A Tale of Two Classes: student & instructor perceptions of two-stage tutorials in introductory genetics classes

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Session outcomes

- Increase awareness of the benefit of using the two-stage collaborative approach across various facets (i.e., in-class activities, assessments, tutorials) of a course.

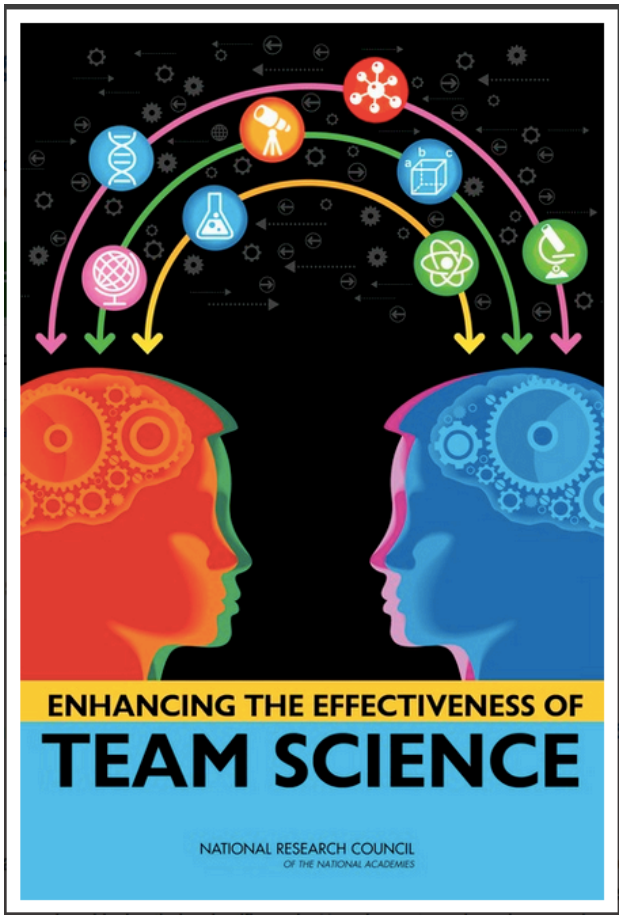
- Gain tips in implementing the two-stage tutorial in your own classes.

The scene…

- Intro genetics: York & UTM
  - Similar student-body demographics
  - Both large classes (York: 250 students; UTM: 410)

- Redesigned our classes to incorporate collaborative learning:
  1. Peer Instruction (in-class)
  2. Two-stage exams (in-class)
  3. Two-stage tutorials (mandatory tutorials)

Collaborative Learning



Science is collaborative

We think collaborative learning is important, so we added it to our LOs

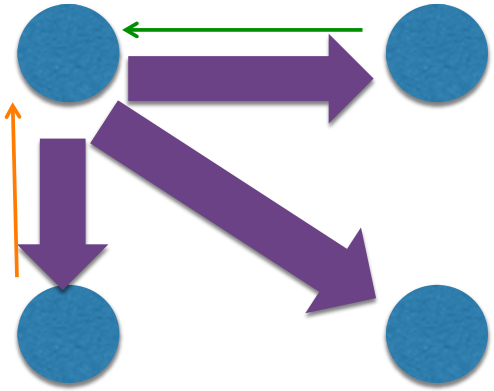
Example from course Learning Outcomes:

B Communicate information, arguments, and analyses accurately and reliably (in both written and verbal form) on your own, in pairs, and in small groups, during lectures (and associated activities), tutorials, and exams.

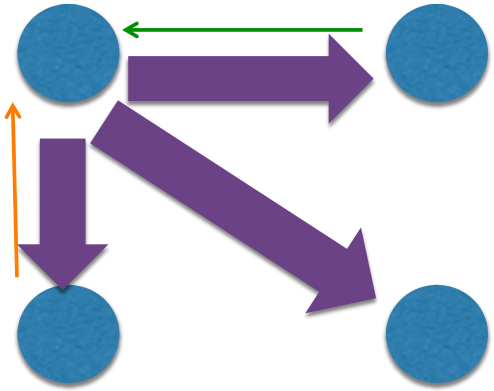
B1. Work effectively and collegially with peers in lectures, tutorials, and exams.
   a. Listen to what your peers have to say, and participate in discussions collegially.

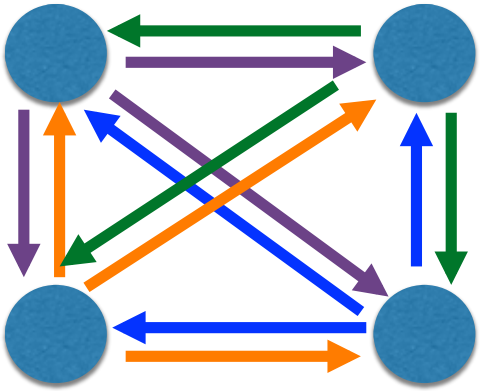
B2. Communicate information, arguments, and analyses accurately and reliably in verbal and written form during class activities, and on assignments, quizzes, and exams.
   a. Given a problem, identify what is asking, what is known, and what information is needed to solve the problem. Summarize provided information into a model if necessary.
   b. Use the scientific method to solve problems: systematically generate (come up with) a hypothesis or prediction, test the prediction, and then accept or reject the prediction.

Collaborative Learning



Collaborative Learning

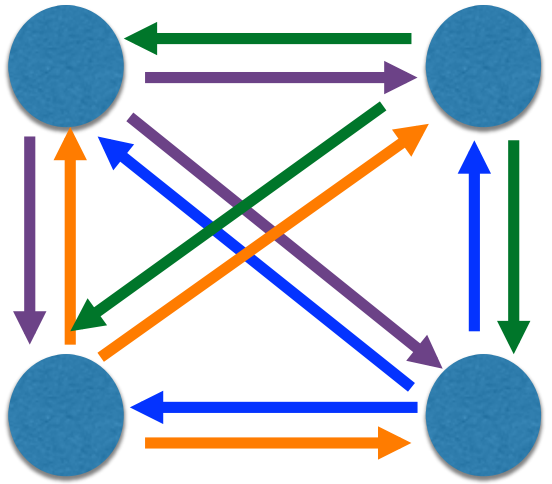




“students to move from viewing instructors and texts as sole authorities to seeing themselves, their peers, and their community as important sources of knowledge.” -Nilson, 2010

1. Peer Instruction/Discussion

- Students work on a clicker problem/worksheet on own
- Submit answers
- Get into groups & discuss same clicker Q or complete a new worksheet, often with more difficult questions.



Peer Instruction can be delivered via “high” or “low” tech methods

Crouch & Mazur, 2001
Crouch et al. 2007
Smith et al., 2009, 2011

Low tech version of PI

Answer this Q on your own

Turn and look at the person to your left. If there's no one on your left, turn to your right.*

Do you have the same genes on your chromosome 12 as the person next to you?

YES NO

**if there is no one on either side of you, move to another part of the room where you are sitting next to at least one other person.*

Low tech version of PI

Discuss this question with 1-3 of your neighbours

Do you have the same genes on your chromosome 12 as the person next to you?

YES NO

2. Two-stage exams

- Individual tasks followed by the same/slightly more difficult tasks as a group

- Marks allocated to the individual and the group
    - 85% individual; 15% group (or some variation)

Students Positively Responded to Two-Stage Exams

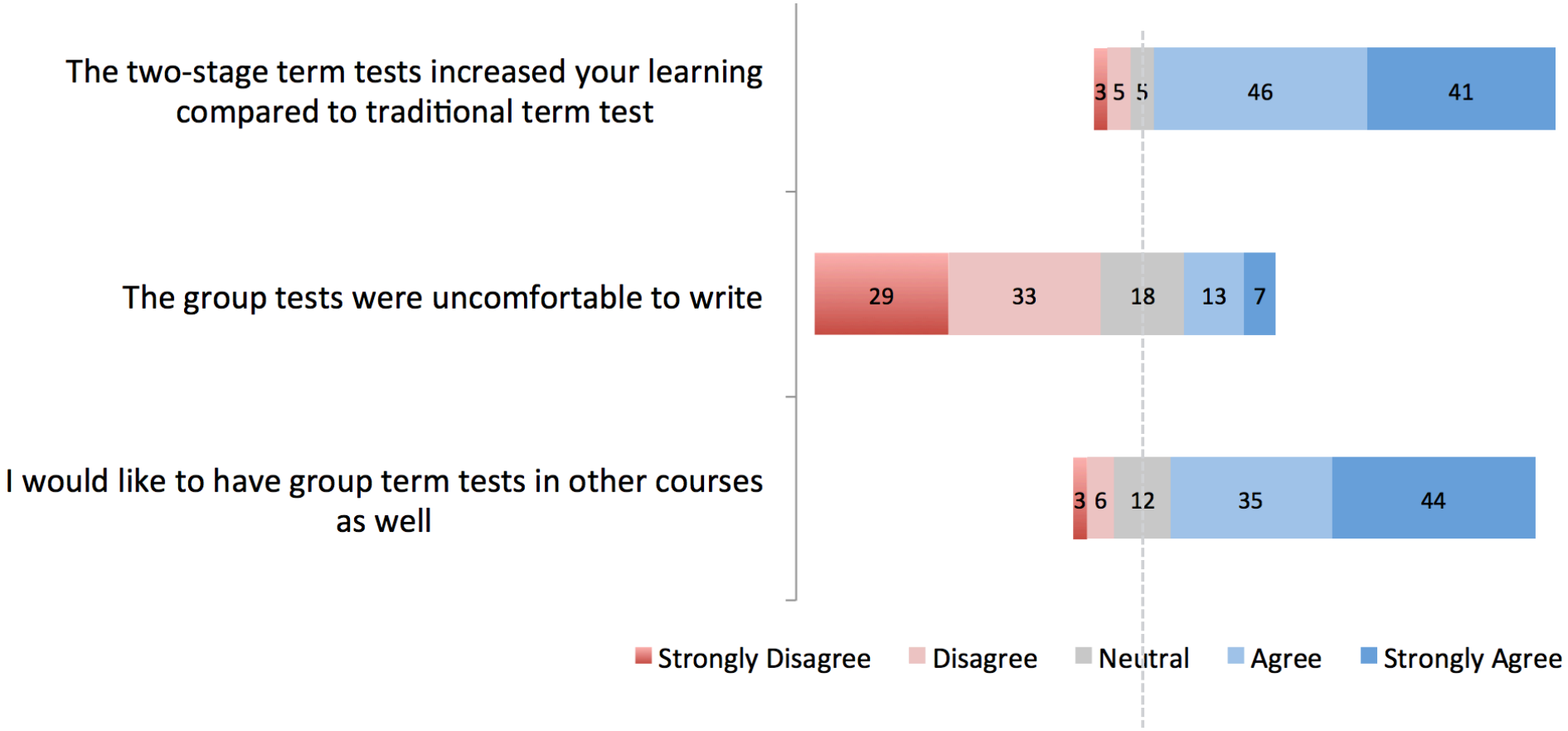
"I like that that some of the questions on the group survey were the harder questions from the individual test … it relieved some anxiety of debating these questions after the test, but it allowed me to understand them better and where I potentially went wrong."

"…gave us a chance to see different perspectives on how to answer the question, especially if we happened to get it wrong on the individual portion. It helps you to learn because you figure out, as a group, how to do it the right way."

"I liked that the two stage test gave us an opportunity to improve our mark and learn instantly from our mistakes instead of waiting till the answer key came out. By discussing the answer with our group it gave us a chance to debate and really stick by what we learned"

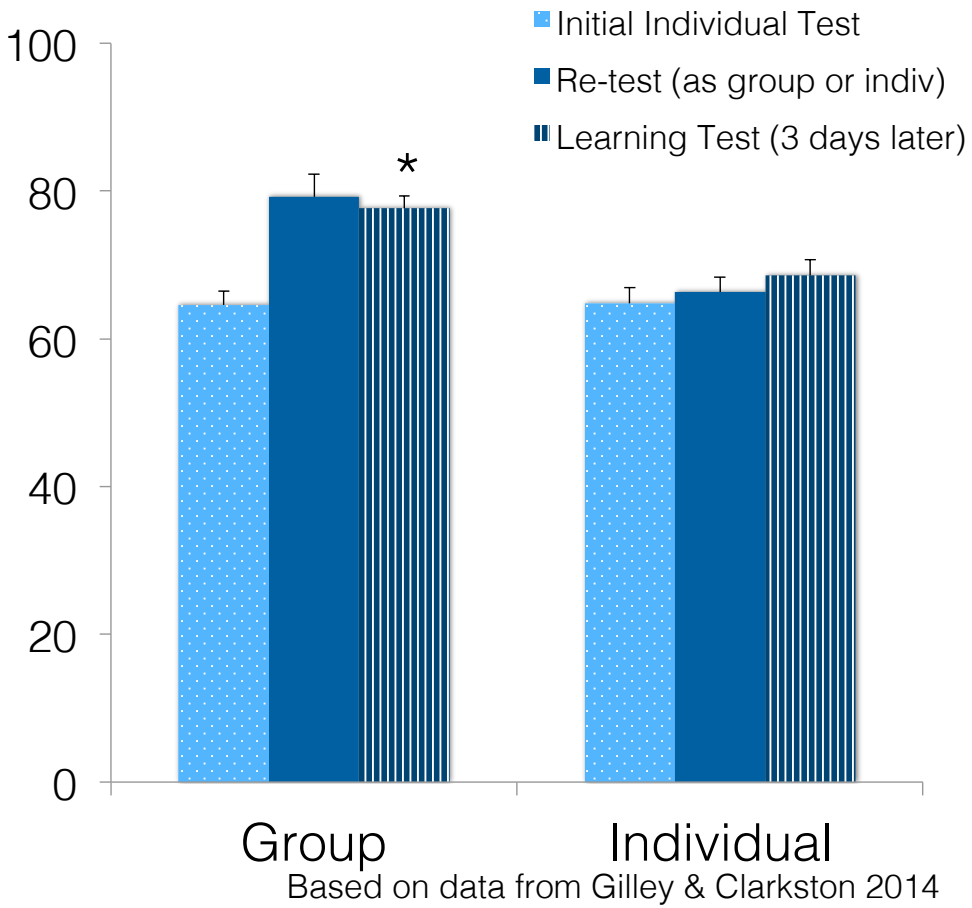
"..was able to learn new approaches to solving questions by other group members … gave me a chance to also justify my solution and reasoning."

"The two-stage term tests allowed us to improve our marks by collaborating with other students and working together to solve the problems. The individual test was a good indicator of our knowledge of the subject, but this was supplemented by the group work. In reality, scientist must work together to solve problems, and so the group portion also served as a way of developing critical thinking and interpersonal skills in addition to the academic benefit."



N=295 (74% response rate)

Two-stage exams



Based on data from Gilley & Clarkston 2014

Collaborative Testing: Evidence of Learning in a Controlled In-Class Study of Undergraduate Students

By Brett Hollis Gilley and Bridgette Clarkston

All individuals wrong
More than one answer

(38)
3%

Group Correct

Group Incorrect

(30)
79%

(8)
21%

Taken from Gilley & Clarkston 2014

Tutorial Time!

- Worksheet – work on your own (4 mins)
- Worksheet in a group of 3-4 (~4 mins)

Logistics of Two-stage Tutorials

- 2 TAs, 48 students
- Grades:
  - 50% indiv, 50% group
- Group Formation (3-4/group):
  - York: self-selection, modified as needed
  - UTM: Self-selection, change 2x in term
- Room:
  - York: round tables, blackboards, whiteboards at tables
  - UTM: Active learning classrooms – round tables, lots of white-boards

York University

Why did we use it?

Lab 4: Genetic Mapping with Molecular Markers – Leucism in Cichlids

Modern plant and animal breeding depend on molecular markers for trait mapping to identify genes that influence yield and appearance. Convict cichlids are a popular aquarium fish, the wild-type has a zebra-like colouration, with vertical black bars on a grayish body. An autosomal mutation (*d*) results in leucistic colouration (different than albinism, which is caused by a reduction in melanin; leucism is due to a decrease in all types of skin pigment), giving the fish a white to pink colour. The wild-type is encoded by allele *D*. Using RFLPs and other molecular markers, previous work mapped this gene to a region of chromosome 6.

Today, you'll try to map this character, on a finer scale, within this region. We know the locations of two RFLP markers are found within the region of interest on chromosome 6. You want to determine the location of *d* gene with respect to these two RFLP markers. Both of the RFLP markers have two alleles each, with differing banding patterns, after being cut with a specific restriction enzyme (which enzyme doesn't matter), as shown in Fig. 4.2. **Remember**: each of these RFLP markers can be thought of as an independent locus/gene, and they can be mapped just as in the example above.

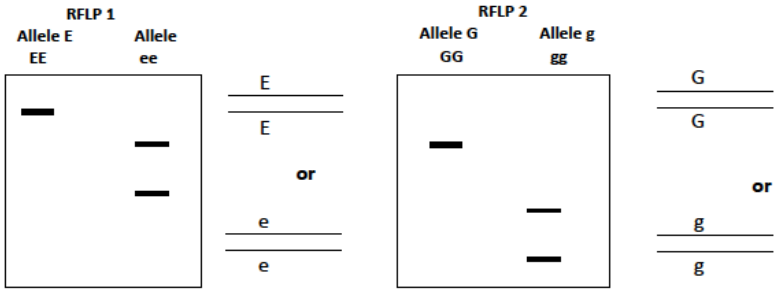
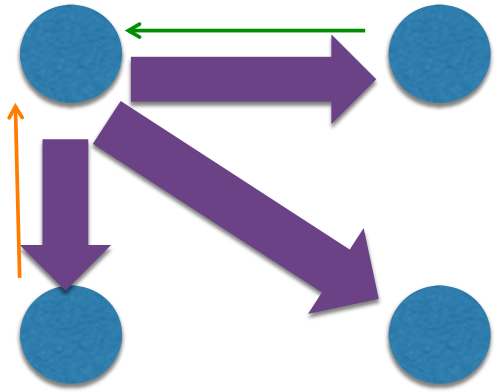


Figure 4.2: DNA gel electrophoresis analysis of alleles for two RFLP markers found near gene *d*. Allele *E* of RFLP 1 shows 1 band, while allele '*e*' has 2 bands because the restriction enzyme was able to cut it. Figures next to the gels depict alleles on homologous chromosomes.



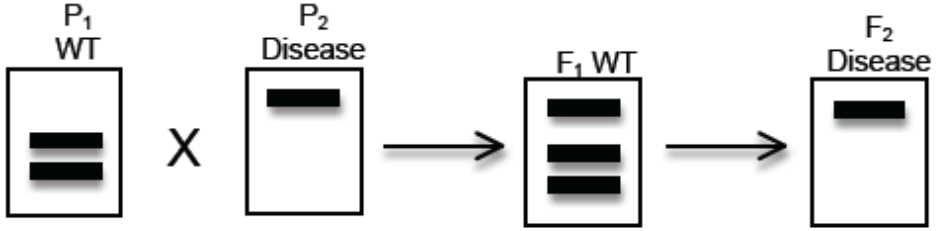
York

Final exam Q

20% correct

). A researcher is interested in whether a disease gene is linked to an RFLP marker that had been previously identified. A cross is made between two inbred mouse lines. Parent 1 (P_1) is homozygous for the wild-type (WT) condition and shows the banding pattern shown below. Parent 2 (P_2) is homozygous for the recessive disease, and has the RFLP pattern shown below. F_1 individuals are crossed with each other. If the disease gene is 20 m.u. from the RFLP marker, what proportion of the F_2 will have the gel pattern below AND have the disease?

A. 1%
B. 2%
C. 4%
D. 16%
E. 64%



The next time round → 2-stage approach

A cross is made between two inbred lines of convict cichlids, P_1, homozygous for *E* and *g* and P_2, homozygous for *e* and *G*. Each parent line has distinct RFLP banding patterns. The parental strains also differ in terms of colour at the *D* locus: P_1 is homozygous for the mutation *d*, which encodes the recessive white-pink colour; P_2 is homozygous for the wild-type *D*. The F_1 has the wild-type phenotype. With respect to their RFLP banding patterns, the progeny resulting from a backcross between the F_1 and P_1 display four different banding patterns – these and their proportions are shown in Fig. 4.3.

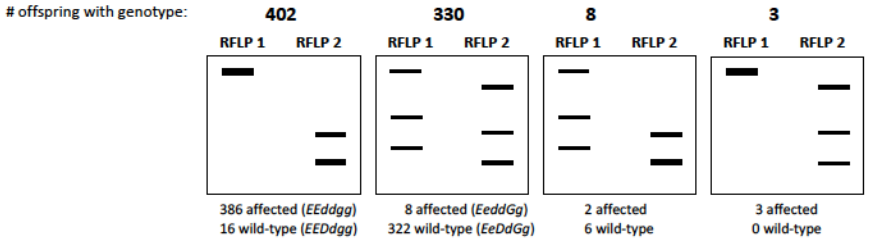


Figure 4.3: Backcross between the F_1 generation (resulting from a cross of two inbred lines, P_1 and P_2) and P_1. Numbers at the top indicate the number of offspring with the corresponding genotypes for loci *E* and *G* shown on the agarose gel below. Numbers of offspring with specific RFLP genotypes are shown at bottom. For the last two gels, you must provide the genotypes of the individuals shown underneath the gels. The thickness of the bands is proportional to the amount of DNA.

Students said they liked it … but did it actually result in learning?

63% correct

). A researcher is interested in whether a disease gene is linked to an RFLP marker that had been previously identified. A cross is made between two inbred mouse lines. Parent 1 (P_1) is homozygous for the wild-type (WT) condition and shows the banding pattern shown below. Parent 2 (P_2) is homozygous for the recessive disease, and has the RFLP pattern shown below. F_1 individuals are crossed with each other. If the disease gene is 20 m.u. from the RFLP marker, what proportion of the F_2 will have the gel pattern below AND have the disease?

A. 1%
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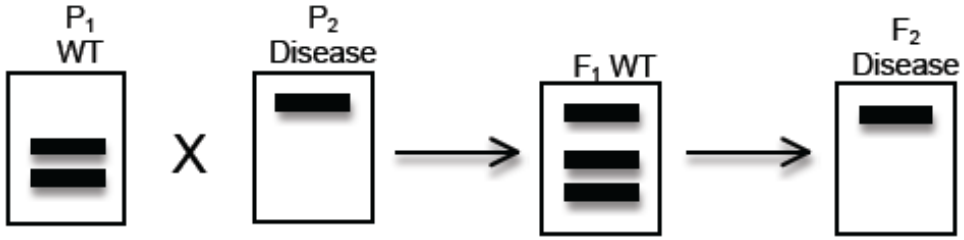


TA Training

Focus: TAs acting as facilitators

- York: session on facilitating vs. telling; goals of using peer instruction/2-stage approach
- UTM: Developed new TA training module for this course
  - Experienced tutorial as students would; designed own framework for acting as facilitators

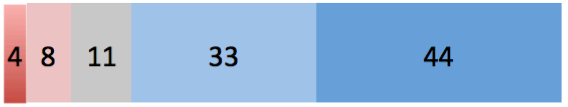
TA Perception…

- Change in TA perspective over the course of the term.
  - UTM:
    - *Beginning* - didn't like the structure. TAs wanted to lecture, wanted to give a review at the beginning of every tutorial.
    - *End* – overwhelmingly positive, saw growth in their students over term
  - York: liked it, but were more used to facilitation role
    - TAs did it themselves for the next course (different instructor, no support for two-stage)!

Student Perceptions

- They hated it … at first. Loved it by the end

The active learning tutorial format increased your learning compared to traditional tutorial formats



"Each week, I found that the tutorials really helped me understand the course content to a much higher degree, and discussing ideas learned in class in a group setting really helped in mastering the major concepts of the course, that would have been difficult if I had to learn it on my own."

… well at UTM they loved it…

- York – time constraints problem (50 mins vs 1.5 hr at UTM)
  - Issues: Individual vs. group timing

Instructor Perceptions

- Was it worth it? >> Absolutely
- Was it a lot of work? >> Absolutely
- Would we do it again? >> Absolutely

Lessons Learned

1. Don’t tell the students you are trying something new.
2. Show the students the evidence.
3. Train TAs as facilitators
4. Be cognizant of timing…this was the #1 student complaint.

Other ways to include the two-stage approach

An Improved Design for In-Class Review

By E. Jane Maxwell, Lisa McDonnell, and Carl E. Wieman

Maxwell et al. (2015) *Journal of College Science Teaching* 44(5): 48-52

References

- Carl Wieman Science Education Initiative (UBC). 2014. Two-stage exams. http://www.cwsei.ubc.ca/resources/files/Two-stage_Exams.pdf
- Cortright RN, Collins HL, Rodenbaugh DW, & DiCarlo SE. (2003). Student retention of course content is improved by collaborative-group testing. *Adv. Physiol. Ed.* 27(3): 102–108.
- Crouch CH & Mazur E. 2001. Peer instruction: ten years experience and results. *Am. J. Phys.* 69(9): 970-977
- Crouch CH, Watkins J, Fagen AP, & Mazur E. 2007. Peer instruction: engaging students one-on-one, all at once. *Research-Based Reform of University Physics. http://www.compadre.org/per/per_reviews/volume1.cfm*
- Gilley BH & Clarkston B. 2014. Collaborative Testing: Evidence of Learning in a Controlled In-Class Study of Undergraduate Students. *Journal of College Science Teaching*. 43(3): 83-91.
- Ives J. 2014. Measuring the learning from two-stage collaborative group exams. *Physics Education*. arXiv: 1407.6442
- Ives, 2011. FFPERPS
- Maxwell EJ, McDonnell L, & Wieman CE. 2015. An improved design for in-class review. *Journal of College Science Teaching* 44(5): 48-52.
- Mazur E. 1997. *Peer Instruction: A User's Manual.* Prentice Hall.
- Rieger GW & Heiner CE. 2014. Examinations that support collaborative learning: the students' perspective. *Journal of College Science Teaching*. 43(4): 41-47
- Smith MK, Wood WB, Adams WK, Wieman C, Knight JK, Guild N, Su TT. 2009. Why peer discussion improves student performance on in-class concept questions. *Science* 323: 122-124.
- Smith MK, Wood WB, Krauter K, Knight JK. 2011. Combining peer discussion with instructor explanation increases student learning from in-class concept questions. *CBE Life Sci. Educ.* 10(Spring 2011): 55-63.
- Wieman C, Rieger GW, & Heiner C. 2014. Physics exams that promote collaborative learning. *The Physics Teacher.* 52: 51 – 53.