How big?
MEASURING STICK		LENGTH	How long?
MOVING ALONG A PATH		LOCATION	Where?
BLEND	5	REIFICATION	What?

- See Video 3 at <https://vimeo.com/319520044>

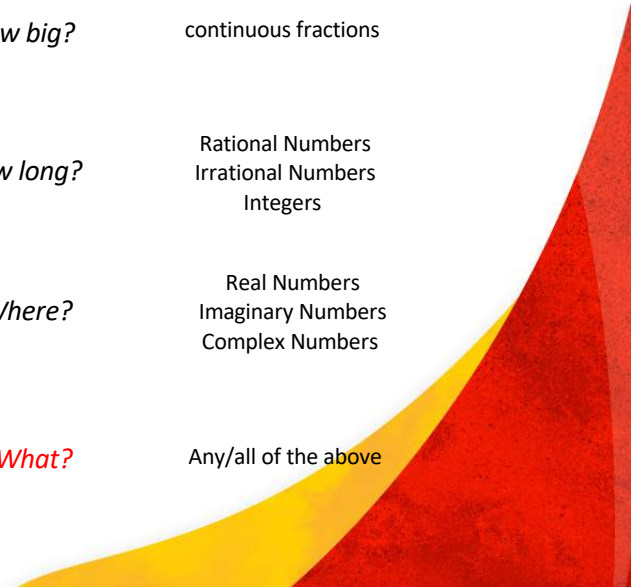
Brief Recap 3



Conceptual Blending Theory



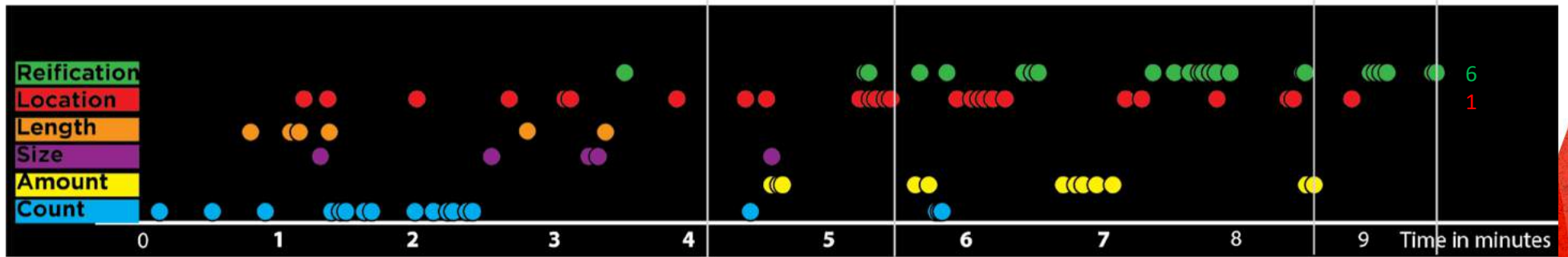
Four Grounding Metaphor(s) of Arithmetic	An instantiation of "5"	Number as ...	Matter addressed	Number systems made available
OBJECT COLLECTION		COUNT	<i>How many?</i>	Whole Numbers Natural Numbers cardinals
BLEND		RANK	<i>Which?</i>	ordinals
BLEND		AMOUNT	<i>How much?</i>	large numbers discrete fractions
OBJECT CONSTRUCTION		SIZE	<i>How big?</i>	continuous fractions
MEASURING STICK		LENGTH	<i>How long?</i>	Rational Numbers Irrational Numbers Integers
MOVING ALONG A PATH		LOCATION	<i>Where?</i>	Real Numbers Imaginary Numbers Complex Numbers
BLEND	5	REIFICATION	<i>What?</i>	Any/all of the above



See video at <https://vimeo.com/325933850>

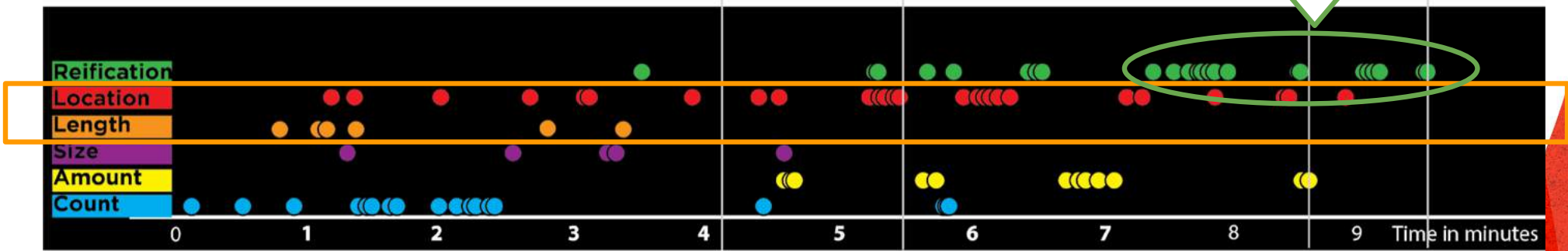


Brief Recap 4

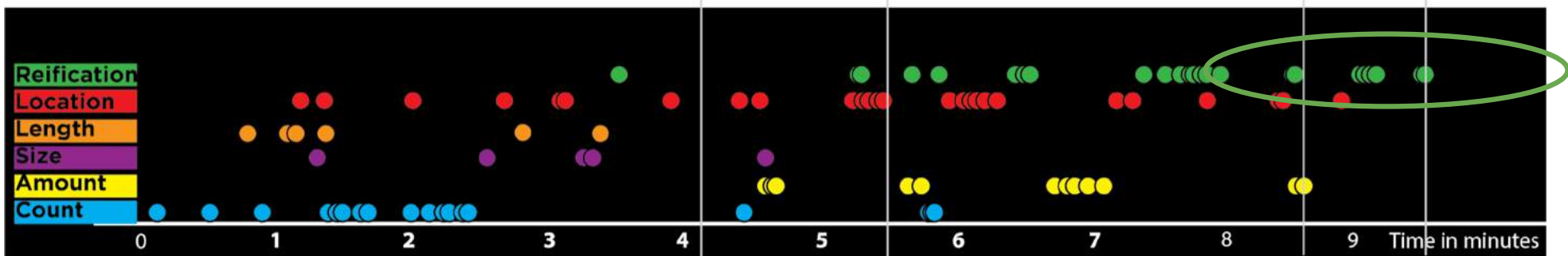


Occurrence of metaphors over time

We think this is a common and important marker of *good-enough common understanding* (or total bafflement).



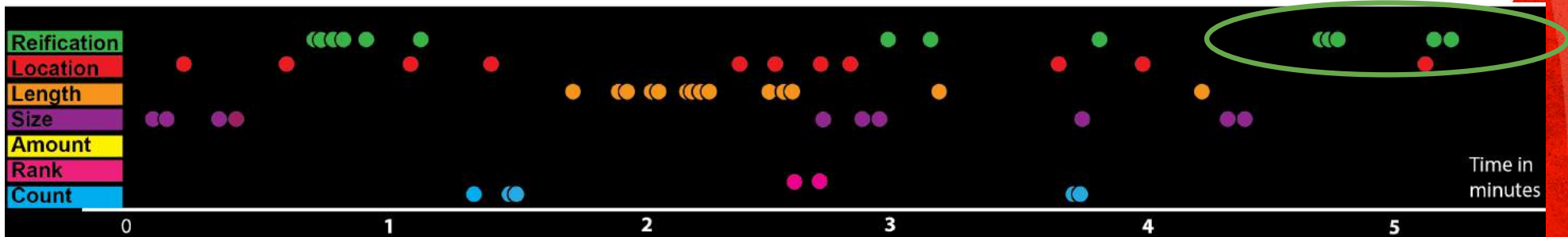
Appropriate instantiations for task were *location* and *length*.



Part 4

Some assertions & conjectures

- ▶ Coding is an offspring of mathematics; it *always already* involves powerful and sophisticated conceptual blends of concepts.
- ▶ The number line is perhaps the most powerful instantiation for number, and coding motion supports rapid familiarization, robust understanding, and flexible usage.
- ▶ Effective pedagogy is enabled by nuanced pre-understanding of which instantiations to invoke when.



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