The transformation of my Calculus II course

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November 14, 2017
The transformation of my Calculus II course

1. Ideals
   - Active learning is beneficial
   - Active learning is fun
   - Implementing active learning is not as difficult as it may seem

2. Active learning techniques
   - WeBWorK (outside of class)
   - Clickers (polling the entire class)
   - Participation points + posting notes on Blackboard
   - Recitation worksheets
   - Ebert-May methods (team work in large lecture)
   - Individual + team quizzes
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Active learning is beneficial to students

Mathematics is not a spectator sport

http://slideplayer.com/slide/6912071/
Active learning is beneficial to students

“Math is not a spectator sport. It’s not a body of knowledge, it’s not symbols on a page. It’s something you play with, something you do.”

-Keith Devlin, quoted in The Game Believes in You

http://blog.mindresearch.org/blog/making-educational-games-tantalizingly-tricky
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Active learning is fun for students
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Student feedback on active learning

On Monday 11/13/17 I asked my students:

Clicker poll question: Which teaching technique do you prefer in large math classes?

A: Active learning  B: Lecture
Student feedback on active learning

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Clicker poll question: Which teaching technique do you prefer in large math classes?
A: Active learning  B: Lecture

[Bar chart showing 76% and 24%]
Student feedback on active learning

“Speaking from my personal experience, I learn much better in an active learning environment, such as you are creating in lecture. In this environment I am much more engaged and learning much more than my other classes (more passive learning).

In the past I have been in math classes where the professor/teacher would go through example after example on the board. This was only helpful to some extent because after class I would leave with only the knowledge how to solve those exact problems. I wish other professors would see the benefit in this teaching style because in the active classroom I feel as if I am building on my skills more so than my ability to memorize content.”

– A computer engineering student in my class this semester
Active learning is fun for instructors
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Implementing active learning in large lectures is not as difficult as it may seem.
Implementing active learning in large lectures is not as difficult as it may seem
Timeline of transformation for my Calculus II

- Spring 2009: Macalester College - lecture.
- Fall 2010: Augsburg College - lecture.
- Fall 2016: (STEM 112) Implemented clickers + participation points. Lectured by writing on the document camera; posted notes on Blackboard. Made worksheets for recitation. Started in the Gateways-ND program.
- Spring 2017: (Ladd 107) Used document camera again, but started using some prepared documents rather than writing everything in real time.
- Fall 2017: (STEM 112) Implemented Ebert-May methods. Prepared theorems and clicker / team problems on tablet before class; worked problems with tablet pen in real time. Individual + team quizzes.
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WeBWorK or other online homework (e.g. WebAssign)

Note: WeBWorK is technically not ‘active learning’, since this phrase refers to activities students do during class.

WeBWorK Demo

Benefits:
- Students obtain instant feedback on whether they are working problems correctly.
- Easy set up for instructors. Automatic grading and import of grades to Blackboard.

TA quote (Adam Buskirk): “It seemed like an excellent way to ensure students were actually working through problems, encouraging them to seek help if they didn’t understand the material.”

Drawback: Students can find answers online for many problems, rather than working the problems themselves (also true for written homework, take-home exams, etc.). Response: Better than requiring no work outside of class.
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Active learning techniques

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Clickers (Polling the entire class)

Clicker and clicker question demo

Benefits of clickers:

- Instructor obtains instant feedback on student understanding from the entire class, not only those willing to speak up.
- Students receive instant feedback on their understanding, helping them identify concepts they need to study further.
- Allows for participation points or graded work to be easily given.
- Easy set up for instructors. Automatic grading and import of grades to Blackboard. Technical support from NDSU Instructional Services.

Possible Drawback:

- Cost for students. **Response:** Unified system for the whole campus and widespread use mean students are likely to already have a clicker or the ResponseWare app.
Kinds of clicker questions

- Conceptual / common misconceptions
  e.g. Is .9999 A: really really close to 1, or B: equal to 1.

- Make a guess
  e.g. Do you think the series will A: converge or B: diverge?

- Techniques
  e.g. What integration technique should we use? (ABCDEFG responses)

- Computational (Numerical response)
  Work a problem individually or in a group and enter your numerical answer.
Using clicker questions in class

Clicker questions + participation points

I give one participation point each day to students who answer at least 50% of the clicker questions (correct answers are not required). Attendance is consistently high, around 80-90%.

A case for participation points: Some students will come to class no matter what, and some students will not come to class no matter what. But there’s a large group of students in the middle who could swing either way, and participation points are something that can give that needed extra bit of motivation to attend.
Clickers vs. response cards

Benefits of using clickers instead of response cards:

- **Versatility:** Response cards are limited to questions with ABCD answers. Clicker questions can use numerical entry or more choices for multiple choice.
- **Students are more likely to participate.**
- **Students are more likely to answer honestly without fear of their peers seeing they were wrong.**
Clickers vs. response cards example

Clicker question: Have you ever played with Spirograph?
Clickers vs. response cards example

Clicker question: Have you ever played with Spirograph?

Spring 2016 with response cards: No students responded ‘Yes’
Clickers vs. response cards example

Clicker question: Have you ever played with Spirograph?
Spring 2016 with response cards: No students responded ‘Yes’
Fall 2016 with clickers: 50% Yes, 50% No
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Participation points + posting notes on Blackboard

Blackboard demo

Benefits of posting notes on Blackboard:
- Students are freed to spend class time thinking, discussing, and working problems rather than feverishly taking notes.
- Students have a way to find out what they missed and take responsibility for it if they are absent.
- Communicates with TAs exactly what was discussed in lecture.

TA quote (Megan Jensen): “Posting the notes from lecture is great! It eliminates the common excuse of “I wasn’t in class so I don’t know what she went over.” It is also very useful as a TA because we know exactly what you covered in class.

Student quote: “I love the notes on the screen and that they are posted online.”

Possible Drawback: Posting notes may make students less likely to attend class. Responses: More resources + Participation points.
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Recitation worksheets

I provide a worksheet for my TAs most Tuesdays; students submit the worksheet as their ‘team work’ for the class, graded for effort.

Worksheet example

Benefits of recitation worksheets:

- Ensures group work is happening in recitation
- One worksheet for all sections allows me to reference the worksheet during large group class.

TA quote (Ben Noteboom): “I’m a big fan of having group work/worksheets in recitation. Group work allows the students who are doing well to further their understanding by explaining concepts to other students and it helps the students who are doing poorly to learn from their peers, which is often more efficient because it is one-on-one. It also allows me to go around and answer specific questions in small group formats, which makes it easier to make sure everyone is following me.”
Timeline of transformation for my Calculus II

- Spring 2009: Macalester College - (interactive) lecture.
- Fall 2010: Augsburg College - (interactive) lecture.
- Spring 2016: (Ladd 107) Taught large lecture primarily using (interactive) lecture on the whiteboard. Asked occasional questions with notecards for ABCD responses. **Webwork**.
- Fall 2016: (STEM 112) Implemented **clickers** + participation points. Lectured by writing on the document camera; **posted notes** on Blackboard. Made **worksheets for recitation**.
- Spring 2017: (Ladd 107) Used document camera again, but started using some prepared documents rather than writing everything in real time.
- Fall 2017: (STEM 112) Implemented **Ebert-May methods**. Prepared theorems and clicker / **team problems** on tablet before class; worked problems with tablet pen in real time. **Individual + team quizzes**.
Gateways-ND

A five-year National Science Foundation (NSF)-funded instructional faculty and staff development program, hosted by NDSU’s Office of Teaching and Learning, designed to offer relevant, collaborative, and sustained support to NDSU educators with a desire to:

- Make their STEM courses learner-focused and engaging,
- Draw on modern evidence-based pedagogy and course design to increase student learning,
- Improve student outcomes in their courses, and
- Join a supportive cohort of faculty interested in teaching and learning.
Gateways-ND perspective

- All students can learn successfully.
- Education research should inform teaching.
- Student-centered teaching practice enhances learning.
- Interaction is a hallmark of student-centered instruction.
- Evaluation of learning and teaching is vital.
- We enrich each other by working together.
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Ebert-May methods (team work in large lecture)

Students form permanent teams of 3-4 on the first day of recitation. Students work in these teams each day in class, both in recitation and lecture and submit their team work.

Organizational materials demo:

Benefits:

- More student engagement/discussion. Much higher percentage of students actually participating compared to previous semesters when I’d ask them to ‘discuss with the person next to you’.
- Effective way to pass back papers, even in lecture.
- Name cards help instructors learn names of students.

Drawbacks + Responses:

- More grading for TAs. **Future response:** LAs.
- Name cards work better in some rooms than others. **Response:** Consistency.
- Transporting boxes. **Response:** Folders convey responsibility.
Notes comparison:

**Drawback**: Time spent on team problems means less time on delivering content via lecture.

**Responses**:
- Preparing some of the notes ahead of time and not spending time writing these things on the board frees up class time for students to work on problems.
- Other ways to deliver content. (Future: Perusall)
- Sage on the stage vs. guide on the side.
- Students find out what they don’t understand.
Active learning is beneficial to students

“The danger of lectures is that they create the illusion of teaching for teachers, and the illusion of learning for learners.” ~ Albert Camus

COPUS comparison

The Classroom Observation Protocol for Undergraduate STEM: An Instrument to Characterize University STEM Classroom Practices

COPUS provides data on how students and faculty are spending their time in the classroom. Every two minutes, the observer marks code(s) for what the students were doing and what the instructor was doing.
Fall 2016 COPUS for my MATH 166 class (prepared by Rebecca Reichenbach)

**FALL 2016 "STUDENTS DOING"**

- **L** (73%) - Listening
- **Ind** (6%) - Individual thinking / working
- **OG** (3%) - Other group activity
- **AnQ** (13%) - Answering questions
- **CG** (1%) - Discussing clicker in group
- **W** (3%) - Waiting
- **O** (1%) - Other

**Student Codes present:** L (listening), Ind (individual thinking / working), CG (discussing clicker in group), OG (other group activity), AnQ (answering questions), W (waiting), O (Other)
Fall 2017 COPUS for my MATH 166 class (prepared by Rebecca Reichenbach)

STUDENTS DOING

- L (listening): 43%
- CG (Discuss Clicker question in groups): 19%
- OG (other group work): 12%
- AnQ (Answering question): 9%
- SQ (student asks a question): 2%
- W (Waiting): 1%
- O (other): 0%

Codes Present: L (listening), CG (Discuss Clicker question in groups), WG (work on worksheet in group), OG (other group work), AnQ (Answering question), SQ (student asks a question), W (Waiting), O (other)
Instructor Codes present: Lec (Lecture), RtW (Real-time-writing, includes ppt slides), FUp (follow up to a question or activity), PQ (Posing non-rhetorical questions), CQ (clicker question), D/V (demonstration / video), Adm (administrative work), W (waiting)
Codes Present: Lec (Lecture), RtW (Real Time Writing incl. computer, whiteboard, doc cam), FUp (Follow-up to an activity or question), PQ (posing a question), CQ (Clicker Question), AnQ (Answering a student question), MG (Moving among / monitoring student groups), Adm (Administrative)
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Individual + team quizzes

Students are given 15 minutes to complete a quiz in recitation. Then students work with their team for 10-15 minutes on the same quiz and submit another quiz together as a team.

Benefits:
- Harnesses post-quiz energy / desire to know the right answer.
- Peer-to-peer instruction.

TA quotes: (Michael Preheim) “The new quiz format has been very effective and it is exciting to see students undergo such animated discussions about mathematics during a quiz.” (Danny Luecke) “Students are super eager to talk about the problems together. I do the same strategy in Bill’s recitation because it seems to work very well. This method has been fantastic for learning.”

Possible Drawback:
- Takes more time. Response: Time well-spent.
Future plans

Spring 2018:

- Continue with Webwork, clickers, posting notes on Blackboard, Ebert-May methods (team problems), recitation worksheets, individual + team quizzes.

- Add **Learning Assistants** to circulate and help students with team problems during lecture. LAs will grade the team problems for content, not only completion, so the students will be more motivated in class to find correct answers to problems and write coherent explanations.

- Add a technique I saw used well in Amy Werremeyer’s class: **calling on students** to share what they discussed during their team work **using name notecards**.
Future plans

Would like to use Perusall to enable/require students to interact with the textbook outside of class.

Perusall demo:

**Benefits:** Students will have worked on learning the concepts before coming to class, freeing up time in class to clarify common misconceptions and for students to ask questions / work problems.

**Challenge to implementation:** This would need department support, since it would involve negotiation with the publisher. (The NDSU Biology department recently negotiated 2-year access to their textbook in Perusall for a much lower price for students than the print textbook.)
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Thanks!

Open invitation: You are welcome to visit my class any time:
12:00–12:50 MWF in STEM 112

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