Fostering Critical Thinking Through Online Collaboration: Building on Past Success and Facing Future Challenges

Sharon Derry
Learning Sciences & Psychological Studies
School of Education

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Research Context: Human Abilities and Learning (HAL) Online

- UG/Grad online course in critical thinking
- Discussion board, blogs, other online tools
- Pedagogy: Small group collaborative tasks
- Evolved over 20+ successful semesters

Objectives of Talk

I. HAL Online Design
II. Evidence of Success
III. Evolution of Design Principles Through Research
IV. Challenges of Scaling Up


I. HAL Online Design

Broad Course Objectives

- Become scientifically literate about human learning
- Acquire *useful* learning-science concepts for
  - guiding learners
  - designing learning environments
  - supporting personal development

  in rapidly changing high-tech world.
- Improve as teachers, parents, mentors, supervisors

Unit I - Understanding Critical Thinking
(Spring 2017 Topics)

1. Memory and Critical thinking
2. Thought & Language
3. Adventures in Argument
4. Statistical Reasoning
5. Problem Solving
6. Teaching for Thinking (Constructivist Approach)

Unit II - Neuroscience Facts and Myths
(Spring 2017 Topics)

1. Neuroscience Basics
2. Brain Development in Language & Math
3. Meditation, Brain Science & Education
4. Expertise and Lifelong Learning
5. Learning Styles and Digital Natives

Online Instructional Strategies

- Interesting readings & multi-media provide conceptual content.
- Challenging small-group collaborative tasks on current issues require using conceptual content.
- Each student's contributions to collaborative work evaluated.
- Students reflect (blog) about their learning.
- Student choices personalize learning.
- Exams require demonstrating mastery of course material through use in problem solving.

Example Small Group Experiences

- Study neuroscience research on meditation then serve on scientific advisory board for middle school. Board debates merits of a proposed meditation-training program and writes a consensus recommendation.

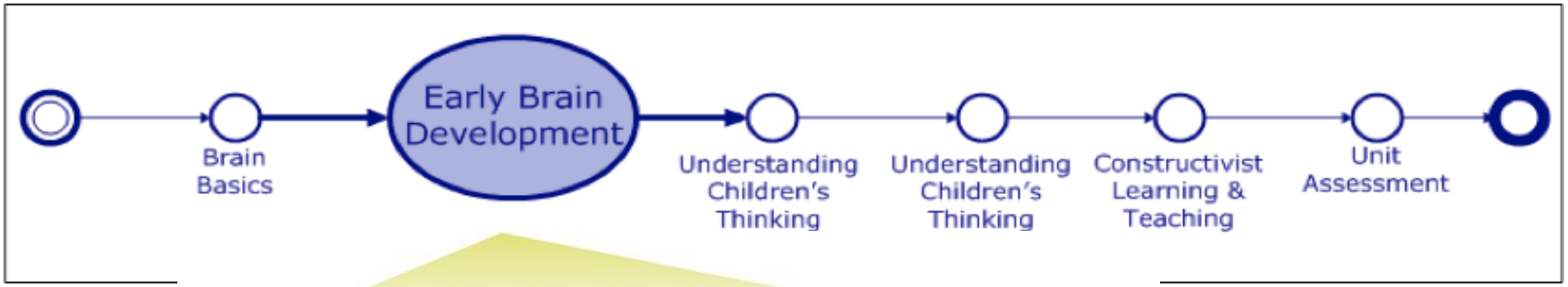
- To evaluate claims about pedagogy and learning made in two famous scientific articles, groups examine evidence from Videomosaic, an online video repository that documents children's mathematical development

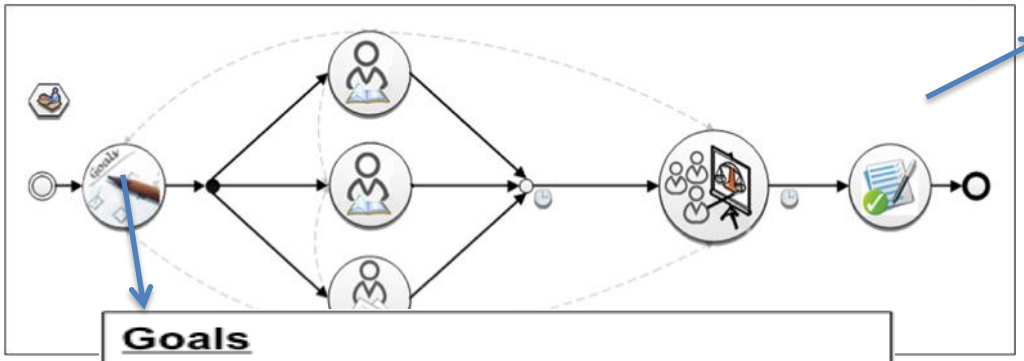
II. Evidence of Success!

Comparison Studies with Pre-Service Teachers

- **STELLAR Research Program (with Hmelo-Silver)**
  - Quasi-experimental study at Rutgers: Students in courses like HAL Online substantially out-performed those in traditional courses teaching same concepts (Derry et al, 2006)
- **Eagan Master's Study**
  - Matched comparison study at UW-Madison: HAL Online students substantially out-performed students in traditional classes (Eagan, 2010)
- **Both studies:**
  - Non-trivial assessments required using science of learning ideas to analyze student thinking, make pedagogical responses.

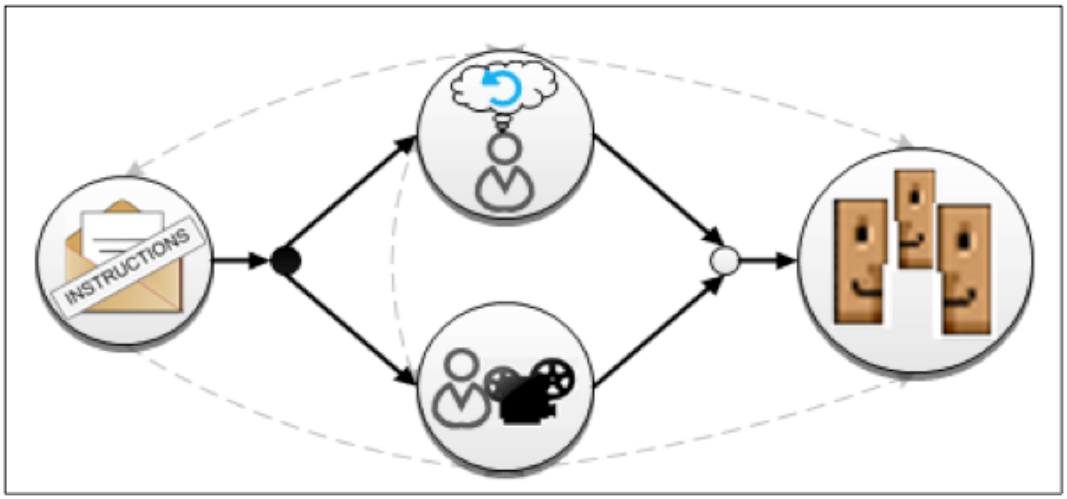
Eagan Study:
Unit I: The Amazing Learning Brain & Children's Thinking





Goals

1. Appreciate new possibilities and limits of brain research for understanding children's thinking.
2. Draw on brain research to support thinking while avoiding misconceptions.
3. Encourage deeper thinking about interconnectedness of language and mathematics in development.



Question

Does the video help you see how the development of language and mathematical thinking are intimately intertwined? Can you see the connections between development of mathematical reasoning and argumentation? Explain what you notice.

Is 1/2 bigger than 1/3?

Research Questions

- **Did HAL unit improve pre-service teachers' ability to**
  - use learning science ideas to analyze the learners' reasoning and make pedagogical responses?
  - take a learner's perspective, empathize with struggle to understand?

- **Informing theories:**
  - Expert blind spot (Nathan & Petrosino, 2003)
  - Pedagogical content knowledge (PCK; Schulman, 1980)
  - Adaptive expertise (Bransford, Brown & Cocking, 2000)

The VAPR-C Assessment

Prompt:

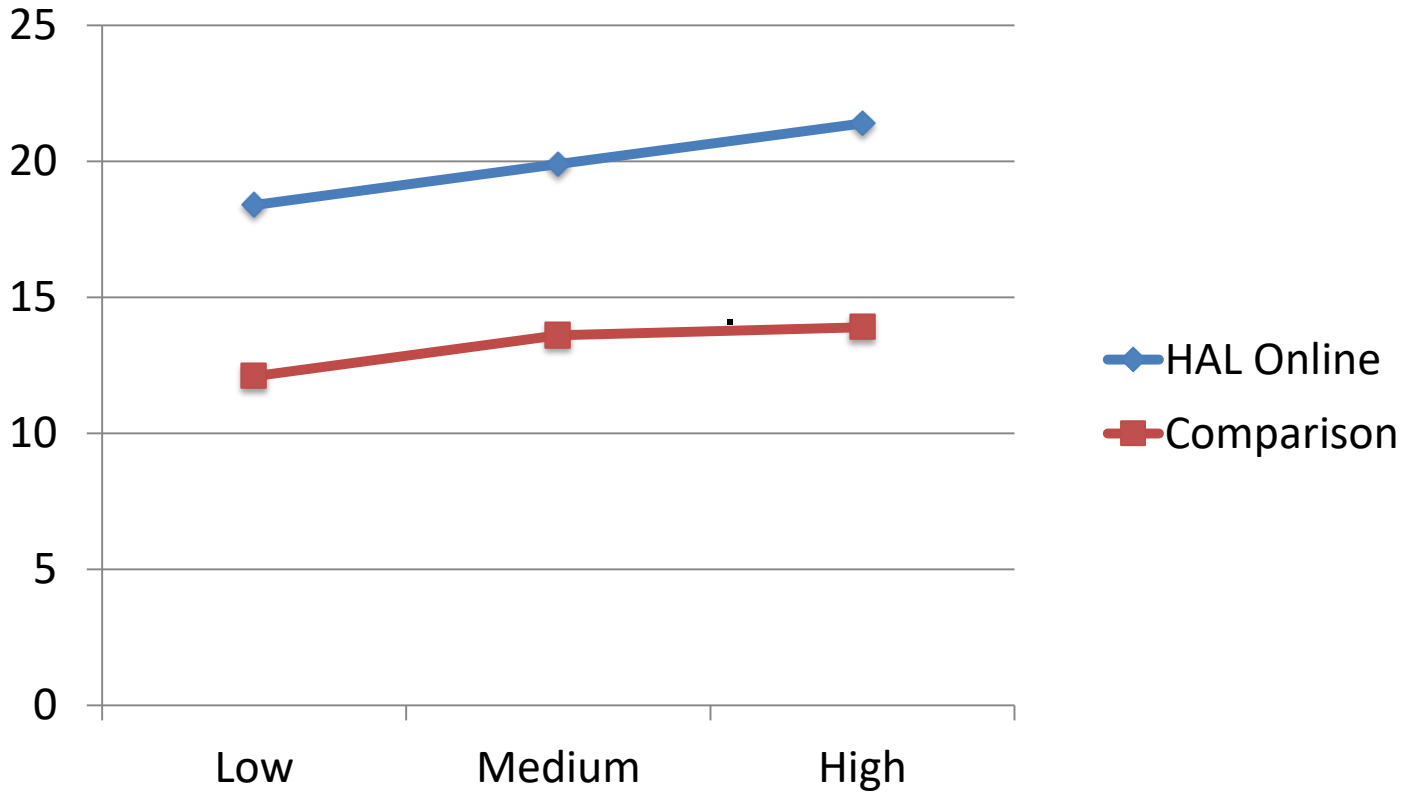
Study the video in which Brandon has solved and drawn connections between two different problems, then answer the following:

1. In this video Brandon solves two problems: One asking how many unique towers four blocks tall can be created selecting from red and yellow blocks; and one asking how many unique pizzas can be created selecting from four toppings. Does Brandon solve both problems correctly? Explain in some detail how you know.

2. Analyze Brandon's performance using the following ideas: strategy, representation, analogical reasoning, insight, deduction, and induction.

3. Explain exactly how Brandon analogically mapped the four toppings pizza problem to the two-color/four-tall towers problem.

Unit Effectiveness for Different Levels of Math Comfort



Comparison Math Ed Major: Expert Blind Spot

Yes, Brandon solves both problems correctly. If you solve this problem combinatorically, you would recognize that for each topping you have two choices of whether the topping is included or not. Thus for each topping you have 2 possible outcomes, a pizza with that topping or a pizza without that topping. Since each topping choice is independent of the previous topping choice . . . you simply take 2^4 because there are two choices for each of the 4 toppings (2)(2)(2)(2)=16.

Elem Ed Major from HAL: No EBS

Brandon solves both problems correctly. He uses a very logical system to ensure that he has done so, and . . . is able to make the connection in how similar his methods for each problem really are. Brandon makes sure to include all the possible combinations by starting with those that involve no toppings (later no yellow blocks in one possible position), then all possible combinations with only one of four toppings (later one yellow block with four possible positions), then all possible combinations with exactly two toppings (later two yellow blocks in six possible positions), then all possible combinations with exactly three toppings (later three yellow blocks in four possible positions), and finally with all four toppings (later four yellow blocks in one possible position). By breaking the problem down into these groups, Brandon has found all the combinations . . .

Findings from Comparison Studies: It Works!

- HAL Online students:
  - demonstrated high-level capacity to think critically with learning-science concepts in practice.
  - demonstrated more sophisticated, flexible use of course content than students taught in traditional high-rated courses covering same content.
- Findings based on complex authentic assessment tasks.

III. HAL Design Principles: Evolution Through Research

Gressick & Derry (2010; 2012; 2013)

Study 1: Online Leadership

- Can groups manage themselves or must course/instructor provide scaffolding?
  - Do leaders emerge?
  - Is leadership shared?
- What type of scaffolding and how much?
  - What forms of leadership are needed?
  - Does group success depend on leadership patterns?

Leadership Study (cont'd)

- Subjects: 5 online interdisciplinary small groups (n=5) of pre-service math & science teachers.
- Collaborative capstone task: Design and justify interdisciplinary instructional unit.
- Distributed leadership theory (Spillane, 2007)

*Coding of Leadership Moves
Acknowledgement/Affective (A/A)
Argument Development (AD)
Seeking Input (SI)
Knowledge Contribution (KC)
Organizational Moves (OM)
Topic Control (TC)

Coding framework adapted from Li, et. al (2007)

Leadership was distributed

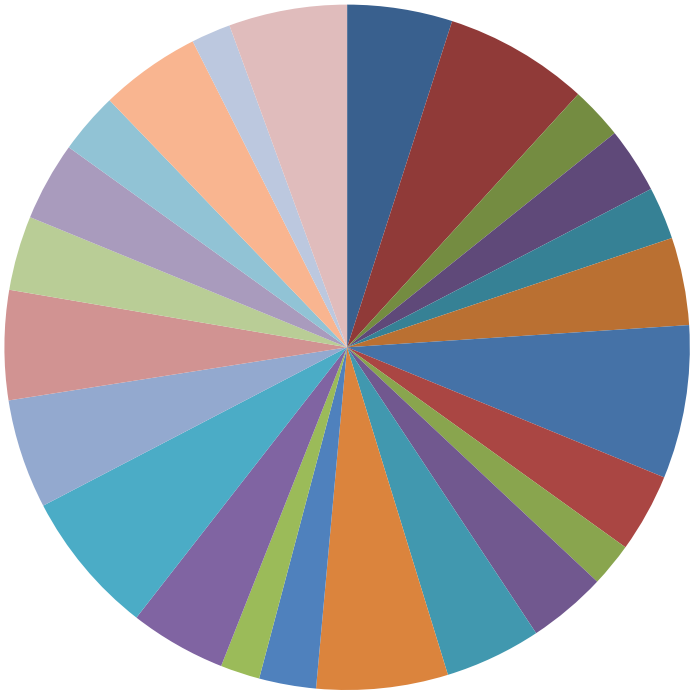
Group 1 (highest performing)							
Group member		Leadership Contribution Codes					
		A/A	AD	SI	KC	OM	TC
	A*	.28	.20	.72	.24	.66	.17
	M	--	.27	--	.33	--	.17
	B	.39	--	--	.12	.14	--
	S	.06	.20	--	.15	.03	.17
	E*	--	--	.27	.12	.14	--
	Instr.	.28	.33	--	.03	.03	.50
Total Group Moves		**18**	**15**	**15**	**33**	**29**	**6**

Group 5 (lowest performing)							
Group member		Leadership Contribution Codes					
		A/A	AD	SI	KC	OM	TC
	K*	--	.06	--	.18	--	--
	A*	--	.06	.75	.14	.12	--
	J*	.22	.29	--	.23	.35	.11
	AH	.11	.06	--	.09	.06	--
	C*	.11	.12	.25	.27	.12	.11
	Instr.	.56	.41	--	.09	.35	.78
Total Group Moves		**9**	**17**	**4**	**22**	**17**	**9**

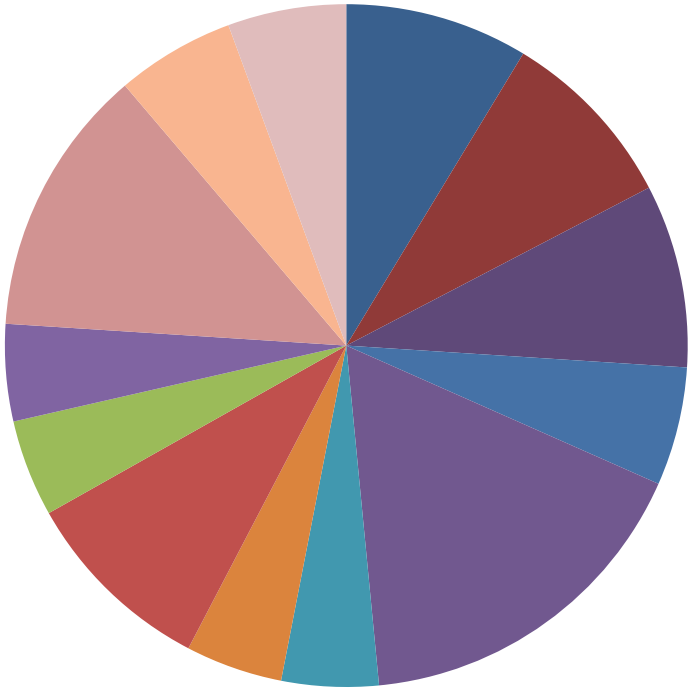
*Indicates Female Student

All forms are shared, but some more than others.

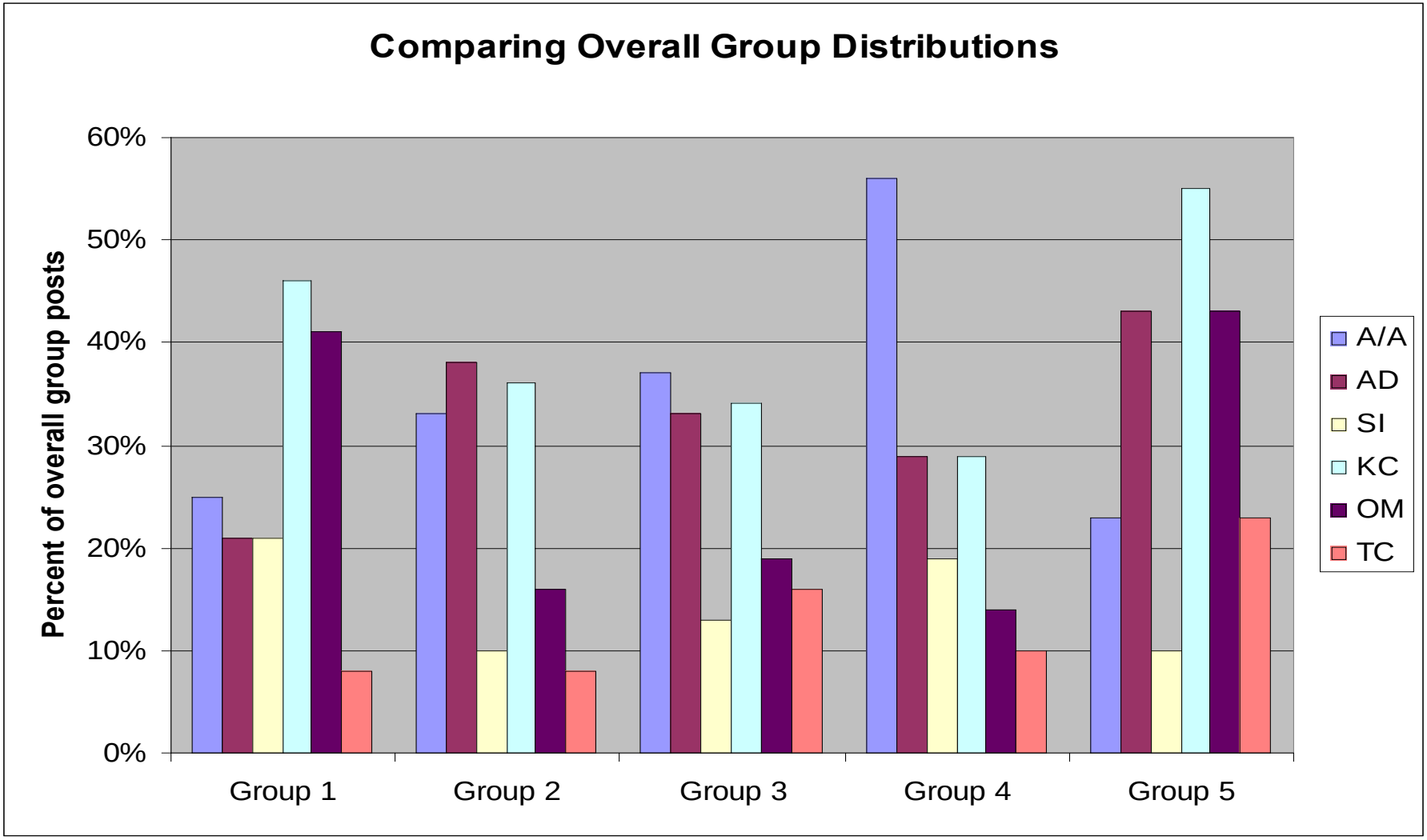
Knowledge Contribution



Topic Control



Patterns Did Not Predict Success



Personal Advocacy Promotes Online Leadership

Topic Control & Argument Development Examples

M in Group 1
Advocates for Math

I also think that we should teach topics like orbit and other properties of the earth and sun . . . We can then combine some more math activities in. Here is a standard that might help…
I do agree with B– we have too many goals . . . But I feel the math goals are very important and should be included . . .

JB in Group 2
Advocates for Diversity

My only comment is regarding what we have seen in the class of teaching to diverse learners. We want to tap on students' prior knowledge and connect the assignment with their life, is it good to assume all of our students take spring-break vacations? How could we expand the assessment to include a larger diversity of students?

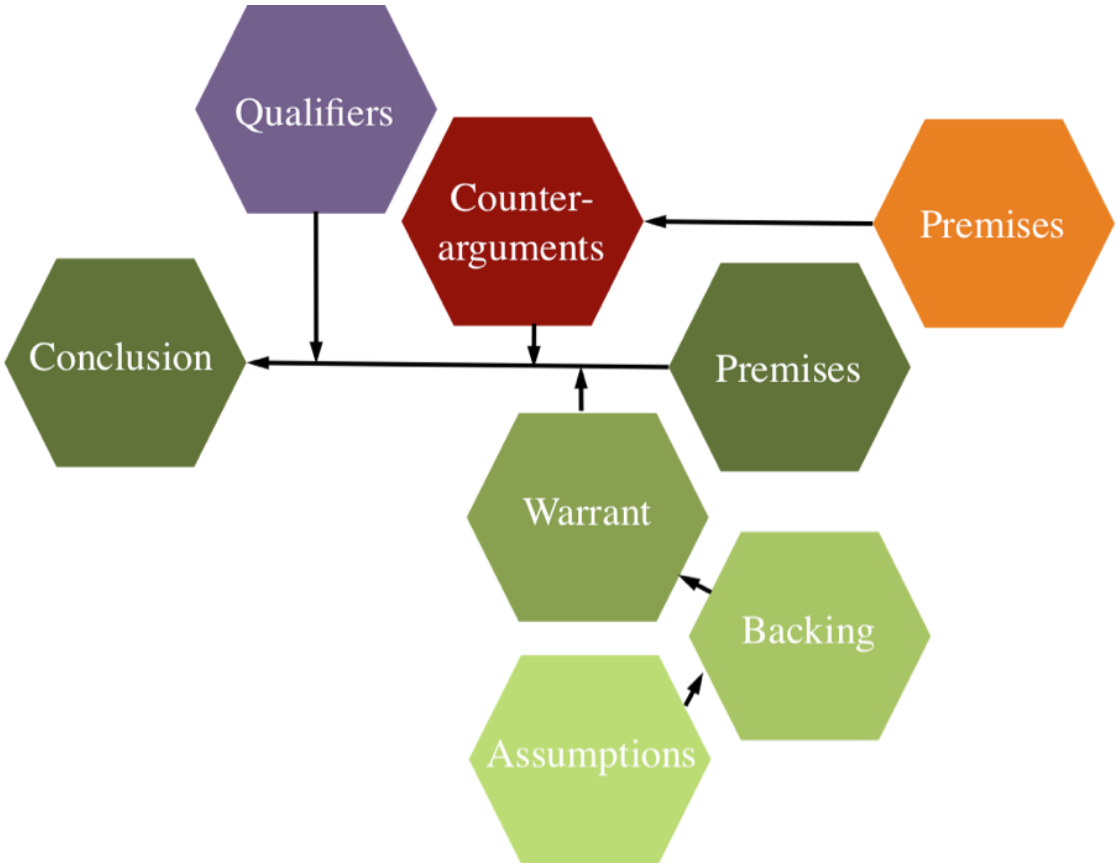
Leadership Study Key Findings

- Leadership was highly distributed.
- All leadership forms emerged and were shared, some more than others.
- Individuals specialized in specific types of leadership.
- Patterns of leadership distribution did not predict group success.
- Leadership related to personal advocacy.

Leadership Study: Implications

- Theoretical construct of distributed small-group cognition (Stahl, 2006) is supported.
- Key design principle: Encouraging distributed leadership to emerge is good alternative to scripting collaboration.

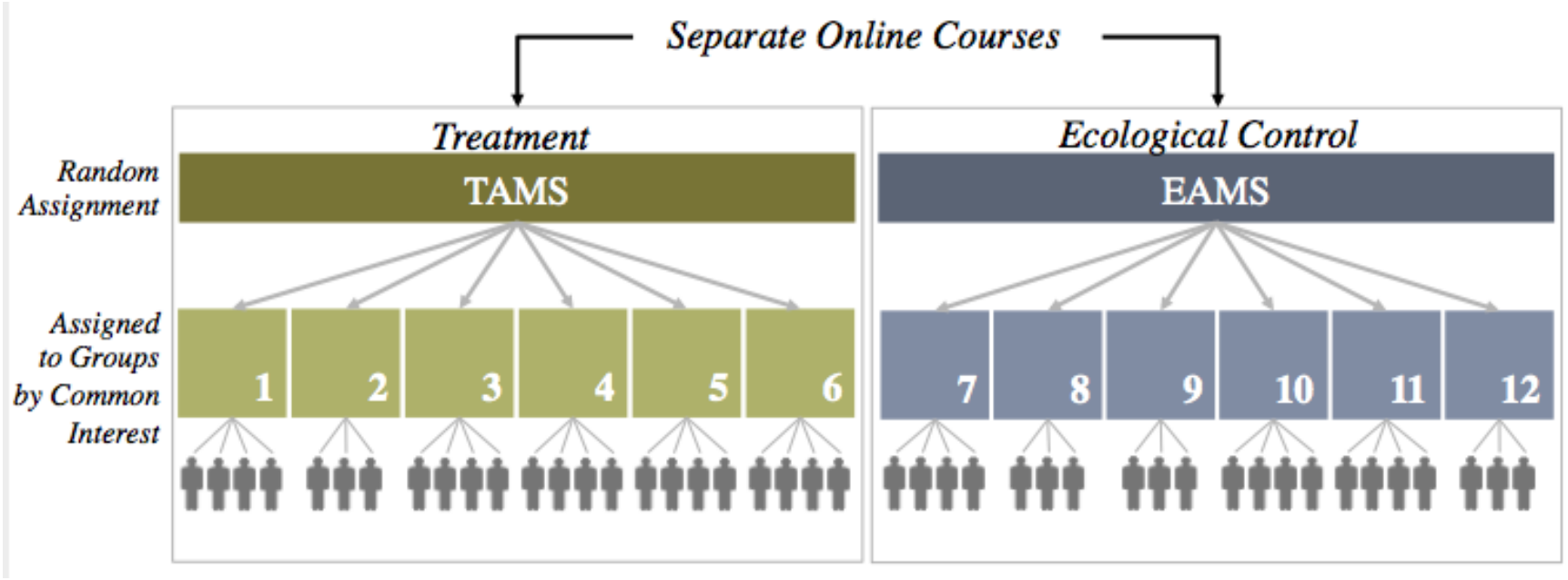
Study II: Can Argumentation Training → Better Online Collaborative Learning?



Toulmin Argument Pattern (Halpern, 2014)

In Vivo Experiment

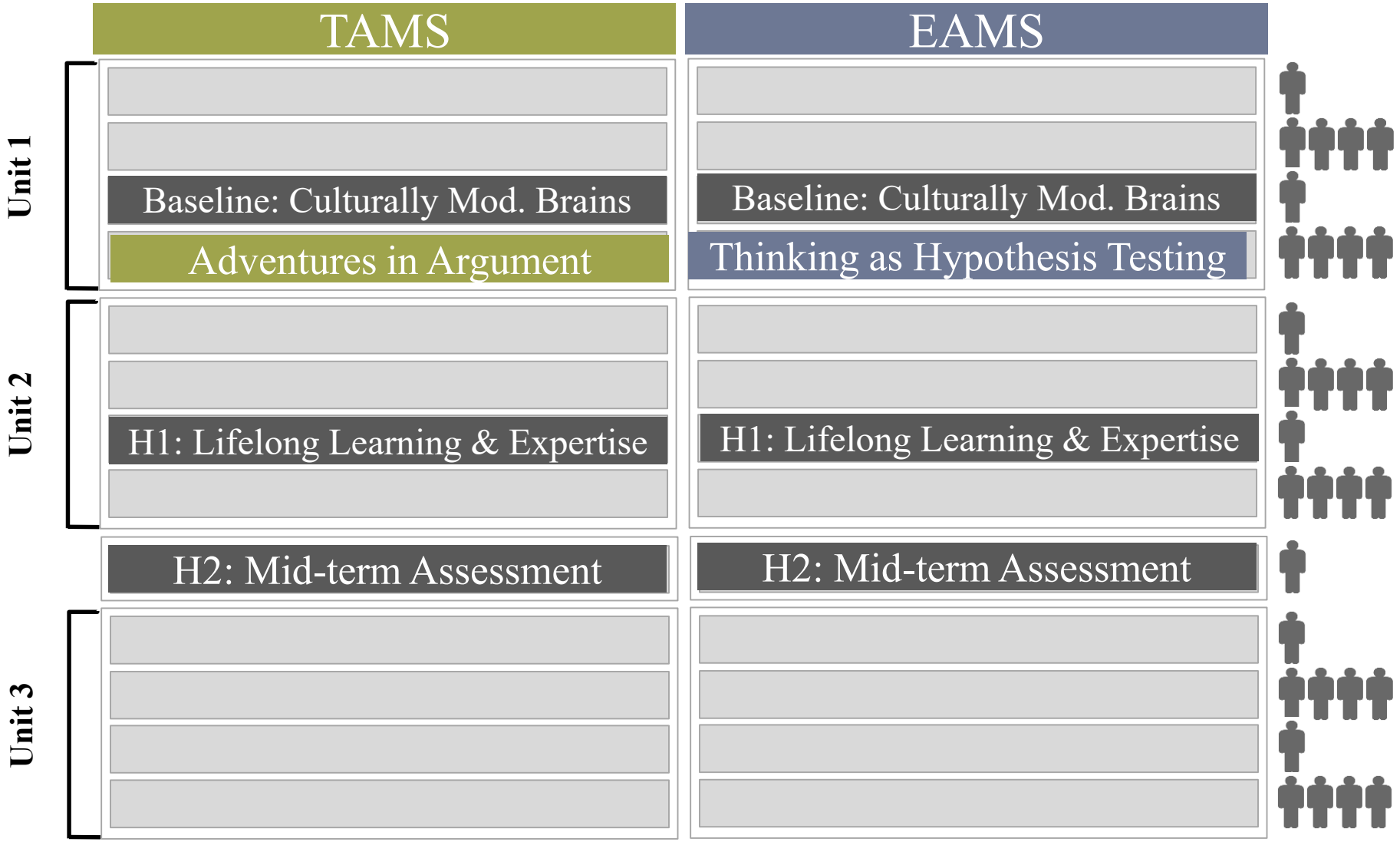
$n = 44$



Study II Hypotheses:

- **For individuals:**
  - H1: AT → Better comprehension of course materials
  - H2: AT → Better performance on test of scientific literacy
- **For groups:**
  - H3: AT → Better use of course material in collaborative learning.
  - H4: AT → Improved collaborative process.
- **AT Effects will last for duration of course.**

Analysis of Individual Learning



Analyses of Individual Learning

- H1: Student blogs scored for comprehension
  - Created semantic webs to represent student blogs
  - Scored webs for # of concepts and connection rate
- H2: Midterm exam scored for scientific literacy
  - Rubric scored by experts

Results

TAMS groups wrote better blogs

✗ *No significant difference in basic number of the course concepts discussed.*

✓ *TAMS students made more coherent, connected arguments*

	TAMS	EAMS
# of concepts used		
Mean Score	4.062	3.667
Std. Error	.220	.229
*Connection rate**		
Mean Score	.862	.701
Std. Error	.062	.064

*$p = .04$ *covariate: baseline*

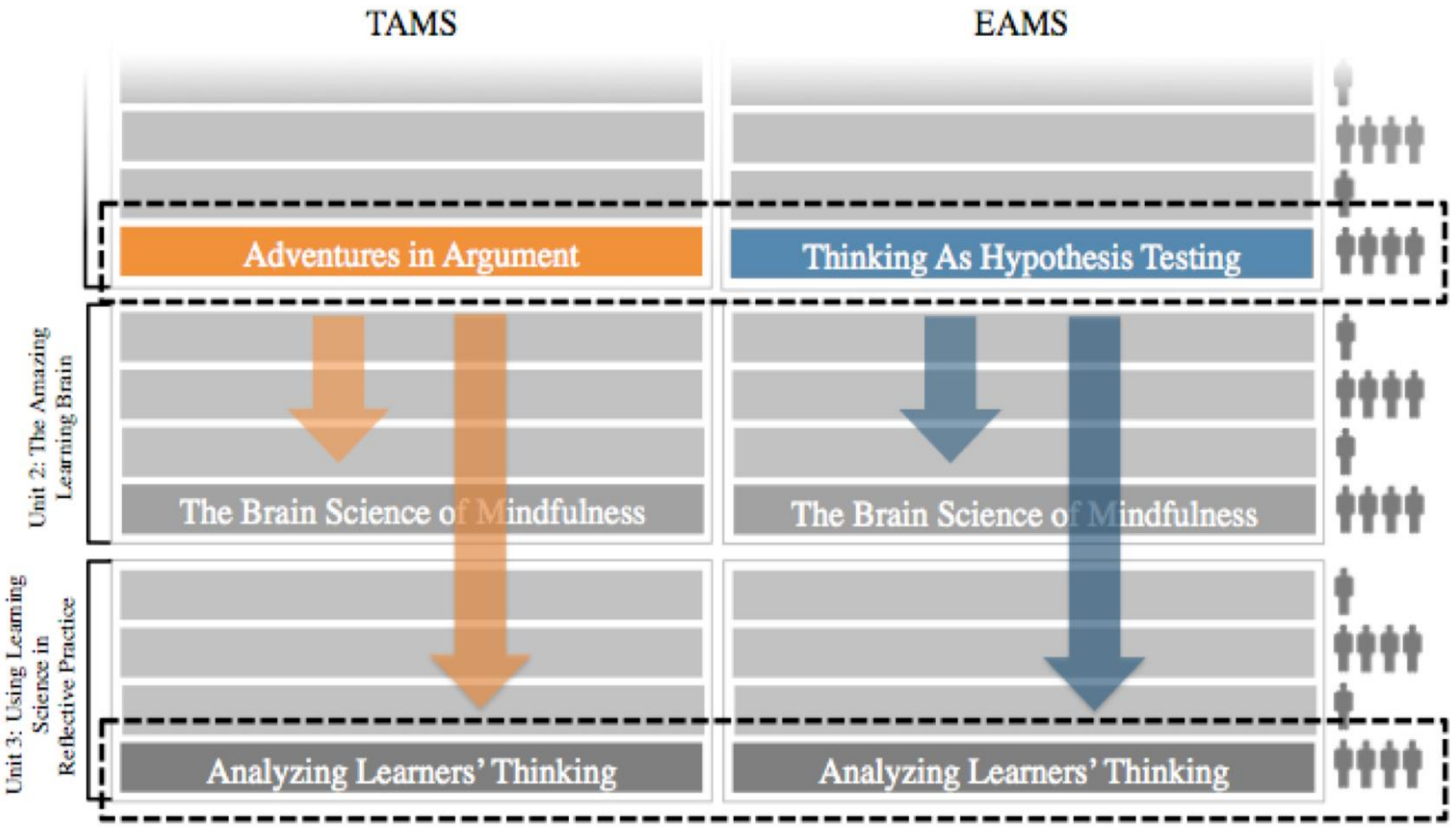
Results

✔ *TAMS scored significantly higher than EAMS (p = .002) on scientific literacy*

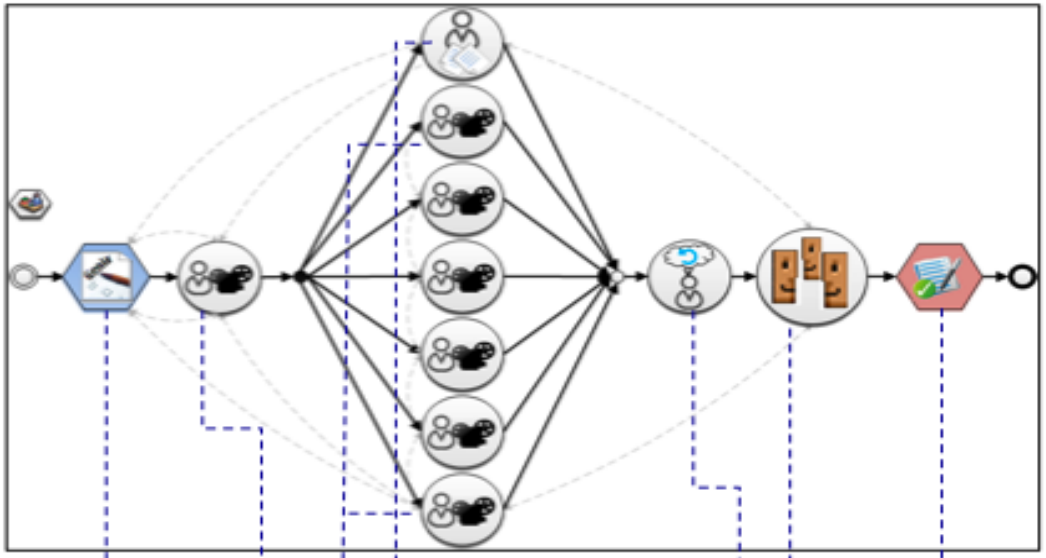
	TAMS	EAMS
Mean Score	9.898	7.111
Std. Error	.531	.556

covariate: baseline

AT Effects on Group Collaborative Process



Lesson on Analyzing Learners' Thinking



Goals
1. To be able to examine students' problem solving over time in depth to identify evidence for transfer conceptualized as preparation for future learning.
2. To appreciate and understand how a teachers' expertise in pedagogical content knowledge related to subject matter (combinatorics mathematics in this example) affects ability to mentor and guide students in accordance with a constructivist philosophy and approach.

Problem and Video Clip Description

Past Assigned Readings:
Rethinking Transfer (Bransford & Schwartz)
Should Schools Adopt a Constructivist Approach to Education? (Windschitl & Hirsch)

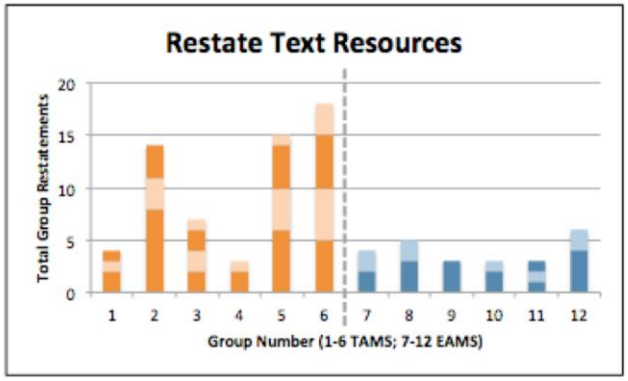
Video Series
Students Solving the "Pizza Problem"
(Stephanie, Grade 11)

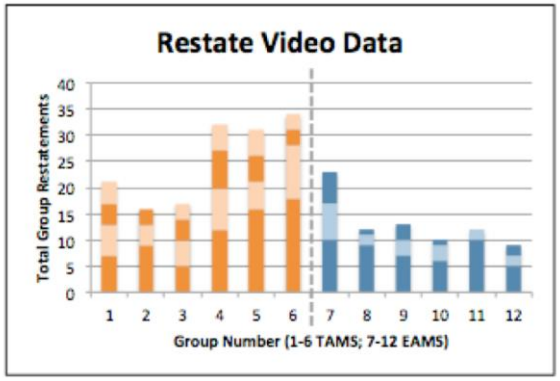
Lesson Assessments
1. Formative assessment is provided to small groups in posts the instructor makes to forum discussions .

2. Summative assessment of forum discussions is provided for individuals using a scoring rubric.

Video
"Gang of Four"
(Stephanie, Grade 4)

Discussion Activity Question
What evidence do you find that early educational experiences have prepared the students in these video clips for future learning? How confident are you regarding claims that these students' earlier educational experiences have had an impact? What convinces you or would convince you?


Restate Text Resources
Total Group Restatements
0
5
10
15
20
1 2 3 4 5 6 7 8 9 10 11 12
Group Number (1-6 TAMS; 7-12 EAMS)


Restate Video Data
Total Group Restatements
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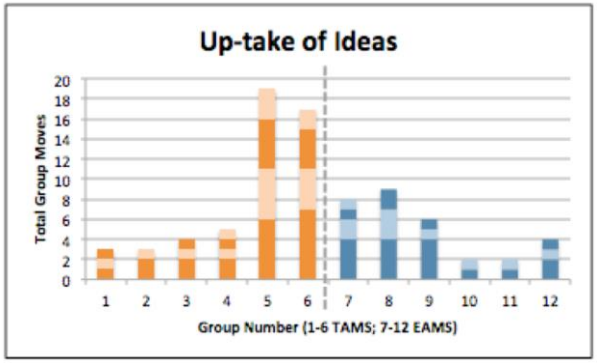
1 2 3 4 5 6 7 8 9 10 11 12
Group Number (1-6 TAMS; 7-12 EAMS)


Up-take of Ideas
Total Group Moves
0
2
4
6
8
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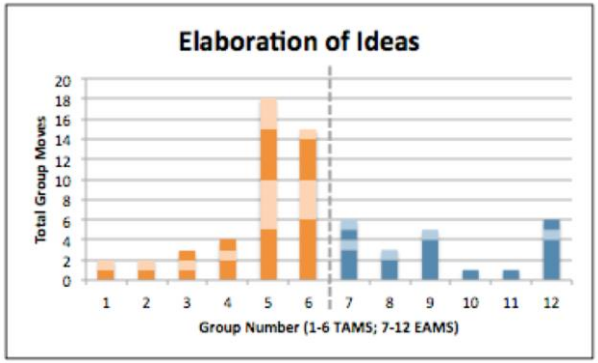
18
20
1 2 3 4 5 6 7 8 9 10 11 12
Group Number (1-6 TAMS; 7-12 EAMS)


Elaboration of Ideas
Total Group Moves
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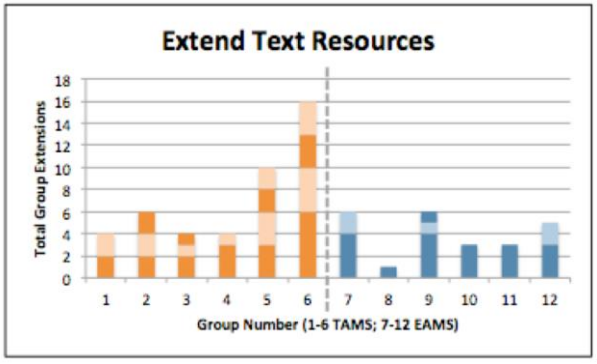
Group Number (1-6 TAMS; 7-12 EAMS)


Extend Text Resources
Total Group Extensions
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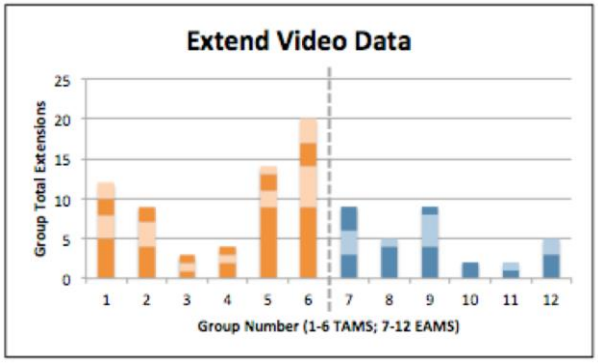
Group Number (1-6 TAMS; 7-12 EAMS)


Extend Video Data
Group Total Extensions
0
5
10
15
20
25
1 2 3 4 5 6 7 8 9 10 11 12
Group Number (1-6 TAMS; 7-12 EAMS)

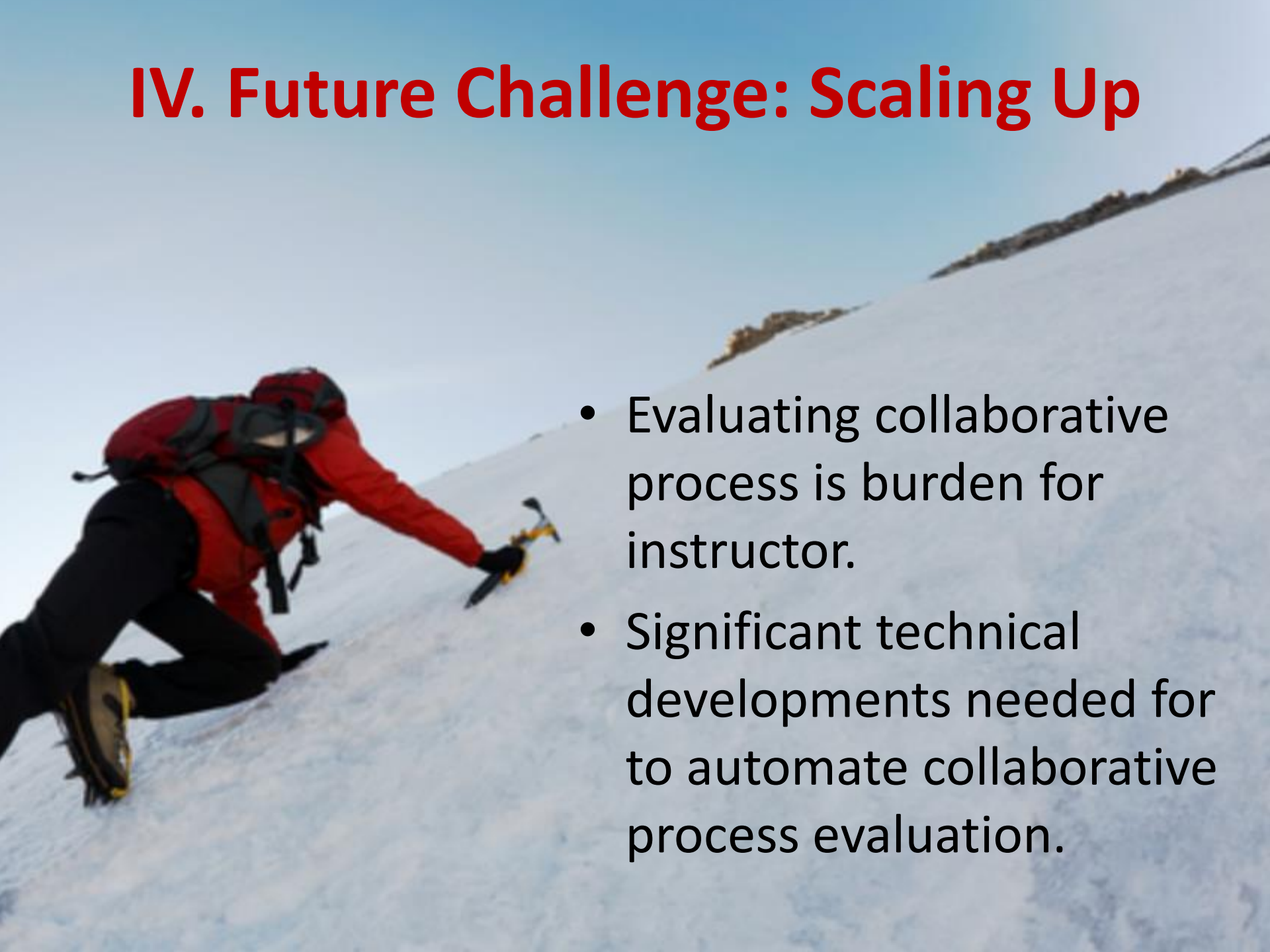
Argument Training

- Individual:
  - ✓Better on scientific literacy test
  - ✓Better comprehension of course material
- Group:
  - ✓*Better uses of course materials during collaboration*
  - ✓*Stronger focus on important evidence items from video*
  - ✓*Better collaborative process*
  - ✓*Effects endured*

Design Principles from Research

- Direct training in argument can improve collaborative learning and group processes online for mature students.
- Prompting emergent leadership through expectations and assessment provides an alternative to scripting
- Assessing argument and leadership process maybe more important than evaluation of final student products:
  - Learning occurs even when projects fail, are not completed or left unpolished.
  - *Group process is the engine that drives deeper learning!*

IV. Future Challenge: Scaling Up



- Evaluating collaborative process is burden for instructor.
- Significant technical developments needed for to automate collaborative process evaluation.

Rubric for Evaluating Individual Contributions to Collaborative Process

1. Do you make a sufficient number of contributions?
2. Do you engage in discourse throughout the discussion period (versus post at the last minute)?
3. Do you “listen” carefully and try to understand and learn from others?
4. Are you engaged, enthusiastic, interested?
5. Are you a good group citizen who takes on leadership by starting discussions, serving as chair or summarizer, helping keep the group on task?

6. Do you connect discussion tasks to assigned material, providing evidence you have studied it?
7. Do you build on others' ideas and remain open to changing your mind if presented with reasons?
8. Do you hold yourself and others accountable for making credible arguments?
9. Do you justify arguments with evidence and reference to credible sources?
10. Are your contributions thoughtful, intelligent, mature, rather than personal opinion?

Envisioned Technical Approaches:

- Unintelligent algorithms:
  - "Bag of words," LSA or basic techniques evaluate which individuals and groups incorporate key concepts or signal words (Rubric item 6, parts of 7, 8 & 10)
- Advanced AI algorithms:
  - Evaluate structure of discourse to determines which individuals and groups use course concepts in *positions* as evidence (Rubric item 9)
- Alternative data streams (facial expressions, eye tracking, etc.)
  - Additional evidence to strengthen inferences

Fostering Critical Thinking Through Online Collaboration

- HAL Online design principles suggest a potentially powerful approach.
- How Implement on a large scale?
  - Two-part solution:
    - *Argument Training* is scalable
    - *Process Assessment* is challenging and resource intensive and will require research into computational solutions.