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Using Interactive Engagement Strategies to Enhance Learning in College Science Courses

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Abstract for DBER Group Discussion on 2016-04-07

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Title

Using Interactive Engagement Strategies to Enhance Learning in College Science Courses

Abstract

The number of decreasing science majors in U.S. institutions of higher education is connected to the quality of science instruction (Seymour, 1994; Daempfle, 2003) and resulted in nation-wide efforts to improve the quality of college-level science education (National Committee on Science Education Standards and Assessment et al., 1996; NGSS Lead States, 2013). This talk presents historical trends in the adoption of interactive engagement (IE) strategies in college-level science courses and presents one such IE strategy, lecture tutorials (LTs), in the context of sedimentology and stratigraphy.

To determine historical trends in the adoption of IE strategies, peer-reviewed journal articles accessible via the Education Resources Information Center (ERIC) reviewed for the period of 1994-2014. The review reveals growth in IE strategy adoption, especially in the field of Biology. Five distinct types of IE strategies emerged from the literature review: polling, whole-class discussion and activities, in-class group work, out-of-class group work, and online activities. One form of in-class group work includes LTs, which are designed to improve students' conceptual understanding. To identify weaknesses in students' conceptual understanding of sedimentology and stratigraphy, geoscience instructors at institutions of higher education across the U.S. were surveyed. Four LTs were designed to address the identified weaknesses and tested using a quasi-experimental design, which compared the learning gains of a control group (lecture-only) with a treatment group (lecture-and-LT). Three of the four LTs produced significant learning gains above the lecture-only scenarios.

IE strategies developed in one discipline (e.g., LTs were initially developed in Physics) offer potential for their transferability to other disciplines. Although the disciplinary content and context will necessarily change, the overriding design and implementation principles developed in one discipline provide a jump start for the creation of curricular materials for similar IE strategies in other disciplines.



Using Interactive Engagement Strategies to Enhance Learning in College Science Courses

Bailey Zo Kreager and Leilani Arthurs

University of Nebraska-Lincoln

DBER Seminar

April 7, 2016



Outline

- Part 1: Historical Trends in the Adoption of Interactive Engagement (IE) Strategies in College Science Courses
- Part 2: Lecture Tutorials Can Improve Conceptual Understanding of Sedimentology and Stratigraphy



History of Science Education and Reform

- Science was adopted into general education in 19th century.

(DeBoer, 2000)



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History of Science Education and Reform

- Science was adopted into general education in 19th century.
- Shift in science teaching post-World War II.
- National Science Education Standards introduced in 1996.
- Introduction of the term “Scientific Literacy”.

(DeBoer, 2000)



Reasons for reform in Higher Education Science

- Decrease in natural science and mathematics majors from 9.8% to 7.9% (U.S. Department of Education)



Reasons for reform in Higher Education Science

- Decrease in natural science and mathematics majors from 9.8% to 7.9% (U.S. Department of Education)
- Two primary deciding factors for students to leave a science major:
 - Lack of student-centered teaching (Daempfle, 2003; Felder, 1993; Seymore, 1997)
 - Failure to perform academically (Daempfle, 2003; Strenta et al, 1994; Seymore, 1997)



Incorporating interactive engagement (IE) strategies into classroom can help counter the reasons why students leave science majors.



An instructor is trying to decide whether what students in a classroom are doing is interactive or not. Below is a list of possible things students in his class could be doing at any given time. Which items are interactive engagement (IE) and which are not (NIE). Explain your reason(s) for your choice.

Reading a short article	IE or NIE	Explanation?
Taking notes	IE or NIE	Explanation?
Lecture Tutorials	IE or NIE	Explanation?
Discussion with neighbors	IE or NIE	Explanation?
Listening to a lecture	IE or NIE	Explanation?



Methods



Methods

- Coding the articles:
 - A compressive list of IE strategies
 - Organizing IE strategies by implementation
 - Rubric created to code articles by IE strategy type and sub-type
 - Two raters, initial agreement of 80%

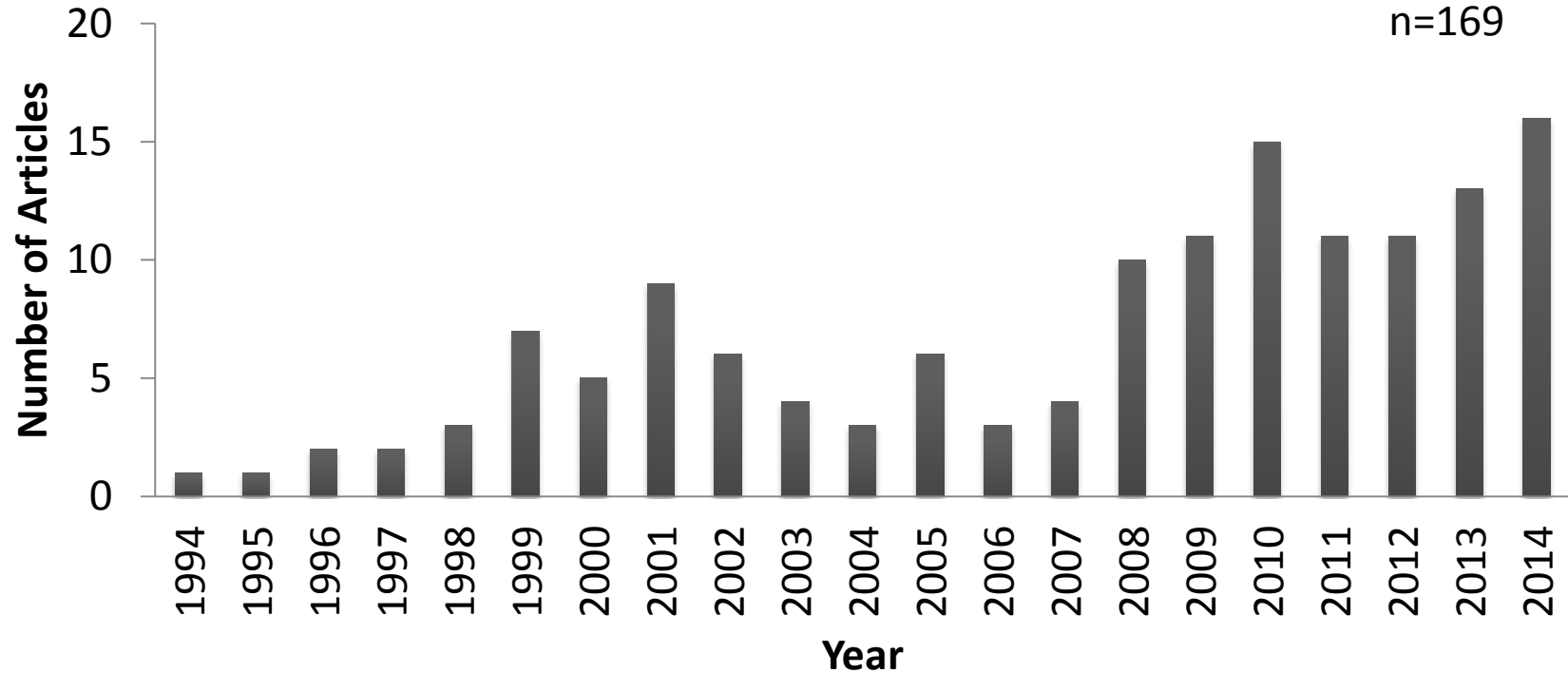


Research Questions

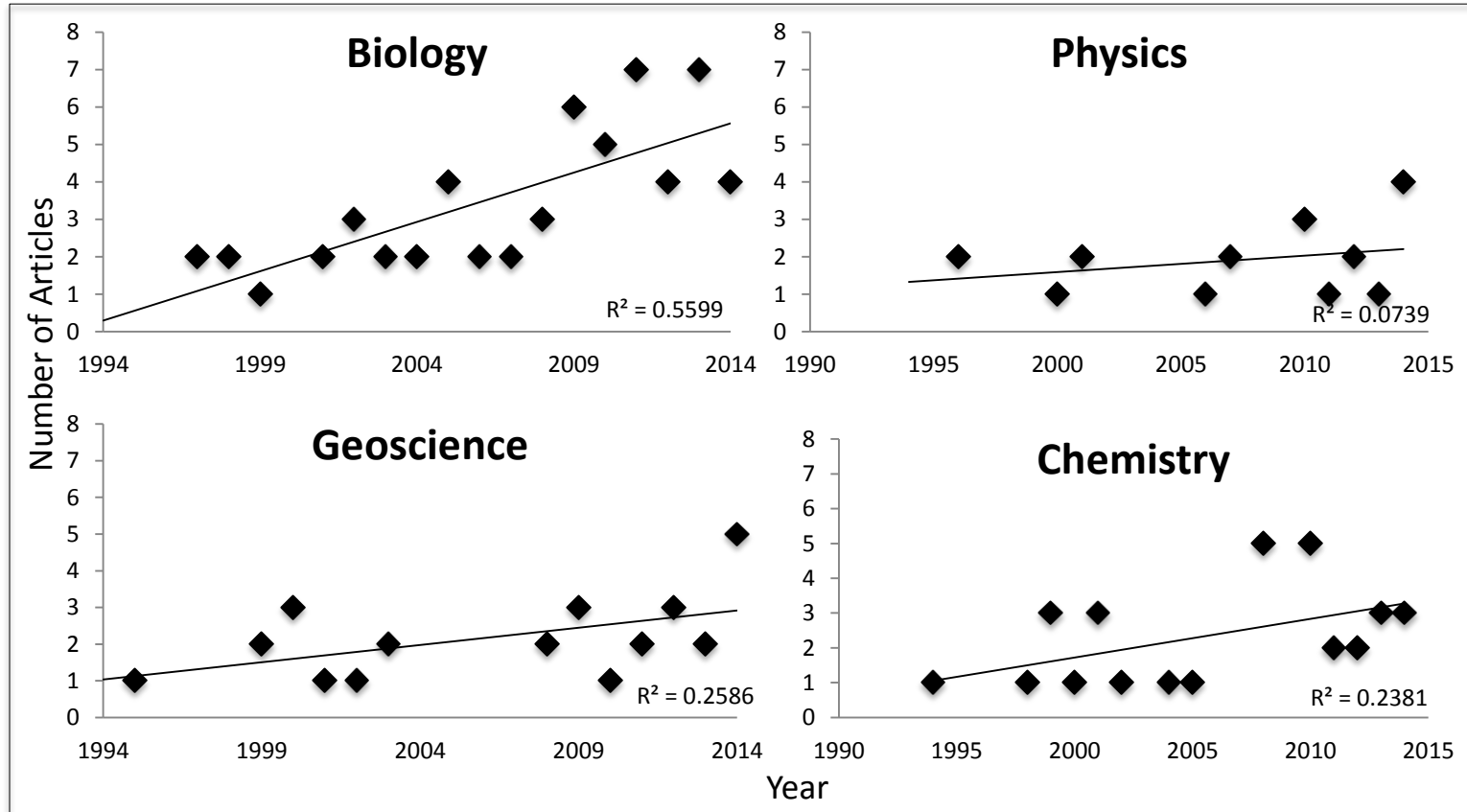
1. What types of interactive engagement strategies are used to teach college science courses?
2. When and how are they used in different disciplines?
3. How does the use of interactive engagement strategies in the geosciences compare to their use in other disciplines?



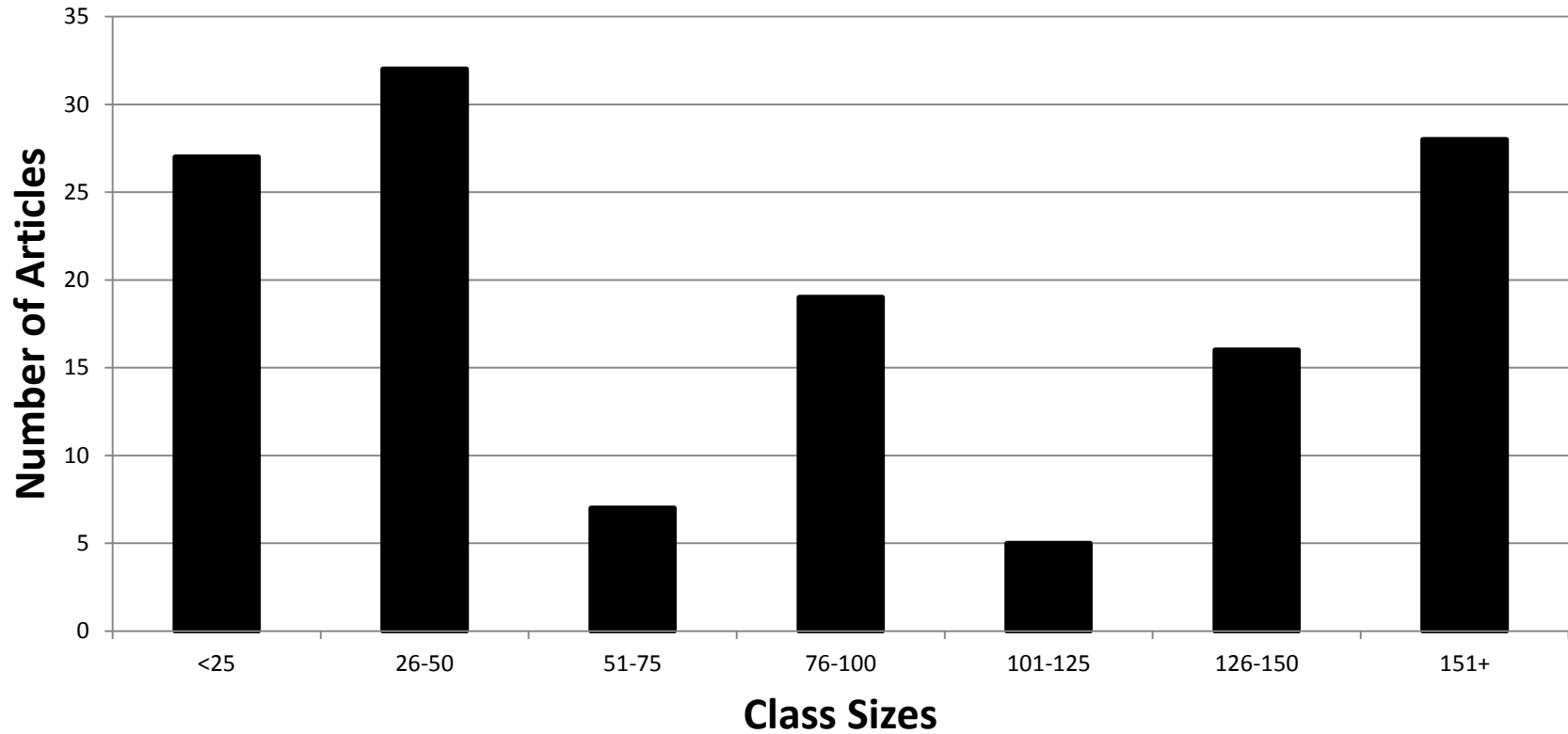
Upward trend in using IE strategies



Upward trend in using IE strategies



IE can be implemented in all class sizes

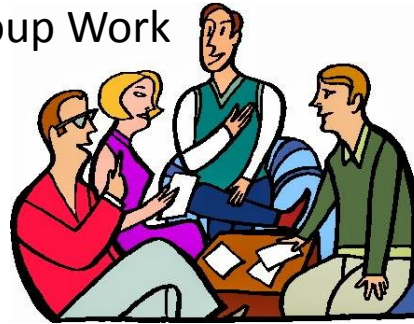


Interactive Engagement Strategy Types

In-Class Group Work



Out-of-Class Group Work



Polling

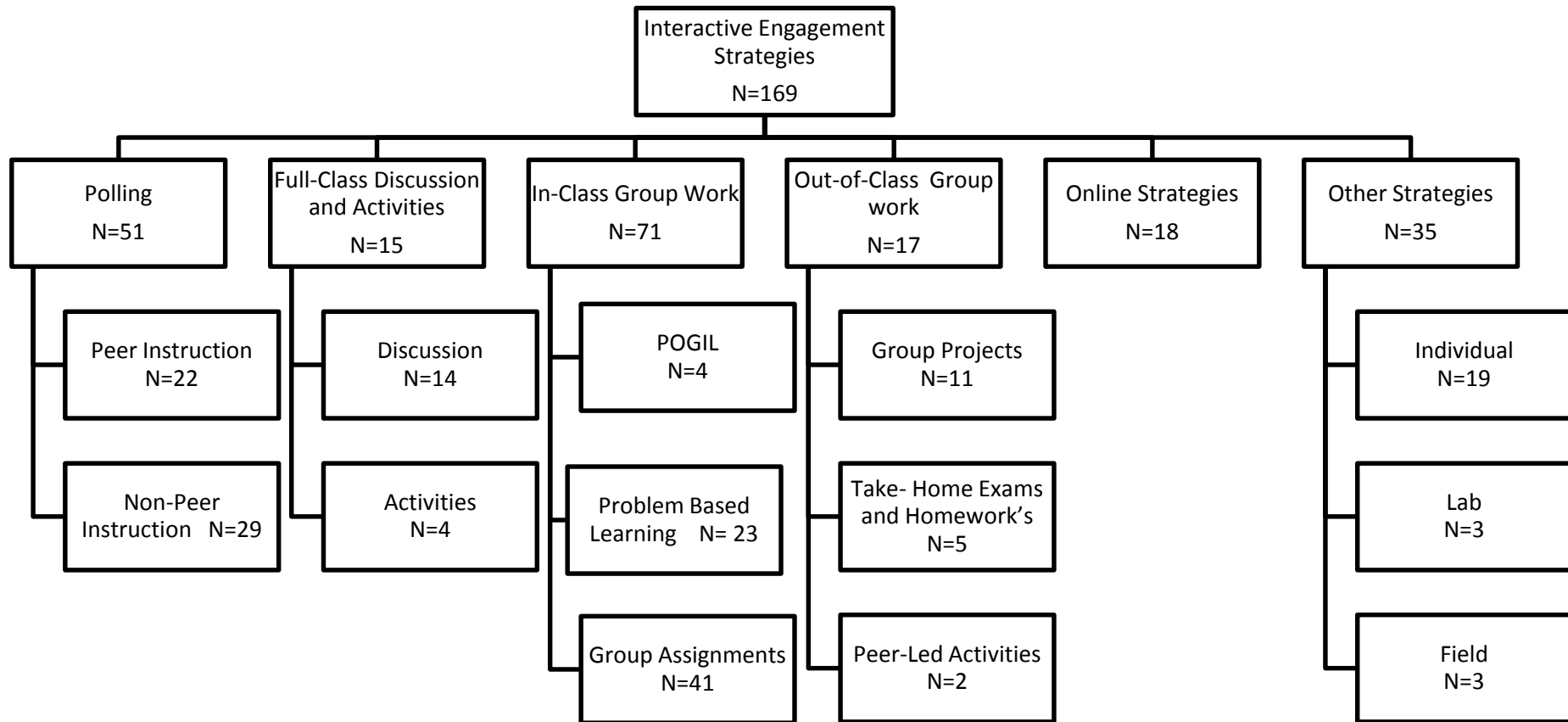


Online Strategies



Full Class Discussion or Activities





Findings

- Geosciences represent a large portion of the literature of online interactive engagement strategies and other less traditional interactive engagement strategies.
- There are many opportunities for geoscience faculty to implement new strategies into their teaching.
- There is room for further crosspollination of interactive engagement strategies from other fields to the geosciences.



Part 2

Lecture Tutorials Can Improve Conceptual Understanding of Sedimentology and Stratigraphy



Problem Statement

- There is little published research about student misconceptions and learning difficulties in the areas of sedimentology and stratigraphy.
- Knowledge of student misconceptions and other difficulties can help inform the development of instructional tools.



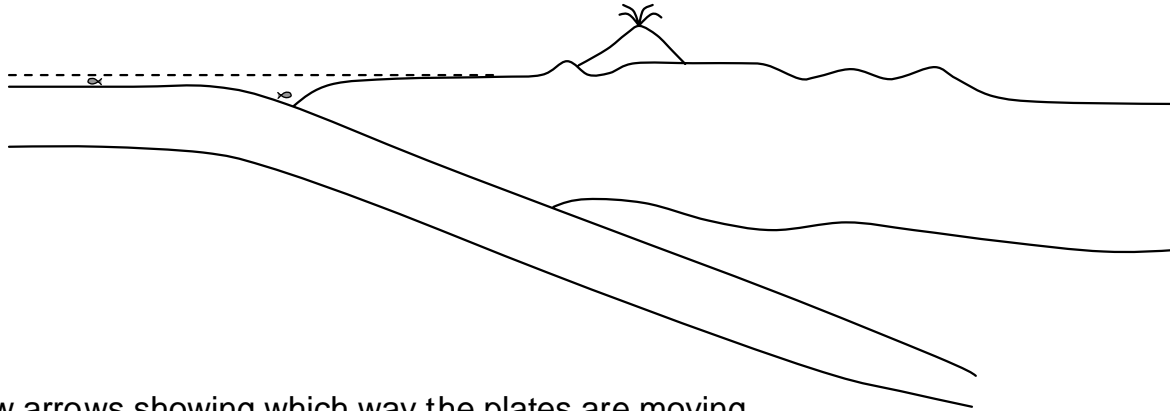
Research Questions

1. What learning difficulties and/or misconceptions do students encounter when learning sedimentology and stratigraphy?
2. How effective are the lecture tutorials that I designed at facilitating the learning of sedimentology and stratigraphy concepts?



Lecture tutorials are an IE strategy used in lecture-style courses.

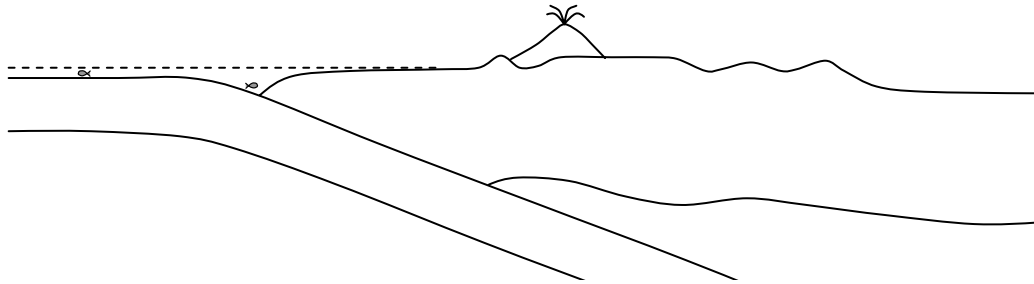
The cross section below shows a subduction zone at an ocean-continent convergent boundary. The ocean surface is indicated by a dashed line.



- 1) Draw arrows showing which way the plates are moving.
- 2) On the diagram, label every feature that geologists can see on the Earth's surface related to plate tectonics. A feature is a thing you can see and not something that is happening.

Lecture tutorials are an IE strategy used in lecture-style courses.

The cross section below shows a subduction zone at an ocean-continent convergent boundary. The ocean surface is indicated by a dashed line.



3) Two students are discussing the features they labeled on the diagram.

Student 1: *I labeled the ocean plate, the continental plate, volcanoes, and mountains.*

Student 2: *I labeled those, plus the ocean trench and subduction.*

Student 1: *I like that you labeled the trench, but I don't think you can label subduction. Subduction is an action of something happening, and it's not a feature.*

Student 2: *But you can see it on the diagram where the ocean plate is being pushed under the continental plate, so I think you can label subduction as a feature.*

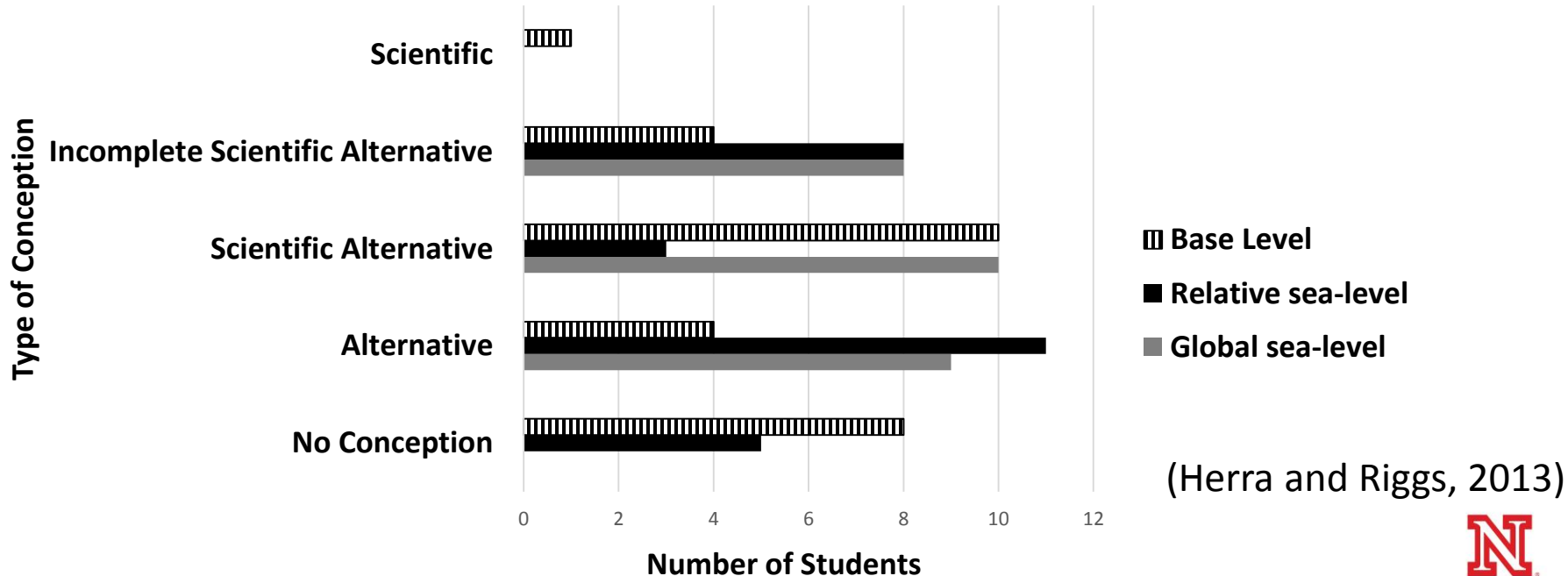
With which student do you agree? Why?

Theoretical Framework

- Scaffolding
 - Reciprocal Scaffolding
 - Holton and Clarke, 2006
- Conceptual change
 - Vosniadou, 2007



Many Students blend scientific concepts with personally created concepts.



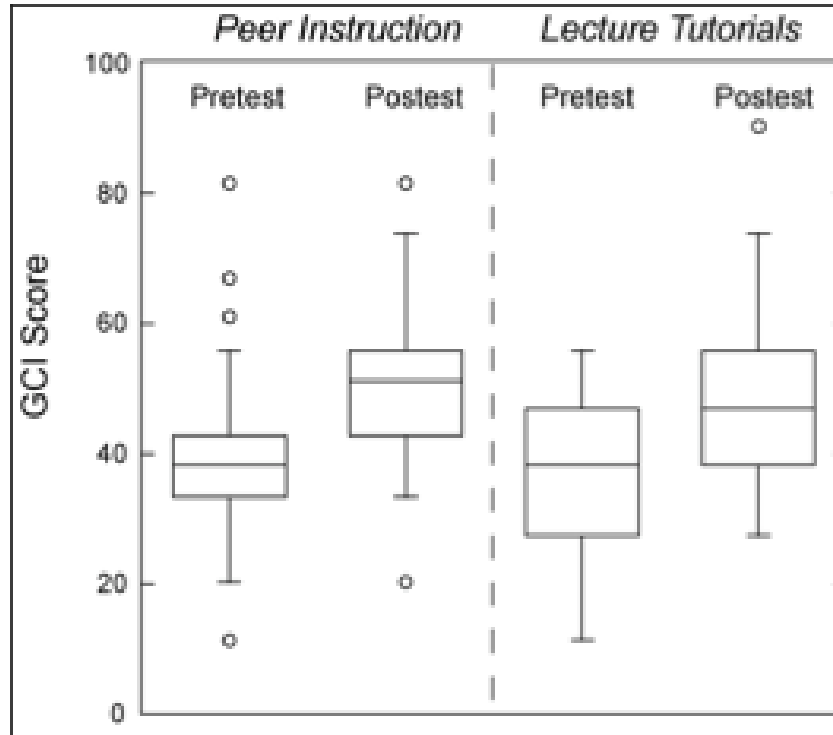
Interactive Engagement strategies improve scores on GCI over traditional Lecture Courses.

Style	N	GCI- pre	GCIpost	GCIpost - GCIpre	G
PI	45	38.2 (SD=13)	49.4 (SD=12.3)	11.2	0.18
LT	37	36.4 (SD=12.1)	46.9 (SD=13.8)	10.5	0.16
Libarkin and Andersen	2493	41.5 (SD=12)	45.8 (SD=13)	4.3	0.07
Kortz et al.	86	39.3 (SD=13)	48 (SD=14)	8.7	0.14

(Mora, 2005)



Lecture Tutorials are equally as effective as other interactive engagement strategies.



(Mora, 2005)

Methods

1. Institutional Review Board Approval
2. Faculty Survey
 - a. Recruitment
 - b. Survey done through Qualtrics
3. Faculty Feedback
 - a. 1-4 LTs sent to faculty
4. Student Think-Aloud interviews
 - a. In person interviews for question readability and interpretation



Methods continued

- Participants:
 - 39 instructors surveyed about observed misconceptions and learning difficulties
 - 9 instructors provided feedback on the LTs
 - 8 think-aloud interviews with upper-level undergraduate and first-year graduate geology students
 - 36 undergraduate non-geology majors in focus group interviews

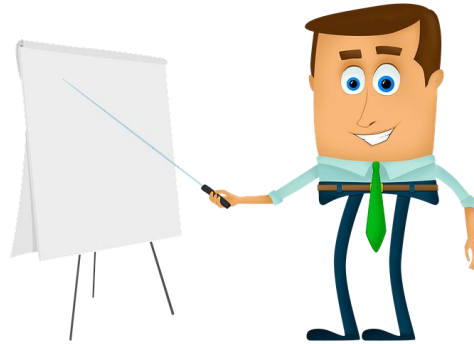


Methods continued

5. Focus group interviews: Type one



Pre-instruction



Lecture



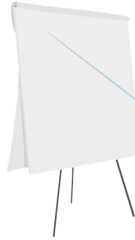
Post-Lecture

Methods continued

5. Focus group interviews: Type 2



Pre-instruction



Lecture

+



Lecture Tutorial



Post-Lecture and LT

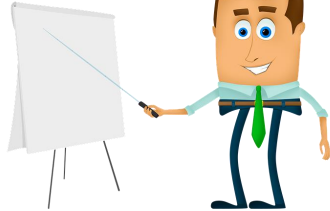


Methods continued

5. Focus group interviews: Type 3



Pre-instruction



Lecture



Post-Lecture



Lecture Tutorial



Post- Lecture and LT



Methods Continued

6. Coding of Student Responses: LT Q. 2

Three researchers are trying to decide how to code the student open ended responses they received from a pre- and post-instruction questionnaire.

Researcher A: I think we should create a rubric based off the expected student answers to use to code each answer. That way the students' answers do not bias our coding.

Researcher B: A rubric should be made based off of the students' answers for each question from the pre- and post- instruction questionnaire.

Researcher C: I agree. The rubric should be based off of student answers, but I think two rubrics should be made. The first rubric should be based off of the students' answers from the pre-questionnaire. The second rubric should be based off the answers for the post- instruction questionnaire.

Which researcher(s) do you agree with the most and why?



Methods Continued

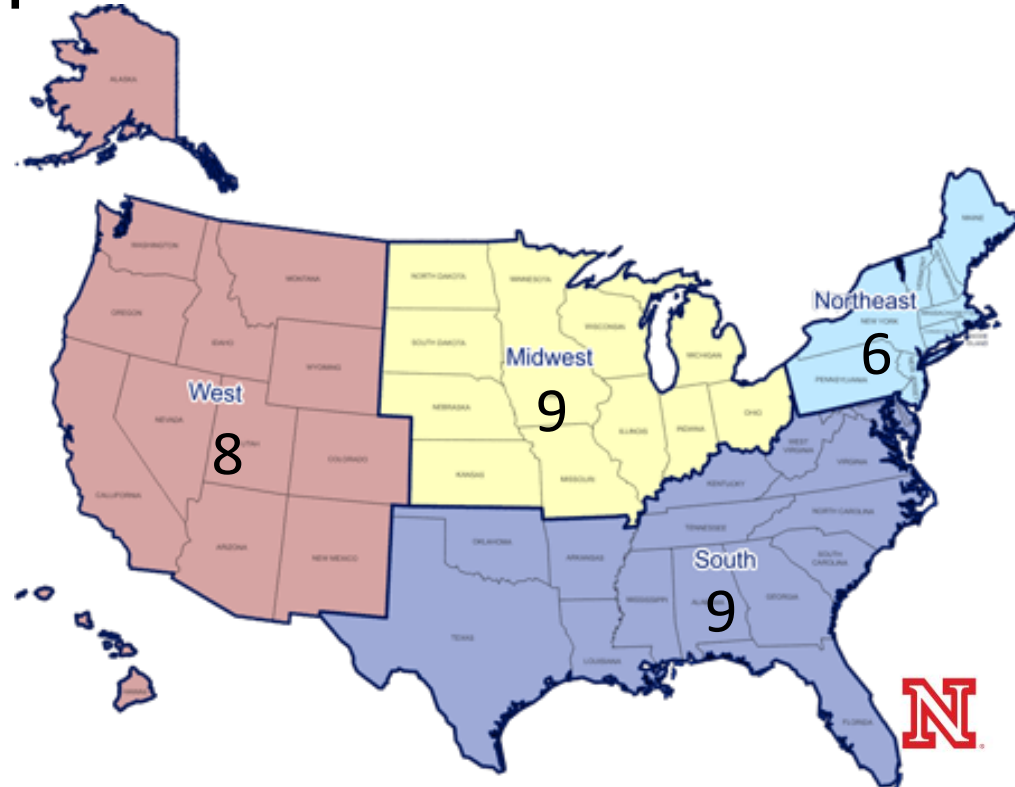
6. Scoring of Student Responses

- Scoring rubric was created based off student answers and used by one rater
- Scoring rubric was then edited and used by both raters with an agreement of 84%
- Scoring met to discuss mismatched scores and found 100% agreement on student scores.



Faculty participants are distributed across the U.S. and institution types.

Very High research	14
High research	15
Baccalaureate and Associates	1
Associates- Public	1
Baccalaureate- Diverse Fields	3
Baccalaureate- Arts and Sciences	4



Faculty identified several different types of misconceptions and learning difficulties.

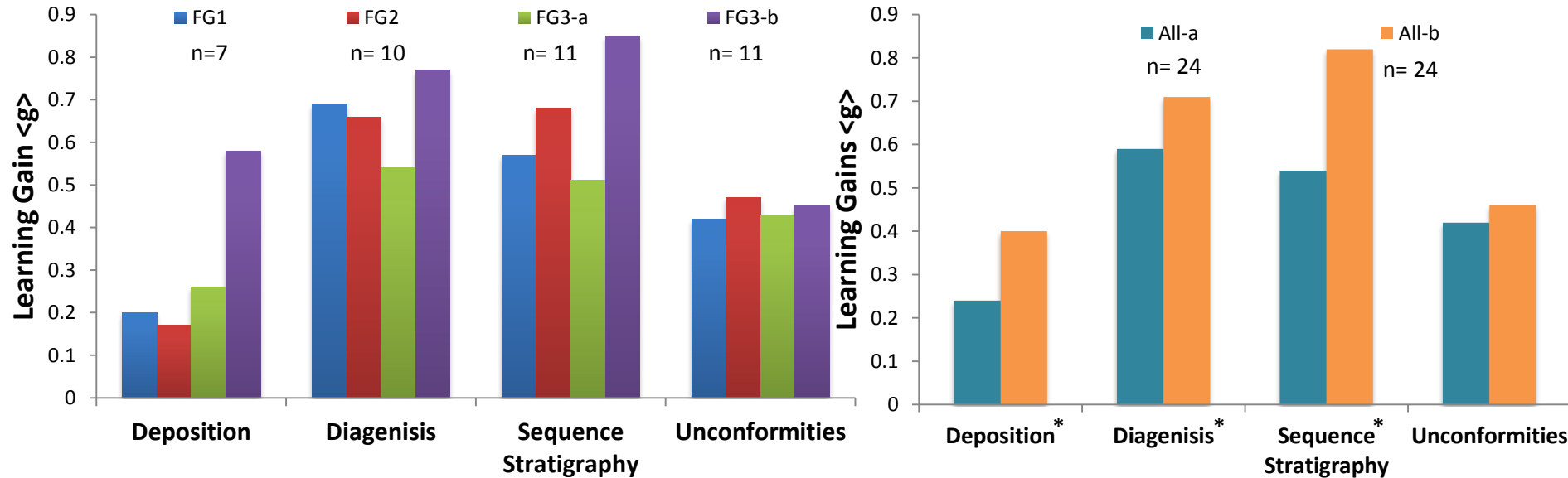
Grouping topic	Deposition	Sequence Stratigraphy	Time and Dimensional Thought	Processes and Resulting Features	Unconformities
% of faculty	38%	30%	38%	15%	13%

Sedimentary Facies	Rock reading Skills	Diagenetic Processes	Data Collection Processes	Other
13%	10%	18%	8%	18%

n=39



Results: Focus Group Learning Gains



* $p < 0.10$



32% of students think the ocean leaves an observable mark on the rock where sea level was.

Student A: *"because it would erode the rock wherever sea level is"*

Student B: *"the sea probably deposits salt on the rocks"*

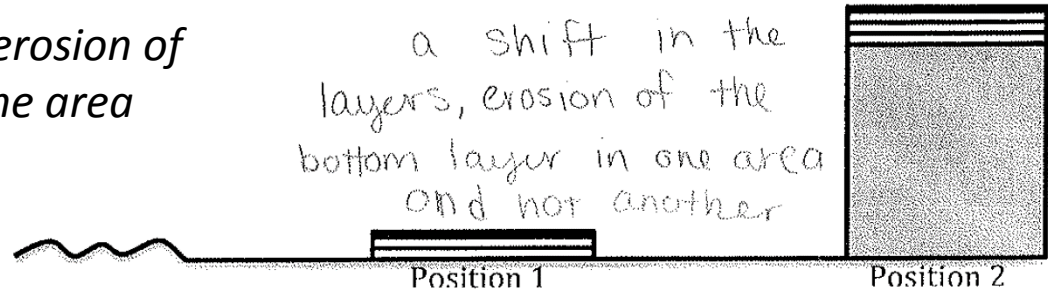
Student C: *"I feel that is very evident as it leaves marks."*



Students bring alternate conceptions on how sediment is eroded, formations are deposited, or how formations are shifted over time.

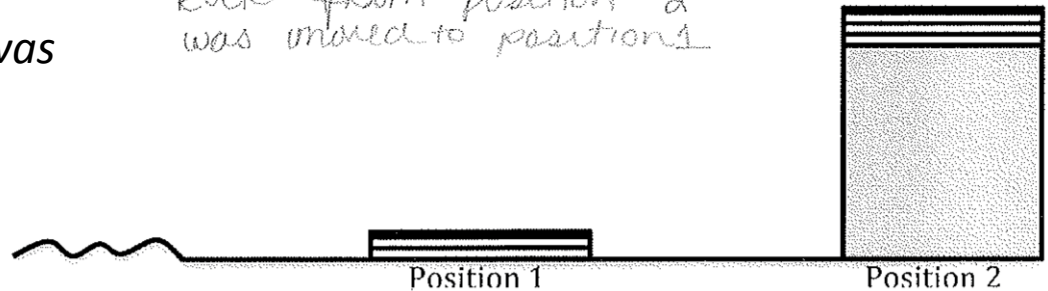
"A shift in the layers, erosion of the bottom layer in one area and not another"

a shift in the layers, erosion of the bottom layer in one area and not another



"Rock from position 2 was moved to position 1"

rock from position 2 was moved to position 1



Students do not initially understand gaps in the rock record and how they form.

Student A: *“as unconformities happen, evolution happens over time and this shows history”*

Student B: *“Layers can show how long ago the earth existed”*

Student C: *“rocks have been around since the beginning of time and are hard to alter by man (impossible).”*



Discussion

- Not all Lecture Tutorials are as useful as others (Kortz et al. 2007)
- Comparing post-lecture to post-lecture and LT scores
 - Deposition and Sequence Stratigraphy = medium learning gains $0.30 \leq \langle g \rangle < 0.70$
 - Diagenesis = Low learning gains < 0.30
- Many student alternate conceptions reflect those seen in the literature



Conclusions/Future Work

- Three of the five Lecture Tutorials produced statistically significant learning gains.
- Sedimentary Facies LT could be worked into a complete LT.
- Currently preparing an Instructors Guide.



Thank You!

Questions? Comments?
Feedback?



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