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Siam Annual Meeting 2018

Best Practices For Active Learning In The Applied Mathematics Classroom

(Or: How To Avoid Lecture!)

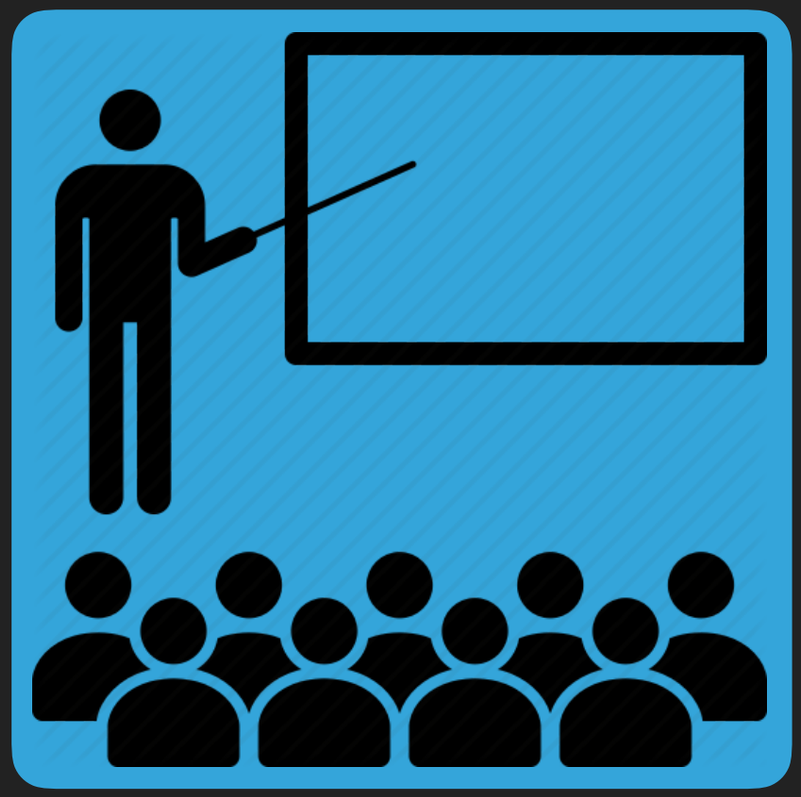
"If this were a medical trial, then it would be unethical to continue with the lecture method."

Freeman et al. 2014

Freeman, Scott, et al. "Active learning increases student performance in science, engineering, and mathematics." PNAS (2014)

Options For Instruction

- Lecture
  - Instructor: “Sage on the stage”
  - Transmission of knowledge
  - Perpetuates previous successes/failures
- Alternatives
  - Instructor: facilitator
  - Constructive learning
  - Codified methods: IBL, PBL, POGIL…

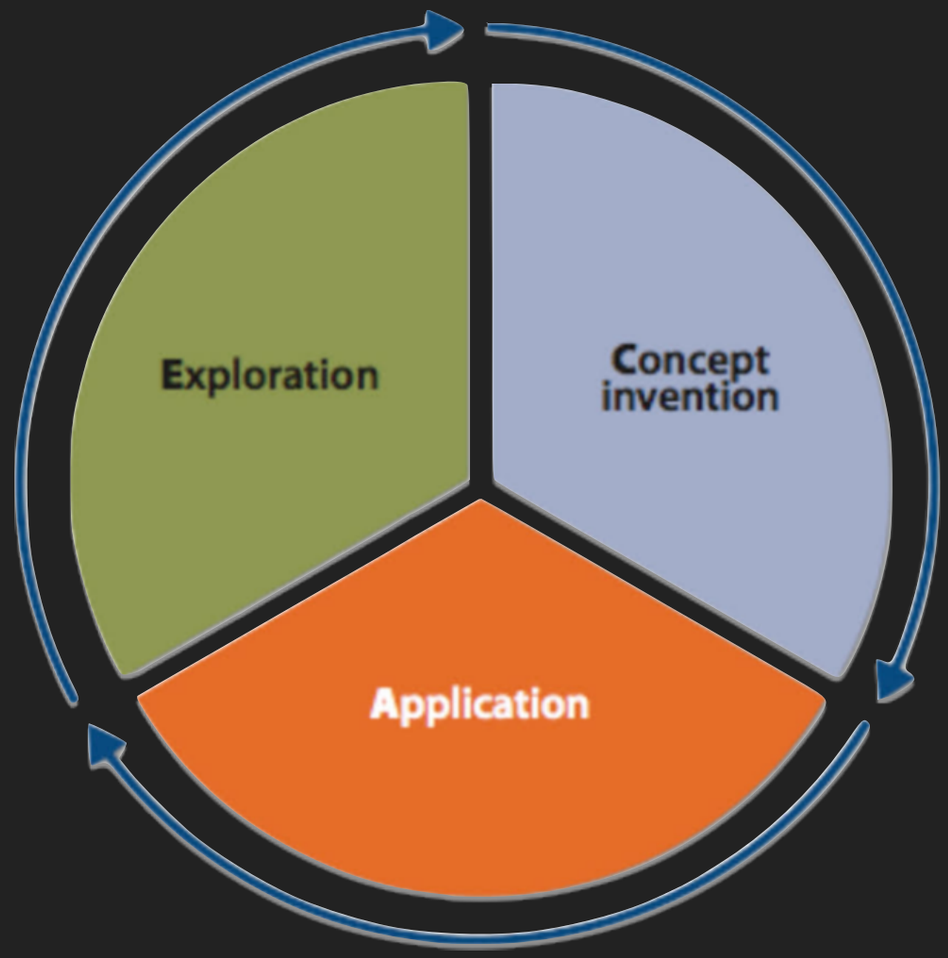


Problem-Based Learning (Pbl)

- “**Project**-based learning:” Dewey, 1897 ("learning by doing”)
  - extensive, long-term, interdisciplinary
- “**Problem**-based:” Origins in medical education, 1960s
- Group work to solve a disciplinary problem
  - open-ended
  - real-world
- Related: case studies (e.g. business)

Process Oriented Guided Inquiry Learning (Pogil)

- Origins in chemistry, 1990s
- Self-managed student teams with defined roles
- Exploratory activities
  - content knowledge
  - “process skills”



pogil.org

Process Skills

- Oral Communication
- Written Communication
- Teamwork
- Problem Solving
- Critical Thinking
- Management
- Information Processing
- Self and Peer Assessment
- Metacognition

Method Effectiveness

- Risk of failing reduced by 38% (meta-analysis)
- In general, for POGIL:
  - Student attrition is lower
  - Content mastery is generally higher
  - Preferred for most students over traditional methods.

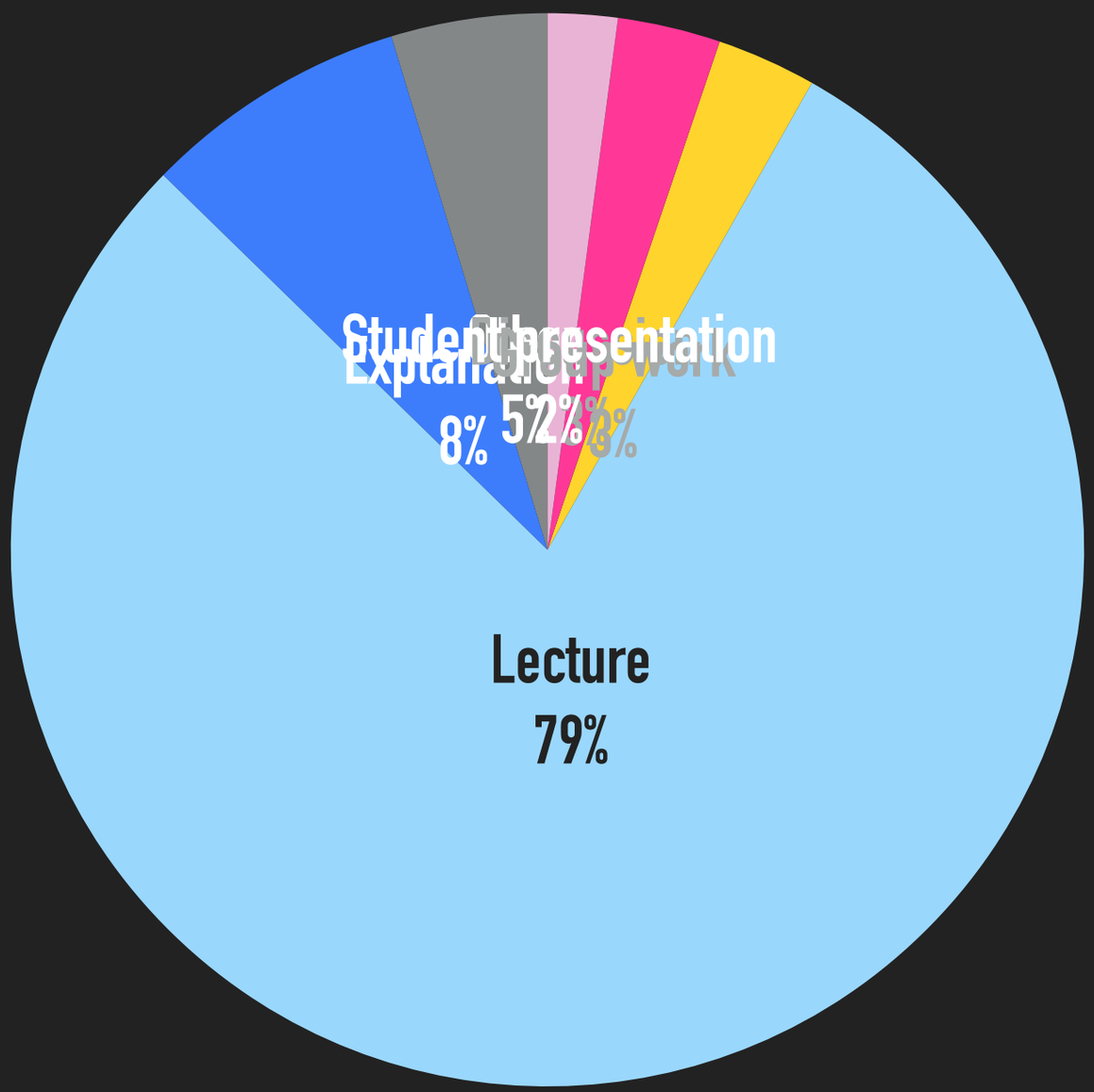
Walker, Lindsey, and Abdi-Rizak M. Warfa. "Process oriented guided inquiry learning (POGIL®) marginally effects student achievement measures but substantially increases the odds of passing a course." PloS one 12.10 (2017): e0186203.

Inquiry-Based Learning (Ibl)

- Origins in math
  - Socratic Method / Moore Method / Modified Moore
- Goals:
  - deep engagement with material
  - learning through peer collaboration
- Class time:
  - “Group-worthy” activities
  - Student presentations

Class Time

Observational study: 31 IBL sections 11 non-IBL

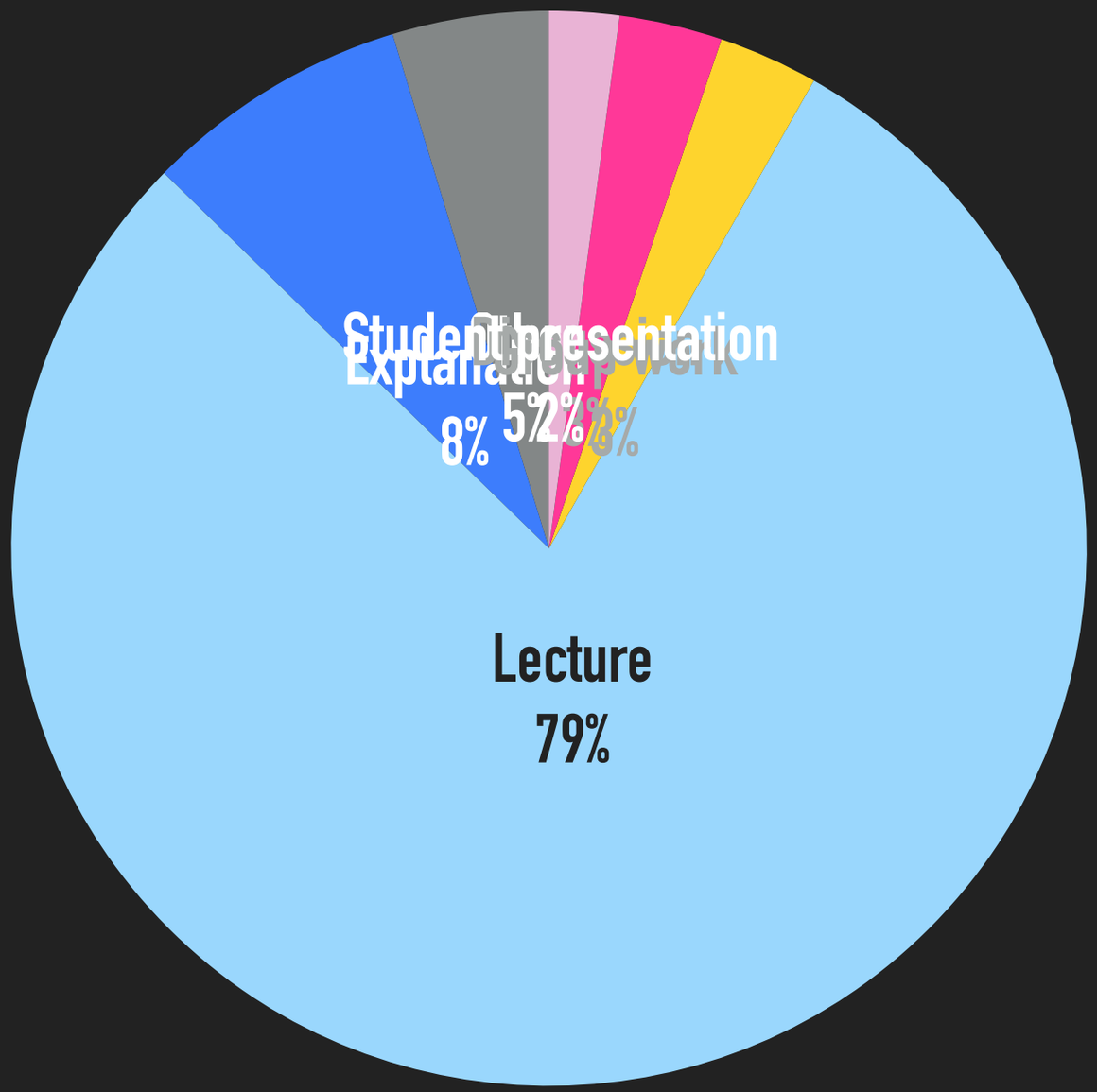


Data from: Laursen, S., Hassi, M. L., Kogan, M., Hunter, A. B., & Weston, T. (2011). Evaluation of the IBL mathematics project: student and instructor outcomes of inquiry-based learning in college mathematics. *Colorado University*

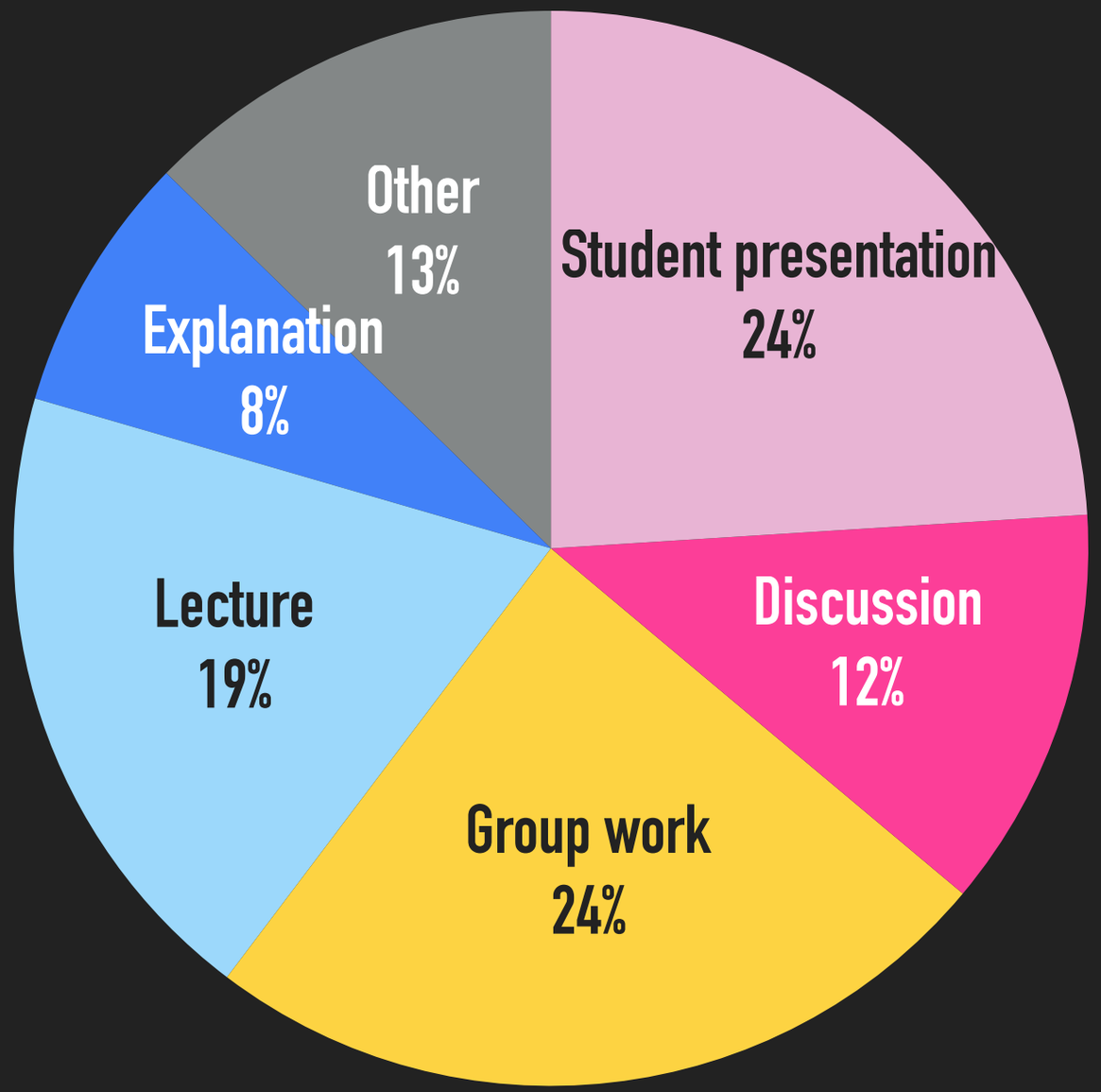
Class Time

Observational study: 31 IBL sections 11 non-IBL

NON-IBL CLASSROOMS



IBL CLASSROOMS



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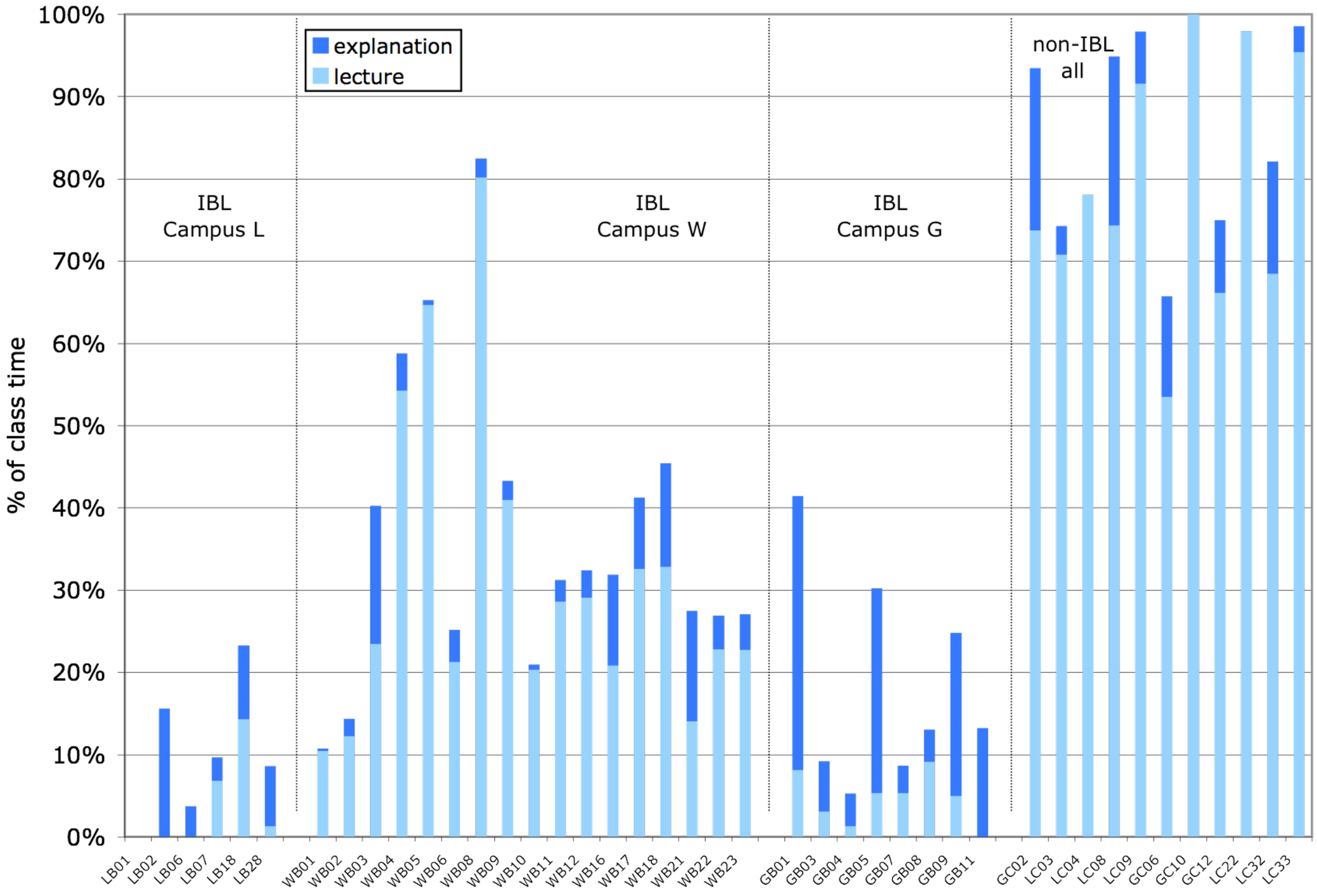
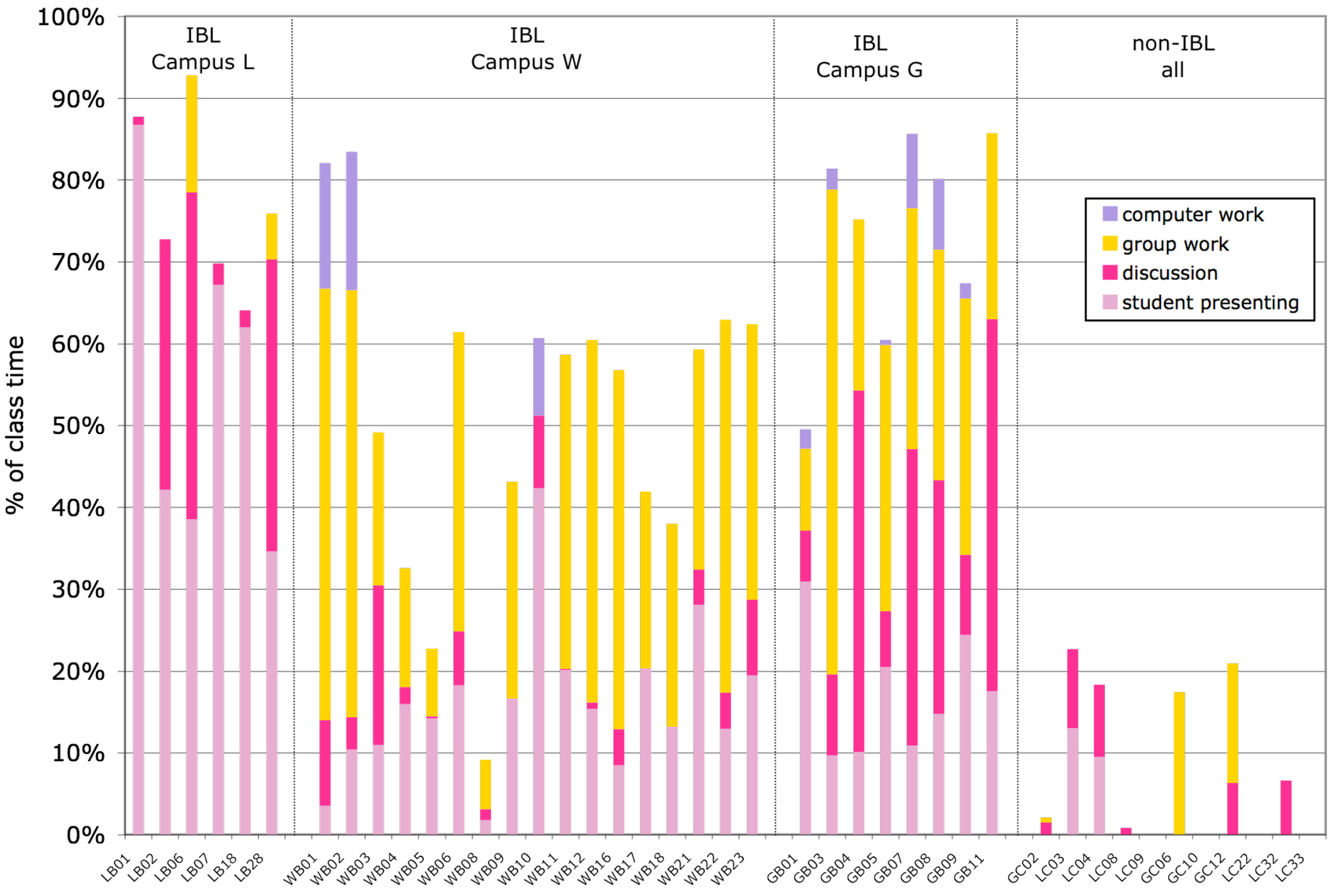
Instructor-Centered Activities, By Section

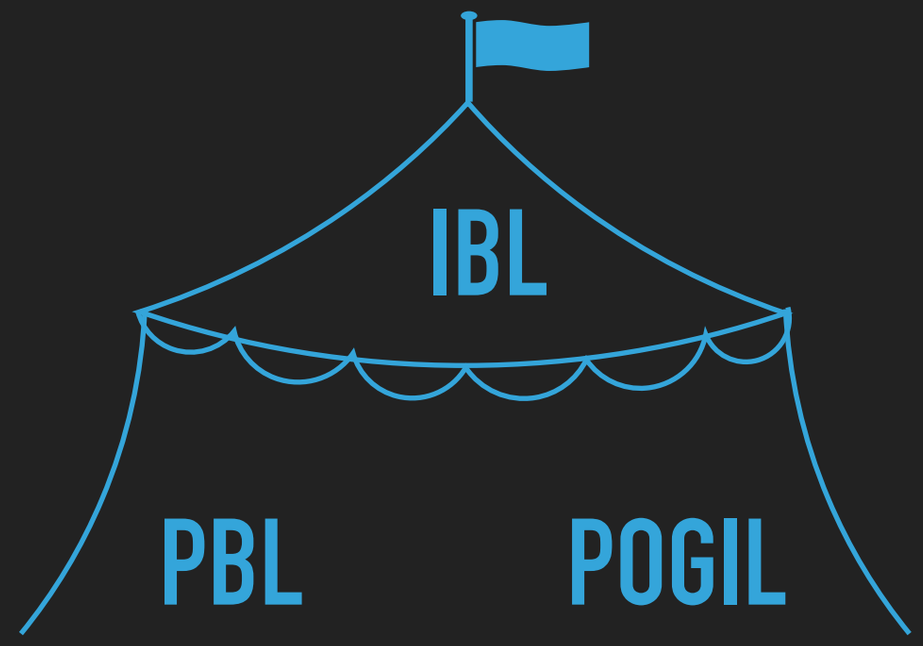


Student-Centered Activities, By Section



Ibl/Pogil/Pbl…

- Very similar!
  - instructor as facilitator
  - “inquiry guided”
- Differences
  - terminology
  - structure



Challenges

- Instructor plan time
- Student buy-in
- Coverage
  - This has been studied!
  - procedural work: similar student performance
  - conceptual work: inquiry has the advantage!

Stan Yoshinobu & Matthew G. Jones (2012): The Coverage Issue, PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies, 22:4, 303-316

Applied Math?

- POGIL: most resources for chemistry (& science)
- IBL: most resources for pure math
  - proof writing and presenting
  - critiquing argument
- Adapt for
  - computational topics
  - numerical topics
  - modeling topics

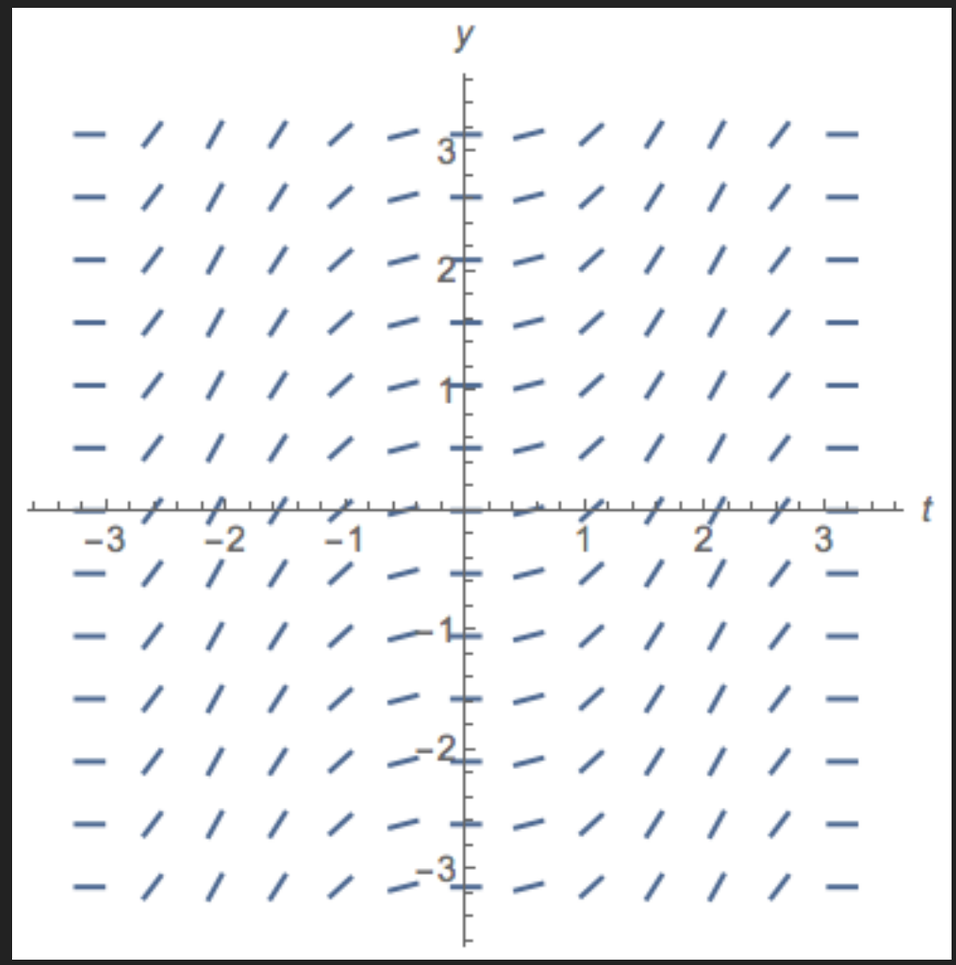
Ex: Instantaneous Rates Of Change (Calc 1)

- Traditional:
  - Examples, then definition (or vice versa)
  - Students memorize (and regurgitate)
- POGIL activity:
  - Given location/time data: find average velocity
  - Different time intervals? (estimate instantaneous velocity)
  - Visuals? (graphing position vs. time)
  - Slopes (secant and tangent lines)
  - Next: Newton's formulation of the derivative.

http://guidedinquiry.org

Ex: Euler's Method (Diff. Eq.)

- Pre-requisites (?)
- Given current state and rate of change, predict next state.
- What does "next" mean?
- How would you visualize this?
- ("reinvent" Euler's method formula)



Ex: Line Integrals (Multivariable Calc.)

- Prior knowledge:
  - arc length
  - double integrals
    - change of variables
- In groups, decide how to find the area of a curved wall
  - constant height?
  - variable height?
- (construct formula for line integrals)

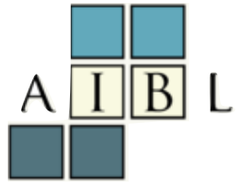
Learn More: Pogil

POGIL Process Oriented Guided Inquiry Learning

- Resources:
  - pogil.org
  - guidedinquiry.org
- Regional summer workshops

Learn More: Ibl

- AIBL



The Academy of Inquiry Based Learning

www.inquirybasedlearning.org

- Workshops:
  - Regional summer workshops
  - “Workshop Zero” (see website!)
- Conferences:
  - MathFest 2018 (Denver)
    - Minicourse Aug 2
    - Contributed talks Aug 3
  - National IBL Conference (held early summer)

Learn More: materials

- JIBLM Journal of Inquiry-Based Learning in Mathematics jiblm.org

- Refereed materials, including course notes
  - “Calculus I, II, & III : A Problem-Based Approach with Early Transcendentals,” Mahavier, W. Ted
  - “Mathematical Modeling,” Miller, Nathaniel
  - “Theory of Computation,” Ajwa, Iyad A.
  - + 3 other calculus authors
  - & more non-refereed

Learn More: here!

- SIAM

- MMHub: mmhub.qubeshub.org
  - Resources for modeling

What Are Your Experiences?

- Do you use any of these methods?
- What do you do other than lecture?
- Favorite resources?
- Suggestions or advice?

Thank You!

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