Implementation of Active Learning in Calculus Problem Sessions

John Zweck

The University of Texas at Dallas

http://www.utdallas.edu/~zweck/

zweck@utdallas.edu
We thank the UT Dallas Center for Teaching and Learning for an AY 2017-18 award to support an expansion of the TA Workshop with an emphasis on Active Learning.

Prior Funding for Active Learning [AY 15-17]:

NSF: Supplement to the UTeach Dallas Robert Noyce Scholarship Program (DUE 1544159)

1PIs: Dabkowski and Zweck
2PIs: Urquhart, Zweck, Minkoff
Active Learning in Calculus Problem Sessions

- **MATH 2415**: In 7 courses since Fall 2012
- **MATH 2417**: Gradual start this semester!

You can incorporate active learning into your problem sessions too!
Basic Responsibilities of TAs

- **Follow instructions** from Course Coordinator
- Attend Instructional Team Meetings for your course
- Read and respond to email from Course Coordinator
- Prepare for each Problem Session
- Be a responsible grader
- Talk to Course Coordinator as soon as problems arise
- **Improve mathematical communication skills!**
Your Goals for Problem Sessions

1. Welcome and include all students
2. Be respectful of all students
3. Identify students missing background material
4. Increase attendance and participation
5. Foster a fun and productive learning environment
6. Help students learn how to learn
   - [link to Chew Videos]
   - [link to JZ Syllabus: See Advice for Exams]
7. Increase students’ skills and confidence
8. Challenge and help all students to succeed
Memory is the residue of thought\textsuperscript{3}

\textsuperscript{3}Willingham, 2009
Active Learning of Mathematics is a method of teaching that promotes:

1. Students’ deep engagement in mathematical reasoning
2. Peer-to-peer interaction
3. Instructor interest in and use of student thinking
Overview of TA Workshop

Tuesday: Practice lecture summaries

- Groups of 8 with Group Leader
- Each TA gives 10 minute presentation
- Then 2 people provide constructive feedback [5 min]
- Feedback: both verbal and written
Overview of TA Workshop

Wednesday & Thursday: Mock AL sessions

- Groups of 16 with 2 Group Leaders
- 2 TAs run 20 min AL session [assigned problems]
- Other TAs play role of students
- Group Leaders observe
- After each session, 10 min discussion
- One group leader moderates, other records
- Address mathematical and social aspects
  - from TA and student perspectives
- Wrap up Thursday at 4pm in FN 2.102
Responding to feedback

“Accepting feedback is easier when you don’t take it personally.”

“To lessen the sting of criticism evaluate how well you handle it.”

“Teams that focus on learning from failure outperform those that don’t.”

4Quotes from "Option B" by Sheryl Sandberg [Facebook COO]
Two Active Learning Methods

1. **The White Boards Method [WB]:**
   - Students solve problems in small groups at white boards.

2. **The 1:3 Method [1:3]:**
   - For every problem TA solves at board, students solve 3 problems on paper.
Active Learning Problem Sessions [WB]

- TA starts with 10 minute summary of lectures
- Then students actively solve assigned problems
- Students
  - Work in small groups of 3-4 at white boards
  - Explain solutions to each other and to TA’s
  - Photograph their solutions
- Teaching Assistants
  - Can’t hold white-board markers
  - Only ask questions, but can answer “Yes” or “No”
  - Model student responses: "So you are saying...."

The room is buzzing with conversation.
Active Learning Problem Sessions [1:3]

- TA starts with 10 minute summary of lectures
- TA and students work on assigned problems
- First TA solves a problem at white board
  - With student input via Think-pair-share, Step-by-step
- Then students solve 3 assigned problems
  - Work solo or in groups of 2 at tables
  - TA circulates, answering students’ questions
  - Students explain solutions to neighbors and to TA

**Everyone is actively solving problems and can get immediate feedback**
Other active learning techniques

1. **Blackboard work** by TA with active student input.

2. **Think-pair-share:**
   - TA poses a question
   - Students think about it
   - Pairs of students discuss thoughts
   - A few students share ideas with entire class

3. **Step-by-step:**
   - Students break a problem up into several short steps
   - Then they fill in the steps
Other active learning techniques

4 **Critiques**: Find flaws in an argument made by TA.

5 **Pair summarizing/checking**
   - One student explains a concept
   - Partner listens and provides constructive feedback

6 **Problem creation**:
   - Each student poses a problem about a concept
   - Then exchange problems with a classmate and solve
1. Get in your Wed/Thurs group
2. Get the assignment sheet for your AL session
3. Find your partner
4. Group Leaders: Make sure TA’s paired up
5. Work out what AL Method you want to use
6. Group Leaders: Ensure have range of methods
Active learning works

MATH 2415
Small Group Active Learning Problem Sessions

- Student survey [S16, 49 responses]
- 88% of respondents said attending problem sessions increased understanding and comprehension

Most effective learning:
1. Solving problems on past exams (2.64)
2. Solving homework problems on paper (2.59)
3. Solving problems in AL Problem Sessions (2.42)
4. Taking notes during lecture (2.37)

Least effective learning:
1. Reading the textbook (1.68)
2. Solving WebAssign homework problems (1.71)
Active learning works

Meta-analysis of active learning in STEM

1. Meta-analysis of 225 studies comparing
   - Active Learning (AL) courses
   - Traditional Lecture (TL) courses

2. Average exam scores 6% higher with AL

3. Improvement on Concept Inventories even better

4. Students in TL courses 1.5 times more likely to fail

---

Footnote:

Freeman et al., PNAS, (111), June 2014
Strategies for Asking Questions

1. Ask many questions at low cognitive levels
   - helps shore up prior basic skills

2. Ask some questions at high cognitive levels

3. **Wait** 3-5 seconds after asking a question

4. Encourage students to respond

5. Balance responses: volunteers and non-volunteers

---

Strategies for Asking Questions

6. Probe students responses
   - for clarification
   - to stimulate thinking

7. Acknowledge correct responses
   - Use praise genuinely, sparingly
   - Praise should be specific

8. Design questions so that \( \approx 70\% \) answered correctly.

\(^7\)From *The Teaching Professor*, October 1994, p3.
1. Effective questioning [see above]
2. Active listening
   - important messages are conveyed by the way something is stated, including choice of words
3. Peripheral vision
   - involves ability to intuit group process
   - when to provide guidance, offer encouragement?
4. Empathy
   - ability to see there is more than one approach
5. Sense of timing: When to
   - ask a question
   - offer a summary
   - be silent

---

8 From *The Teaching Professor*, June/July 1995
Leading Effective Discussions

6 Clarity
- move discussion forward with understanding
- involves restating “muffled” ideas

7 Differentiation
- leader cannot become totally absorbed by discussion

8 Variability
- Be light, serious, supportive, confrontational

9 Connecting with the class
- Reach each student, accounting for emotional, intellectual and physical states
Mechanics of Active Learning Sessions

1. Make sure you know how to solve all problems
2. Use active learning right from start of course
   - with modest, achievable goals
3. Must explain
   - What active learning is
   - Why we are using active learning
   - How active learning works
4. After a couple of weeks session runs smoothly
Mechanics of White Boards Method

1. Get buy-in from course instructors!
2. It helps to have a room with lots of white boards!
3. TA brings markers and erasers
4. Students bring laptops to access
   - assignment sheet [more problems than most can do]
   - textbook
   - past exams
5. First 10 minutes only
   - TA reviews theory, soliciting questions and input
Mechanics of White Boards Method

6. Students self-organize into small groups (3-4)
   - Change composition until all are working well

7. Group writes down problem # and statement

8. Students take photos of solutions

9. Each **group explains** some of their solutions to TA

10. When a group is stuck, **TA asks** probing questions

11. Vary approach depending on course, students
   - Can adapt to courses with quizzes
   - Caution: some students can’t work in groups
Rooms with lots of White Boards

- CB1 1.102, CB1 1.104, CB1 1.106
- CB2 1.202, CB2 1.204
- CB3 1.302, CB3 1.304, CB3 1.306, CB3 1.308, CB3 1.310, CB3 1.312, CB3 1.314
- FN 2.106, FN 2.202
- FO 2.702
- PHY 1.103
Rooms without White Boards

- CB2 1.206 (Marginal)
- ECSN 2.112
- FN 2.104, FN 2.204
- FO 3.222
- GR 3.420, GR 4.204
- JO 4.708
- JSOM 11.210
- SLC 2.202, SLC 2.302, SLC 2.304, SLC 3.102
Faculty and TAs with Experience in AL

**Faculty:** JZ, Sue Minkoff, Farid Khafizov, Changsong Li, Irina Martynova, Mietek Dabkowski

**TA's:** Sonny Skaaning, Yanping Chen, Fatih Gelir, Jing Guo, Abdullah Helal, Elvira Kadaub, Jordan Kaderli, Arafat Khan, Sonam Lama, Jonathan Popa

**UTeach Dallas TA’s:** Henry Curtis, Ariel Dezeeuw, Carl Finley, Dalia Franco Cortes, Danika Lelina, Andrew Marder, Mikaela McMurtry, Nikunj Patel, Matthew Portman, Erik Ringqvist, Jonathan Sok, Josilyn Valencia
Handouts / Summary Slides

1. What is Active Learning?
2. How Does Active Learning Work? [WB Method]
3. How Does Active Learning Work? [1:3 Method]
4. Why Do Active Learning?
What is Active Learning?

We use Active Learning in our Problem Session.

With Active Learning you will:

1. Engage in mathematical reasoning
2. Solve problems with your fellow students
3. Explain your thinking to each other and the TA
How Does Active Learning Work?\(^9\)

- TA starts with 10 minute summary of lectures

Then you

- Actively solve assigned problems
- Work in small groups of 3-4 at white boards
- Explain your solutions to each other and to TA’s
- Photograph your solutions
- May have a quiz at the end

The Teaching Assistant

- Checks in regularly with each small group
- Mostly asks questions, but can answer “Yes” or “No”
- Helps you explain math: "So you are saying...."

\(^9\)White Boards Method
How Does Active Learning Work

- TA starts with 10 minute summary of lectures
- You and the TA work assigned problems
- First TA solves a problem at white board
  - With your input via Think-pair-share, Step-by-step
- Then you solve 3 assigned problems
  - Work solo or in groups of 2 at tables
  - TA circulates, answering your questions
  - You explain solutions to neighbors and to TA

You are actively solving problems and can get immediate feedback
Why Do Active Learning?

Educational Research on STEM courses shows:

1. You learn significantly more with an active learning technique than with traditional methods.

2. Your chance of failing with an Active Learning format is 66% less than with a traditional format.
Why Do Active Learning?

Your peers in a UT Dallas Calculus course say:

“The problem sessions, too, were much better than any I’ve had in the past. They were relaxed, engaging, and helpful to my comprehension.”

“The problem sections were much more productive with the students working problems in groups as opposed to another lecture from the TA.”

“The structure of the problem sessions is the best I’ve ever seen. You get to learn by working with others. Allowing us to explain material with a TA’s guidance is highly beneficial.”