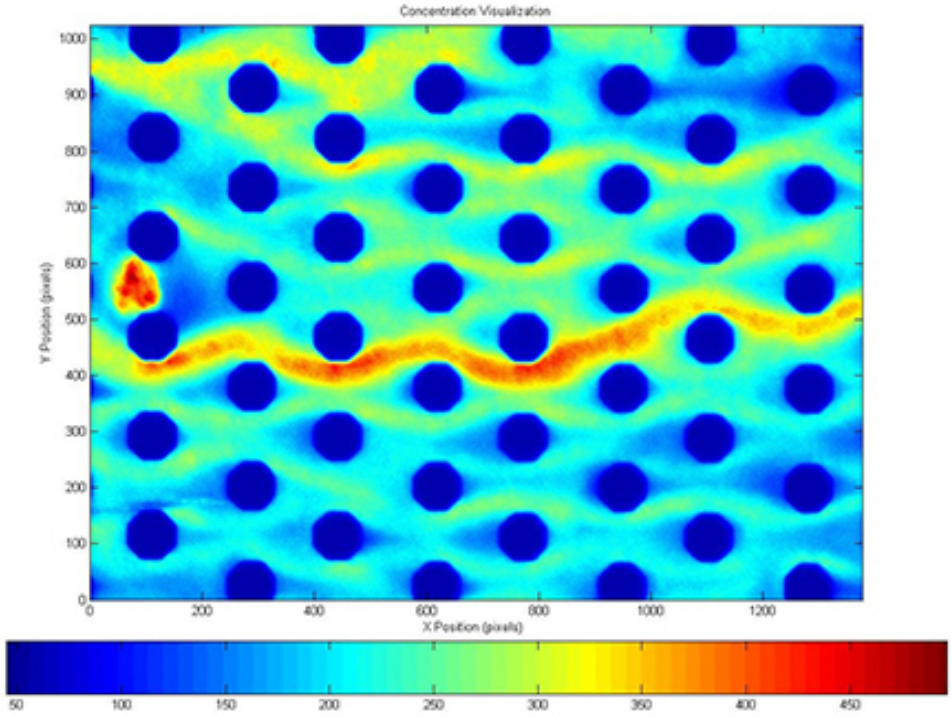
Student Led Example Problems in a Graduate-Level Advanced Transport Phenomena Course

Adrienne R. Minerick
Chemical Engineering
Michigan Technological University
Houghton, MI 49931

Michigan Tech
Create the Future

Background: Transport Phenomena Course

- Traditional core graduate-level course in Chemical Engineering.
- Utilizes foundations in vector and tensor analysis, ordinary and partial differential equations
- Momentum, heat, and mass transfer, which have parallel underlying mathematical representations of conservation principles.

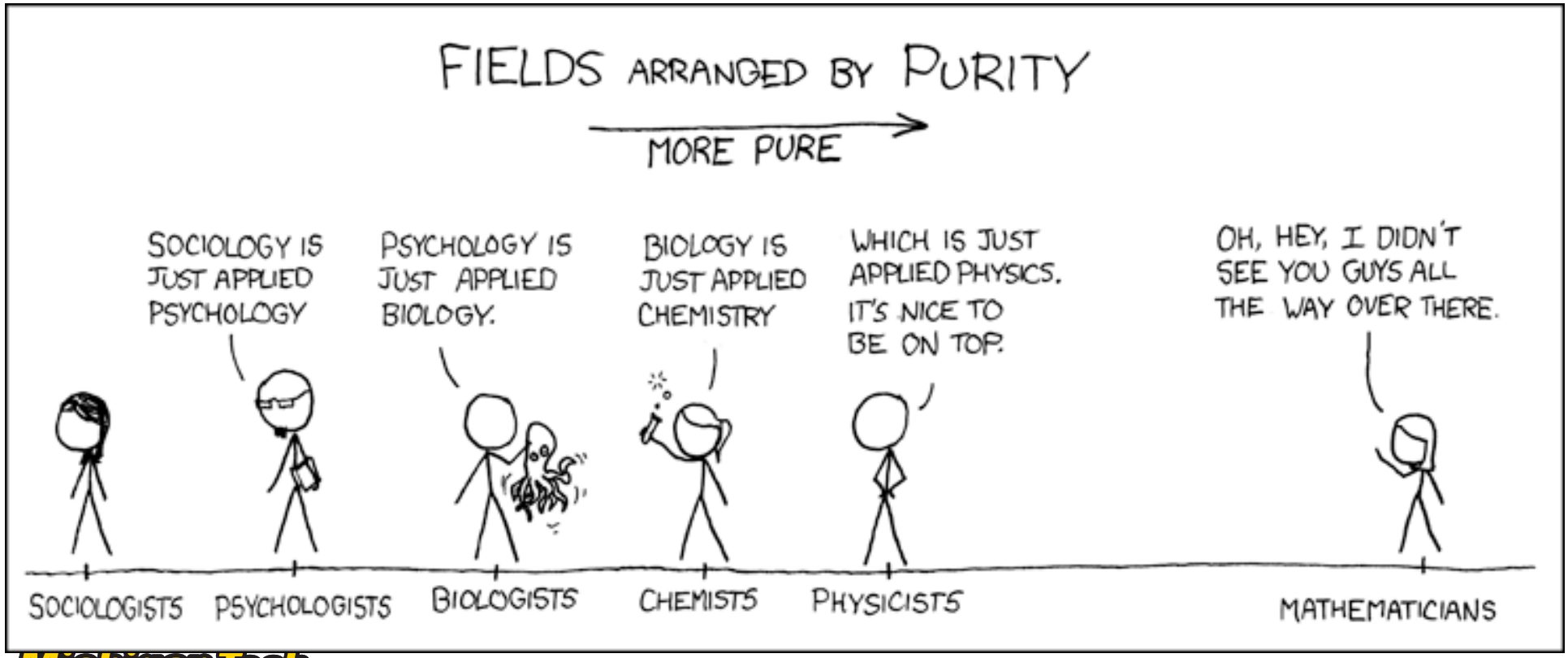


Concentration of a Viscoelastic Surfactant in a Silicon Micromodel. Image courtesy Prud'homme Research Group

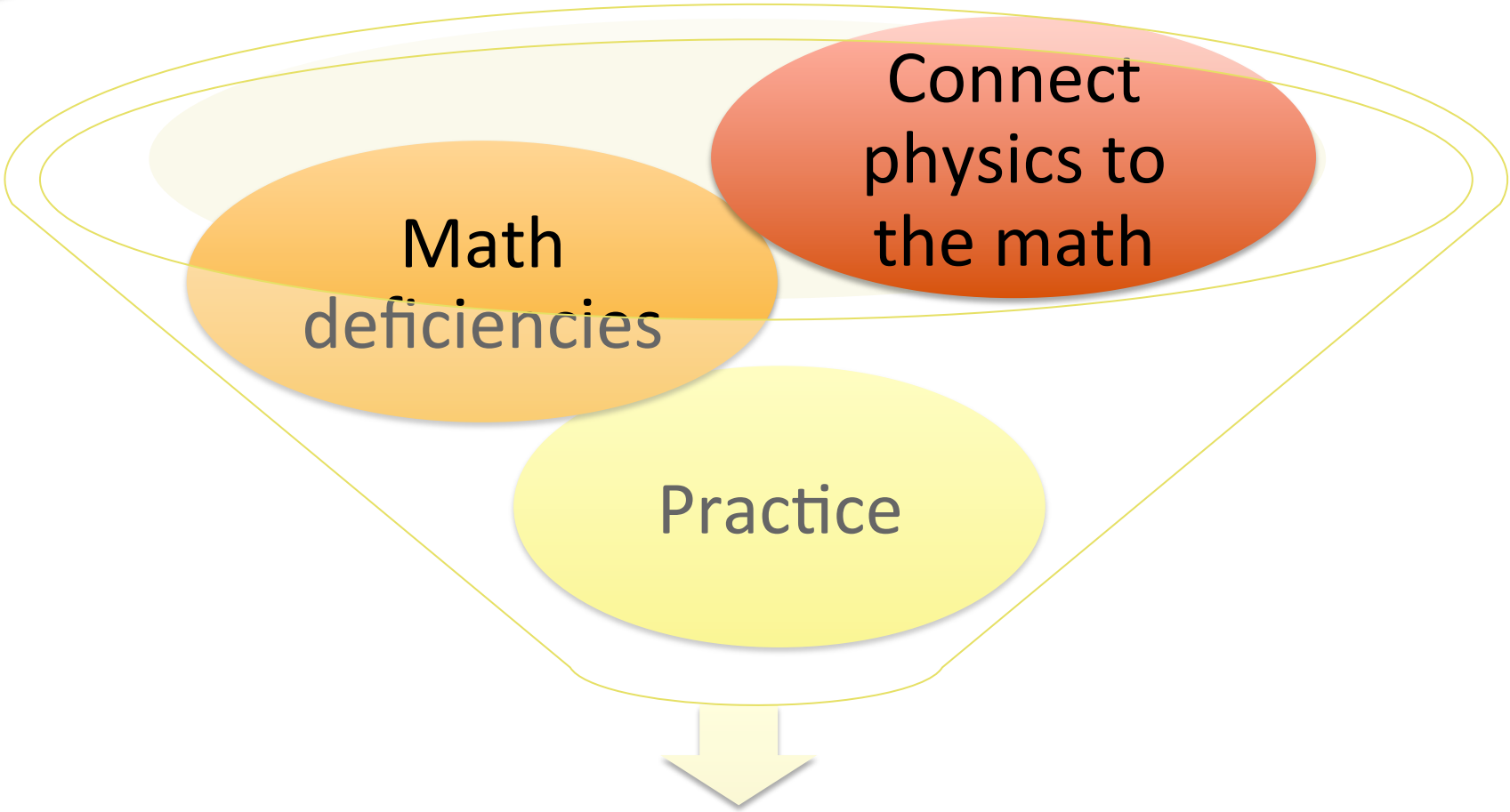
Michigan Tech
Create the Future

Challenge in the Course

- Translate between the transport physics and the mathematical representation



Reasons why students struggle



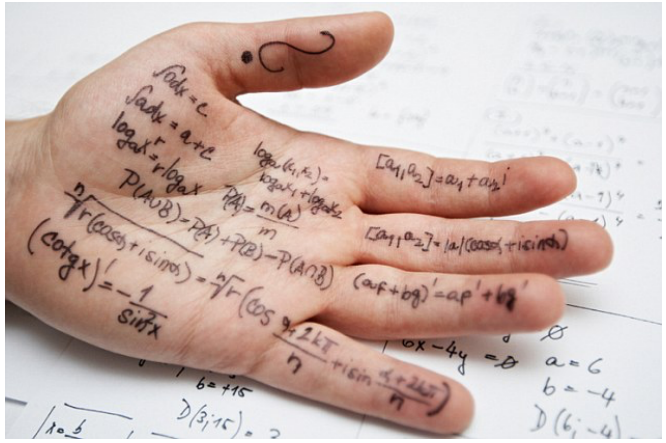
Goal: Optimize to True Material Mastery

BEFORE (2011-2012)	AFTER (2015)
• Guide students through material (in person) • Provide opportunities for practice (Required HW) • Office Hours • Grade HW • Test	• Guide students through material (online) • Provide opportunities for practice • Framework to ensure practice (student led examples)

Increasing Student Control & Active Engagement

BEFORE: Traditional HW model

- Cheating as high as 80% with a higher percentage on assignments [1, 2]
- Homework intensive courses do not benefit learning of all students. Engineering students classified as
  - "why" learners (14%)
  - "what" learners (21%)
  - "how" learners (49%)
  - "what-if" learners (19%) [3]
- Most complete HW with solution manual open → conforms students to rote problem solving



http://i.dailymail.co.uk/i/pix/2014/05/03/article-2619387-1D89EE7800000578-606_634x421.jpg

Small learning communities enable peer-to-peer communication of concepts to benefit a broader spectrum of learners.

Intervention Pedagogy

Homework

On own, individual, small group, solutions manual

2011 (credit)

2012-13 (no credit)

Student Led Examples

Team of 2, 1 problem, content feedback, delivery feedback, Students conduct in class

Lectures

2011 on whiteboard

2012 Doc camera, PPT

2013, In-person class, Recorded PPT

2014, In-person class, Recorded PPT

Flipped Classroom

2015, pre-recorded lectures

Online questions, in class answer session (recorded)

Student Peer Instruction

- Majority of student peer teaching efforts conducted in laboratory [5, 6] or workshop settings [4].
- Peer tutoring enhances content mastery for both student sharing information and student receiving information [5, 7].

https://ovpi.uga.edu/student-opportunities-resources

- Many students have lower inhibitions asking questions of other students than of the instructor [4, 5].
- Student to student instruction also more effectively conveys steps that the instructor may overlook [4, 6].

Student Peer Instruction is not all =

- **Control Group:** students studied material for a test
- **Preparation Group:** students prepared materials to teach
- **Teaching Group:** students prepared and taught the materials

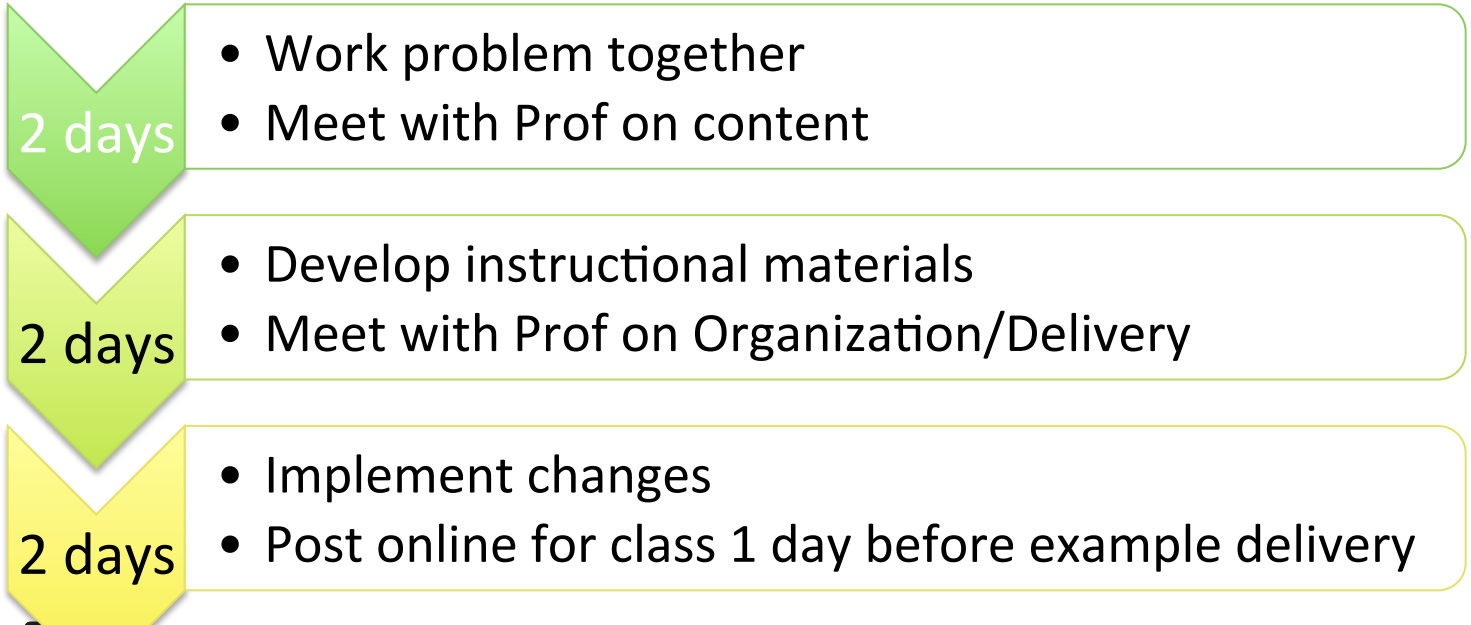
http://www.hercampus.com/high-school/preparing-college/picking-professors-what-keep-mind

- When students actually teach the content, they develop a deeper and more persistent understanding of the material than from solely preparing to teach or than simply studying [8].
- Bargh and Schul [9] found that students personally involved a teaching situation scored higher on an achievement test than those who did not teach.

Implementation in Transport

- To create time for student led examples in class, flipped lectures.
  - Pace of three online, 50 min lectures per week
  - One Q&A session per week
  - One student led example per week

Team of 2 students assigned problem >1 week in advance



Michigan Tech
Create the Future

Logistical Advice

- Assignment sheet includes clear outputs expected
  - Lecture materials with narrations
  - Fill in the blank handouts with narrations for students
  - Quality of the lecture (Correct, Accessible)
- Rubric provided to students in advance
- Advice (reinforced in feedback)
  - Do not “blow people away” by going too fast
  - Do not refer to steps as “elementary” or suggest things are “obvious”.
- Set improvement goals for 2nd student-led example

Rubric

Person 1		Grade	Notes
Class Materials for Example (40 points)			
a) Neat, well organized materials and diagrams (File #1 and #2)	10		
b) Handouts designed to be interactive (File #1)	5		
c) Thorough: student accessible phrases and diagrams explaining concepts (File #2)	15		
d) Incorporates instructor feedback, proactive communication	10		
e) Submitted on time (1 point will be removed for every minute the materials are late, max 20)			
Example in class (30 points)			
a) Well organized delivery	10		
b) Helpful, logical approach with appropriate detail/explanation	5		
c) Strategic interaction with class to make them think	5		
d) Pace, friendly delivery	5		
e) Invite questions & keep students engaged	5		
Class Feedback for Team	10		from evaluations
Class Feedback for Individual	10		from evaluations
Team Evaluations	10		
Overall Individual Grade	100	0.0	

Comments here

Assessments

#1) Formative evaluation by the class, reviewed, then provided to the students

#2) Summative evaluation presenting students do of themselves and their team

- Anonymous survey (IRB approved with consent, mid- and post-semester):
  - A. Exam preparation
  - B. Student-led example sets
  - C. Attitudes toward course structure/style
  - D. Attitudes toward time
  - E. Knowledge and application of that knowledge

Years/Students

Progression:

- In both 2011 and 2012, one less chapter of material was covered than in 2013, 2014, and 2015.
- Lectures were recorded in 2013 and 2014.
- The lectures from 2014 were utilized in 2015 for the flipped classroom.

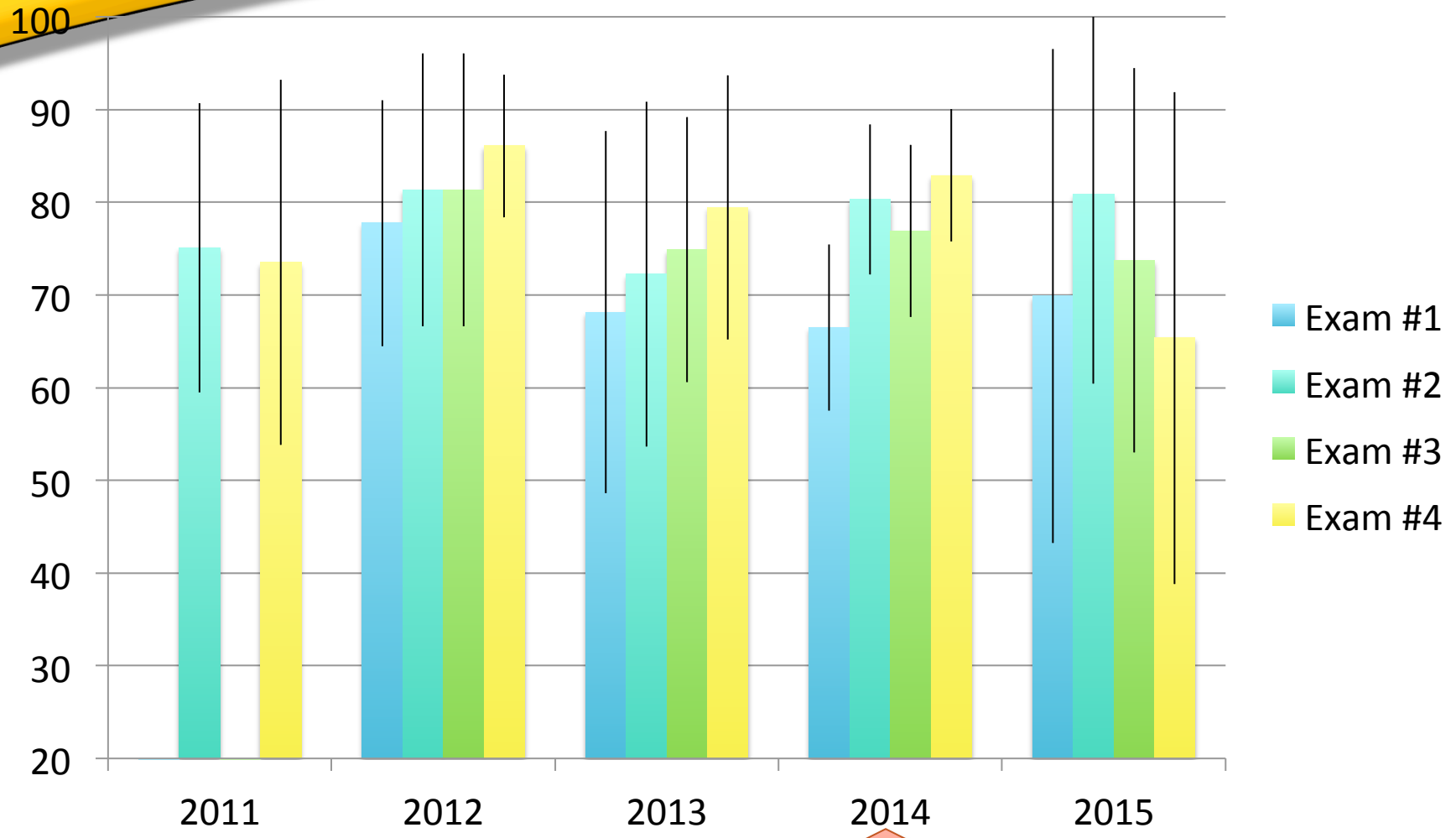
Repeat students in classroom

Year	Enrollment
2011	19
2012	21
2013	18
2014	12
2015	11

~3 to 4 students struggle each year

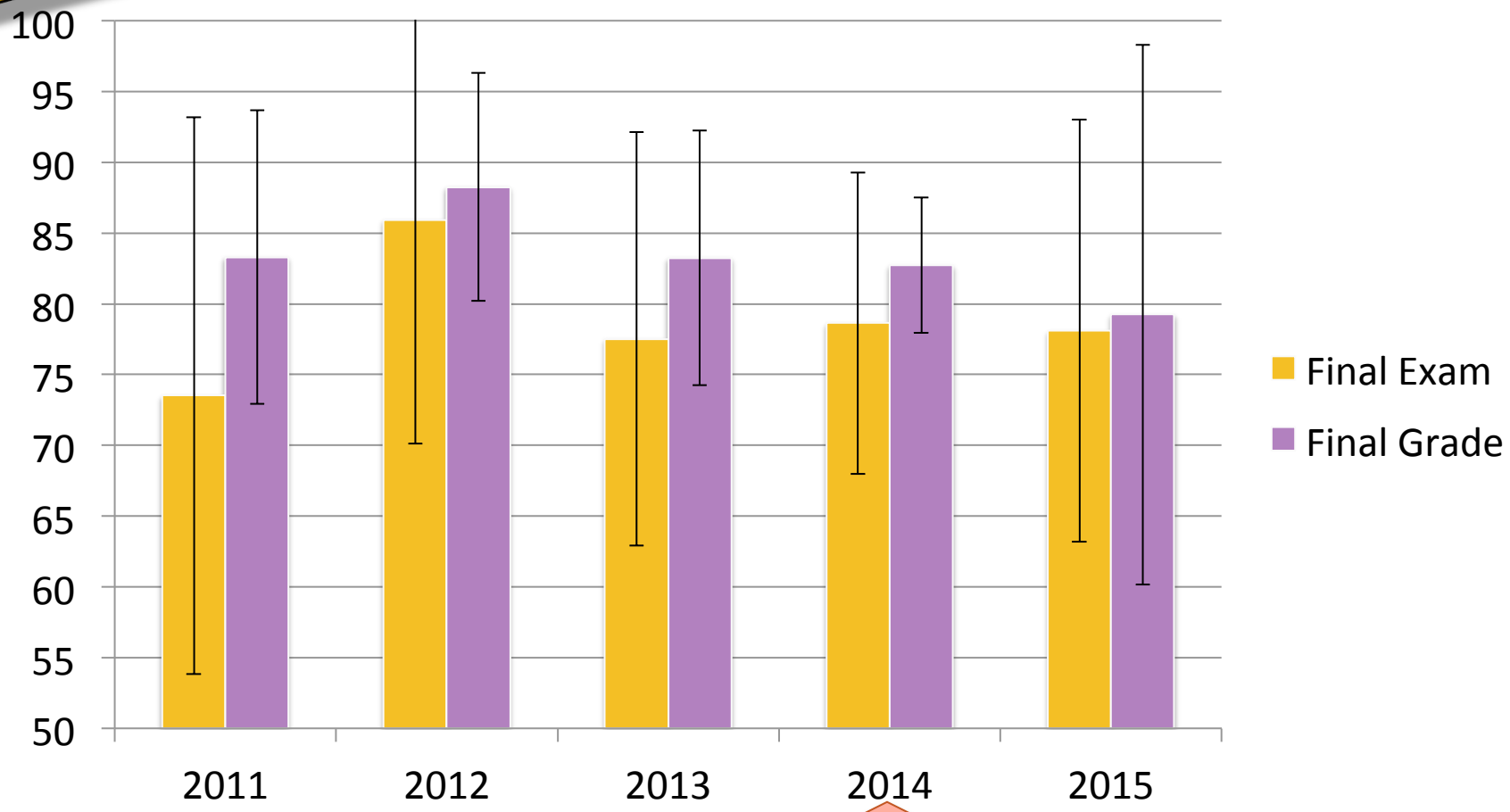
Michigan Tech
Create the Future

Student Exam Performance



Student Led Examples

Final Exam Performance

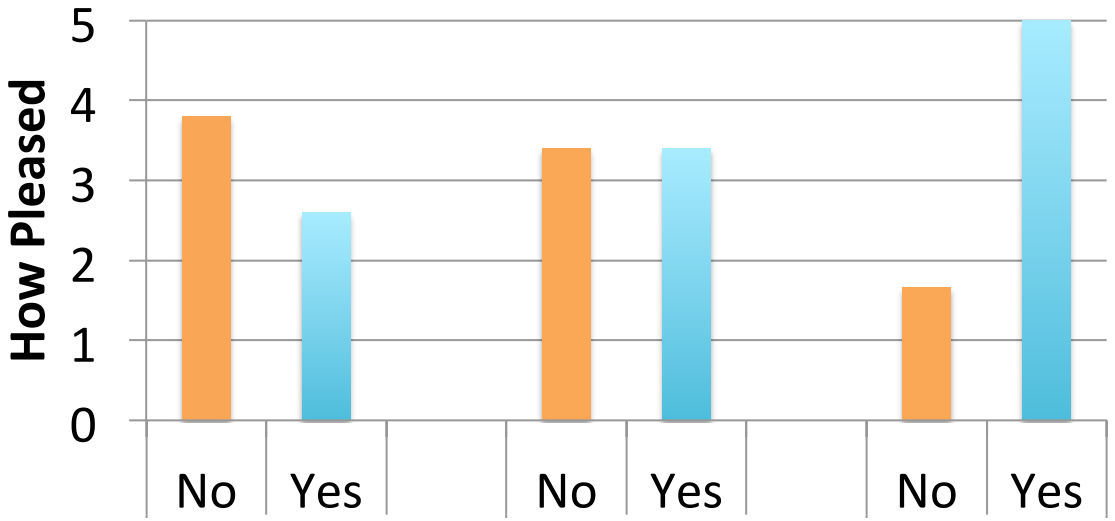


Student Led Examples

Michigan Tech
Create the Future

Assessment: Attitudes

- 10/11 participated in mid-semester survey, 5/11 in end-semester survey
- Section A: How pleased the students were with their performance exams roughly correlated to the number of hours they studied, but not to whether they had completed a student led example.



Michigan Tech
Create the Future

Assessment: Attitudes

Section B: Student-led example sets

- Prepare: How much did preparing example materials improve your understanding of concepts?
- Deliver: How much did delivering the example materials in class improve your understanding of concepts?
- Retain: Did delivering the example materials increase retention of difficult material?

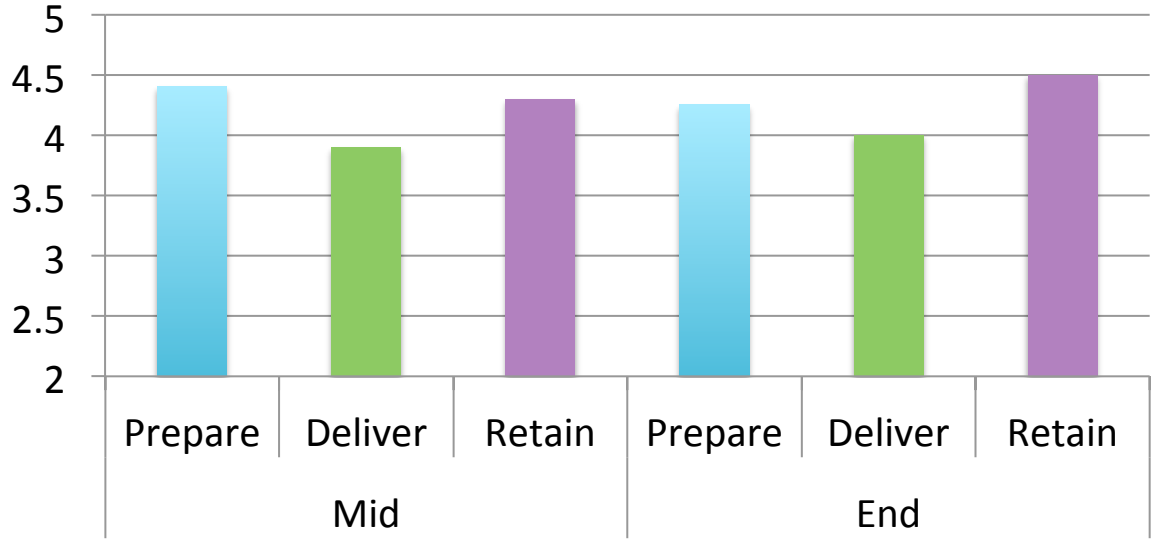
5 - Substantially Improved

4 - Improved

3 – Neutral

2 - Reduced

1 - Substantially Reduced



Michigan Tech
Create the Future

Assessment: Attitudes

- C. Attitudes toward course structure/style
- D. Attitudes toward time
- E. Knowledge and application of that knowledge

In paper….

Student Attitudes

- I really liked this student led presentation. It was a good learning experience. I wish you could do it twice a week!

- I am a busy grad student and didn't have time to devote 20+ hours to one presentation. Time guidelines for the project may help future students have an idea of how much time is expected to be spend on this. [My team mate and I] had very different views on how much time each task would require, which caused some issues, I think. Good – I really learned that material and felt confident about the concepts.

- I would like to be a teacher someday, but a good one. The experience with this course is not only reinforcing my transport phenomena knowledge and understanding, but also is teaching me strategies to share knowledge with others. I really feel and intensive activity of learning, with hard work and without pain.

- I feel these example problems are helpful because the students get to learn from each other and we can see the problems worked out different ways. Having examples in general help with learning the material. It can be improved by having the students do less of a presentation format and more of an open discussion format. Not sure how to accomplish this though.

Conclusions: Student Led Examples in Transport

- Imperative for students to connect the physics of transport with the mathematical representation of that physics.
  - Requires regular practice
- Student led example problems facilitate purpose-driven study environments to understanding of the physics, the mathematical representation of that physics, and math skills.
  - Mechanism to flip traditionally math intensive graduate classroom
  - Students are actively solving problems, practicing, and discussing the physics in the classroom with the assistance of fellow students and the instructor.
  - Process is open, interactive, and iterative
- Resources provided to guide material preparation, rubrics used for assessing the example in class, and team member evaluations.
- Student…
  - Proficiency on tests was unchanged
  - Feedback was mostly positive
  - Self-assessments support prior research that teaching improves learning and understanding.

Conclusions: Student Led Examples in Transport

- From an instructor's perspective…
  - A greater level of proficiency is reached via the student-led examples than was achieved with the traditional graded homework format.
  - Student-led example approach led to much more intellectually beneficial interactions.

References

[1] R.M. Felder, Random Thoughts... HOW TO STOP CHEATING (OR AT LEAST SLOW IT DOWN), Chemical Engineering Education, 45 (2011) 37-38.

[2] H.J. Passow, M.J. Mayhew, C.J. Finelli, T.S. Harding, D.D. Carpenter, FACTORS INFLUENCING ENGINEERING STUDENTS' DECISIONS TO CHEAT BY TYPE OF ASSESSMENT, Research in Higher Education, 47 (2006) 643-684.

[3] L.E. Bernold, Paradigm Shift in Construction Education is Vital for the Future of Our Profession, J. Constr. Eng. Manage. , 131 (2005) 533-539.

[4] J.M. Foley, A.M. Verhoff, J.J.P. Jr., K.M. Ropella, Workshops on Fundamental Engineering Skills: A Graduate Student-Led Teaching Initiative, American Society for Engineering Education Annual Conference, 2014.

[5] E.M. Kim, T.F.S. Jr., F.G. Jacobitz, Student Peer Teaching in Engineering Laboratory Situations, American Society for Engineering Education Annual Conference, 2014.

[6] M.A. Munoz-Garcıa, G.P. Moreda, N. Hernandez-Sanchez, V. Valino, Student Reciprocal Peer Teaching as a Method for Active Learning: An Experience in an Electrotechnical Laboratory, J Sci Educ Technol, 22 (2013) 729–734.

[7] D. Borrelli, S. Masten, Empowering Engineering Students in the Educational Process, American Society for Engineering Education Annual Conference, 2008.

[8] L. Fiorella, R.E. Mayer, The relative benefits of learning by teaching and teaching expectancy, Contemp. Educ. Psychol., 38 (2013) 281-288.

[9] J.A. Bargh, Y. Schul, ON THE COGNITIVE BENEFITS OF TEACHING, Journal of Educational Psychology, 72 (1980) 593-604.

[10] N.M. Mazzarella, Students Teaching Students Boosts Enthusiasm, Learning, The Teaching Professor, 17 (2003).

[11] M.J. Borrego, M.J. Prince, C.E. Nellis, P. Shekhar, C. Waters, C.J. Finelli, Student Perceptions of Instructional Change in Engineering Courses: A Pilot Study, American Society for Engineering Education Annual ConferenceIndianapolis, IN, 2014.

[12] Esat Alpay, P. Cutler, S. Eisenbach, A. Field, Changing the Marks Based Culture of Learning through Peer Assisted Tutorials, American Society for Engineering Education Annual Conference, 2009.

[13] K. McDonald, Increasing the Class Participation Experience for Engineers, American Society for Engineering Education Annual Conference, 2006.

[14] C.D. Schmitz, M.C. Loui, R.A.R. Alonso, Improving Student Engagement Via Content Personalization, ASEE Annual ConferenceAtlanta, GA, 2013.

[15] A.R. Minerick, Desktop Experiment Module: Heat Transfer, Chemical Engineering Education, 44 (2010) 274-279.