

Building Thinking Classrooms in College Mathematics



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Thought Experiment

Imagine the most awesome, engaging math class that you can possibly dream up.

What does this class look, sound, feel, and smell like?

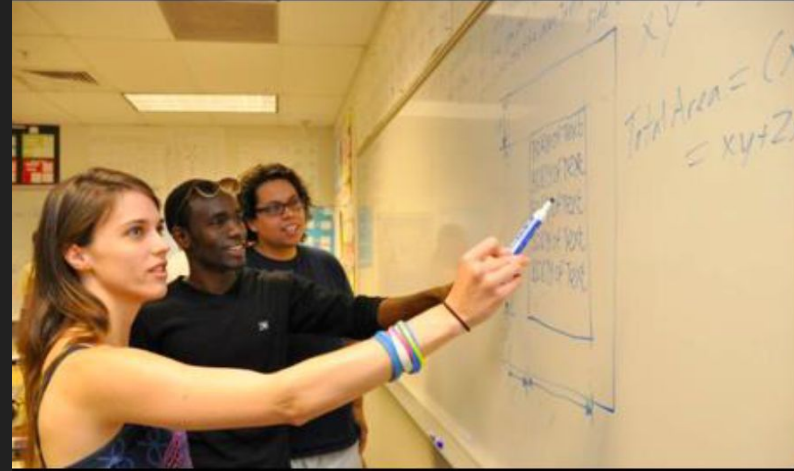






SEMINAL: Student Engagement in Mathematics through an Institutional Network for Active Learning
(collaborative project between San Diego State, University of Colorado-Boulder, and University of
Nebraska-Lincoln)

Active Learning Guiding Principles



Teaching methods and classroom norms that promote:

1. Students' deep engagement in mathematical thinking
2. Student-to-student interaction
3. Instructors' interest in and use of student thinking
4. Instructors' attention to equitable and inclusive practices

Instructor's Interest In and Use of Student Thinking

*“Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to **adjust instruction continually** in ways that support and extend learning” (NCTM, 2014, p.53).*

BUILDING THINKING CLASSROOMS

RESEARCH: @pglitjedahl
 SKETCHNOTE: @wheeler_laura

① Begin w/ a Problem

Give a problem-solving task

To start:
 Problems should be
 engaging
 non-curricular
 collaborative
 Promote talking

Later:
 Problems can be curricular
 eg textbook problems


② Visibly Random Groups

- Randomly assigned eg playing cards
- Daily & in front of students
- 2 or 3 students / group
- Sit & stand together



③ Vertical NonPermanent Surfaces


- Vertical
- Erasable



WHITEBOARD CHALKBOARD WINDOW

- 1 marker = chalk per group
- ↳ promotes discussion

④ Oral Instructions



give instructions orally

Project

- data
- long expressions
- diagrams


↳ groups will discuss (instead of decoding text)

⑤ Defront the room

Desks

- orient in various directions
- pull away from wall (room to stand @ VNPS)

Teacher addresses the class from a variety of locations.




⑥ Answering Questions

Acknowledge, but don't answer:

- Proximity questions (b/c teacher is close by)
- Stop thinking questions

Answer:
 Keep thinking questions
 ↳ give HINTS not answers



⑦ Meaningful Notes


Student created:

- select
- synthesize
- reorganize

↳ ideas

Based on their & others' boards

Provide time for this after levelling.



⑧ Build Autonomy

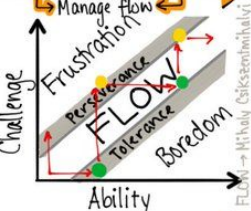
- Model how groups can visit other groups when they are stuck or done.
- Hints & extensions come from peers (not just the teacher).

↳ Helps manage flow



⑨ Hints & Extensions

Manage flow



Challenge

Ability

Flow → with any collaboration

⑩ Level to the Bottom

- debrief
- class discussion
- direct teaching the "lesson"

Once all groups pass a minimum threshold.

- Debrief 1 or more groups' solutions!
- Work through a new problem w/ whole group

⑪ Check Understanding

Assign 4-6 "check for understanding" questions

Students choose to work

- individually
- in groups

at desks or VNPS

Purpose: self-evaluation (NOT marks)

⑫ Formative Assessment

measure → communicate

where student is currently

where student is going

Multiple & varied opportunities to demonstrate learning

observation → product conversation

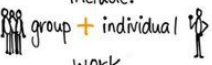
can't doesn't isn't dis... vs fully very completely always

⑬ Summative Assessment

PROCESS > product

Evaluate what you value!

Include:
 group + individual work



⑭ Reporting

Based on data (NOT points)

One aggregated mark


↳ disaggregated evidence

Analysis of data

Counting of points

What has this student learned? vs What can they improve?

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Sketchnote: @wheeler_laura

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equity

- MULTIPLE ENTRY POINTS
- CHALLENGE FOR ALL STUDENTS
- HIGH EXPECTATIONS FOR ALL STUDENTS TO THINK

This lock has a **3 digit code**
 Can you crack it
 using **only these hints?**



CODE

2	9	1
2	4	5
4	6	3
5	7	8
5	6	9

One number is correct and in the right place

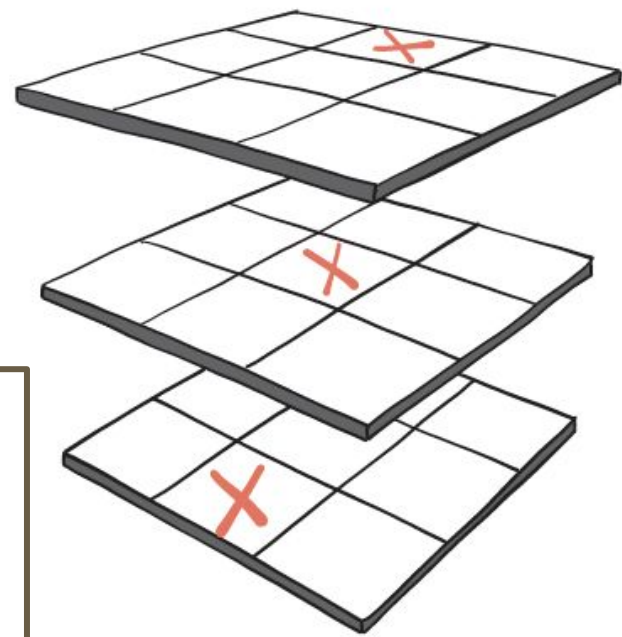
One number is correct but in the wrong place

Two numbers are correct but in the wrong place

Nothing is correct

One number is correct but in the wrong place

tic ♥ tac ♥ toe



Stride Length and Stride Rate

Sam is running along a road at a constant speed. Sam's running speed is determined by two factors: stride length and stride rate. Suppose Sam has a stride length of 3 feet per stride and a stride rate of 2 strides per second. Describe the change in running speed if both stride rate and stride length change simultaneously.



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Change stride **rate**, then analyze how speed changes.

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Product Rule for Derivatives!

Breakout Groups!



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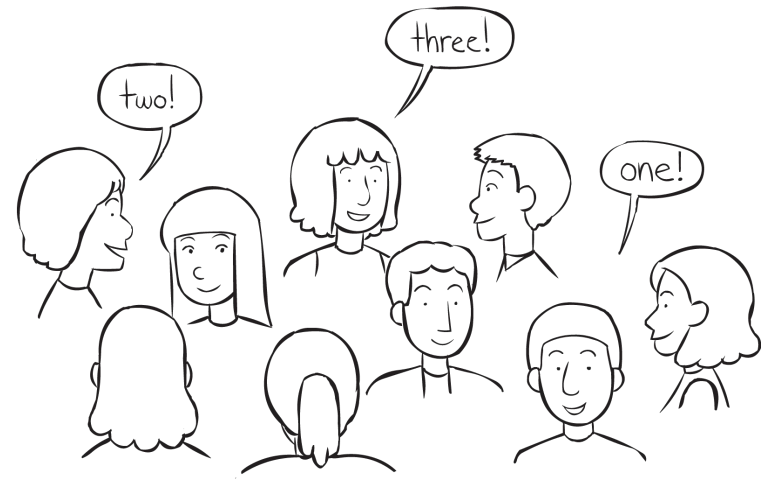
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equity 

- MULTIPLE ENTRY POINTS
- CHALLENGE FOR ALL STUDENTS
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equity 

- ELIMINATION OF SOCIAL BARRIERS
- WILLINGNESS TO COLLABORATE
- MORE STUDENTS DO MORE THINKING
- KNOWLEDGE COMES FROM GROUPS
- PUTS STUDENTS' UNBELIEVABLE CAPACITY FOR EMPATHY IN MOTION



flippity MAT 220 Calc 1 Spring 2024

Spinner Single Name Lineup Groups of 2 Groups of 3 Groups of 4 Groups of 5 2 Teams 3 Teams 4 Teams 5 Teams Chart More...

↔ ↺ 🗑️ 🖨️ 📏 ⌚ ⓘ 📄

1 Brenden Joe	2 Jaxon Ethan	3 Brenda Emma	4 Lianna Jaelyn	5 Ash Charlie	6 Waseem Isaac
7 Diego Connor	8 Jeff Martin	9 Grant Liberty	10 Collin Dev		



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WHITEBOARD



CHALKBOARD



WINDOW

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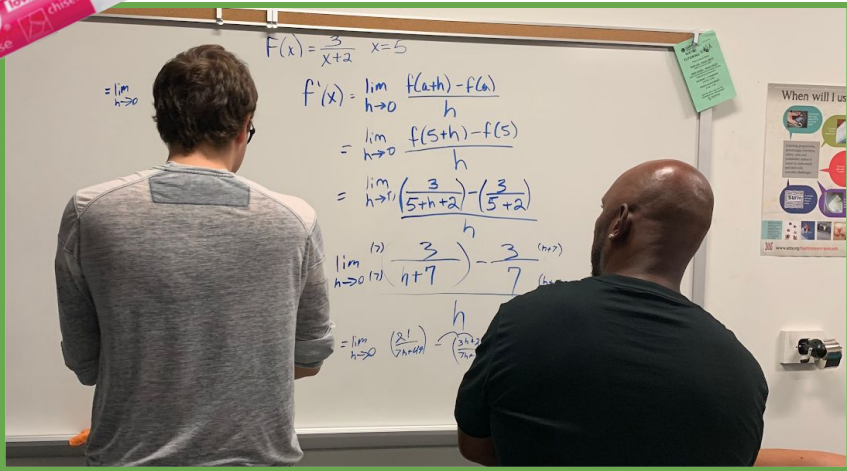
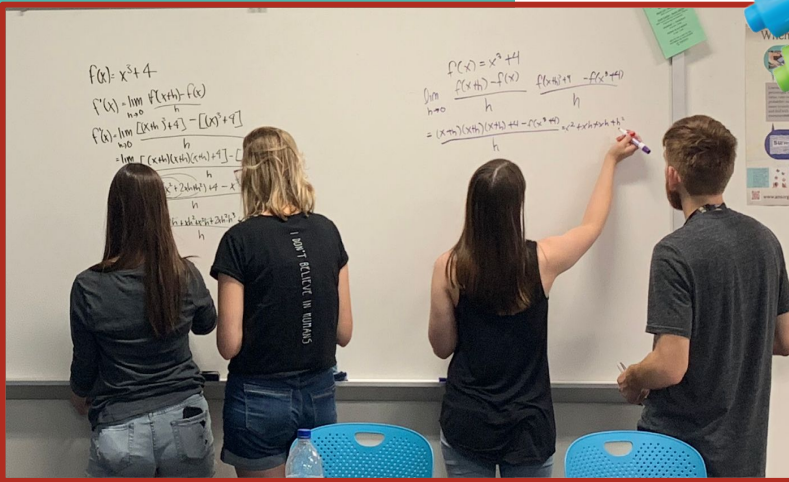
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- INCREASED RELIANCE ON EACH OTHER INSTEAD OF TEACHER
- STUDENTS DO NOT FEEL ANONYMOUS WHEN STANDING
- OPPORTUNITIES FOR REAL-TIME DIFFERENTIATION
- NEW COMPETENCIES EMERGE
- SKILLS DEVELOPED: PATIENCE, COMMUNICATION, PERSEVERANCE



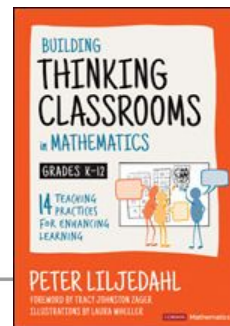


Table 1 Average times and scores on the eight measures

	Vertical whiteboard	Horizontal whiteboard	Vertical paper	Horizontal paper	Notebook
<i>N</i> (groups)	10	10	9	9	8
1. Time to task					
2. Time to first notation					
3. Eagerness					
4. Discussion					
5. Participation					
6. Persistence					
7. Non-linearity					
8. Mobility					

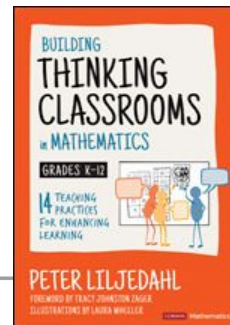


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<i>N</i> (groups)	10	10	9	9	8
1. Time to task	12.8 s	13.2 s	12.1 s	14.1 s	13.0 s
2. Time to first notation	20.3 s	23.5 s	2.4 min	2.1 min	18.2 s
3. Eagerness	3.0	2.3	1.2	1.0	0.9
4. Discussion	2.8	2.2	1.5	1.1	0.6
5. Participation	2.8	2.1	1.8	1.6	0.9
6. Persistence	2.6	2.6	1.8	1.9	1.9
7. Non-linearity	2.7	2.9	1.0	1.1	0.8
8. Mobility	2.5	1.2	2.0	1.3	1.2

Toolkit #1



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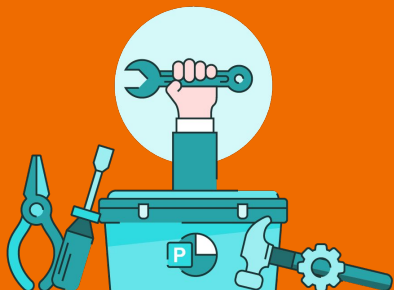
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 CHALKBOARD

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Chat about Toolkit #2



④ Oral Instructions

give instructions orally

Project

data
long expression
diagrams

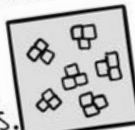
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is this right?

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ideas

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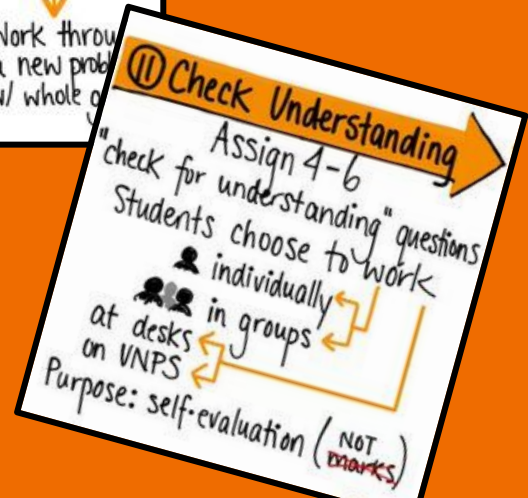
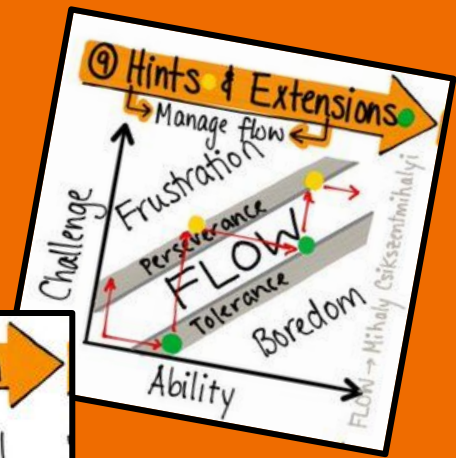
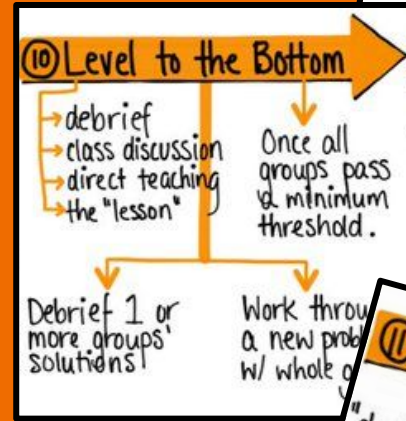
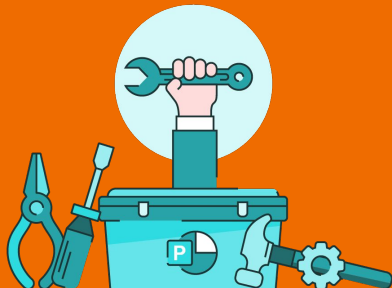
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Chat about Toolkit #3





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Thank You!

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