Team-based Learning: A Transformative Strategy for Your Courses

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Agenda

I. Introductions and outcomes: participants and team-based learning (TBL)

II. The readiness assurance process

III. Effective dose of active learning and TBL

IV. Application activities

V. The power of teams

VI. Stacking the odds for the success of teams

VII. Transformative course design

VIII. Gathering evidence of engagement, efficacy and transformation

IX. Wrap-up, Q&A and conclusion
Who I am, what I do...

Biology Professor for 22 years at University of Minnesota, Macalester College, and San Jose State University.

I teach:
• Foundations of Biology (Genetics)
• Cell Biology
• Bioinformatic Analysis
• Personal Genome Analysis

I investigate:
• Active Learning at the University Level
• Approaches to Genome Analysis and Genome Education
Introductions: participants

• Introduce yourself to the people sitting next to you
  – Your name
  – Your discipline
  – Your interest in the workshop
    Why this? Why now

• Be sure to leave enough time for the other person/people to introduce themselves, too.
Introductions: team-based learning (TBL)

Team-based learning (TBL) is a structured form of small-group learning that emphasizes student preparation out of class and application of knowledge in class.
Introductions: team-based learning (TBL)

TBL is an instructional strategy developed by Larry Michaelsen for developing high performance learning teams that can dramatically enhance the quality of student learning:

- Enhances problem-solving skills
  - Learners must actively participate in and out of class through preparation and group discussion
- Replaces or reduces lecture time
  - Class time is shifted away from learning facts and toward application and integration of information.
  - The instructor retains control of content, and acts as both facilitator and content expert.
- Ensures that students are prepared for class
- Creates a remarkable amount of energy in the classroom
- Promotes team work
Introductions: team-based learning (TBL)

Team-Based Learning implementation is based on four underlying principles (Michaelsen & Richards 2005):

– Teams should be properly formed (e.g. Intellectual talent should be equally distributed among the groups). Composition of teams is fixed for the whole course.
– A regular readiness assurance process holds students accountable for their pre-learning and for working in teams.
– Team assignments must promote both learning and team development.
– Students must receive frequent and immediate feedback.
Outcomes we’ll work toward today

1. You can define TBL and describe its essential elements
2. You can explain the concept of effective dose, and why TBL is a strategy not a spice
3. You can evaluate an activity’s suitability for inclusion in a team-based learning course
4. You can describe four ways that teams of students differ from groups of students
5. You can give four ways in which the likelihood of success of a given team can be improved
6. You can describe how to design a TBL-based course and how to transition from a traditional-format
7. You can describe a well-rounded, actionable assessment plan and explain why it matters to have one
8. You commit to reading *Team-based Learning* and to transforming one of your courses to TBL format
Do you want...

• Students who come to class?
• Student who come to class prepared?
• Students who participate in class?
• Students who engage the material critically?

Team-based learning can transform your course, your students and what your teaching can achieve.
The Readiness Assurance Process

Preparation is everything

- David Robinson
Individual Readiness Assurance Test

Let’s try it out!
(~10 min)
Team Readiness Assurance Test

Let’s try it out!
(~10 min)
Question 1

1. All of the following are considered *essentials* of team-based learning *EXCEPT*
   *A. Teams must regularly work on small problems that require sequential reports or complex products.*
   *B. Groups must be properly formed and managed*
   *C. Students must be made accountable*
   *D. Team assignments must promote both learning and team development*
   *E. Students must receive frequent and immediate feedback*

*Learning objective 4*
*Micahelsen pg. 2-7 on the essential elements/principles of TBL*
Question 2

2. Compared to learning in a traditional, lecture-oriented courses, learning in large, team-based learning (TBL) format classes markedly improves

A. Students’ understanding of a discipline’s central facts but not necessarily their higher cognitive skills.
B. The development of independence and intrapersonal skills but not necessarily their listening and note-taking skills.
C. The already high (typically) student enthusiasm for work in informal groups of rotating composition.

*D. The social support received by at-risk students but not necessarily as well (or significantly) with short duration TBL courses.
E. Faculty interest in the scholarship of their discipline as a reaction to the increased busy work and remedial instruction required by TBL-format courses.

Learning objective 4
Michaelsen pg. 19 on the benefits of team learning
3. The most important aspect of an active learning course in contrast to a traditional format course is that in truly active learning courses
A. There is no lecture but instead all class time is used for group work.
*B. Students have ample opportunities in class to clarify, question, apply, and consolidate new knowledge.
C. The instructor regularly asks the class as a whole questions during class.
D. Fun puzzles, games, video clips, etc. are employed to change things up frequently and hold on to student attention.
E. Students are placed in groups so they can work together outside of class – e.g. share notes, participate in informal study groups, practice peer teaching).

*Learning objective 2
*Beichner slide 37
4. SCALE-UP is based on all of the following elements EXCEPT:
*A. Accepting a *slightly* higher failure rate (compared to traditional courses) in exchange for significantly higher learning gain for both at-risk and top students alike.
B. Access to group whiteboards and other collaborative work spaces.
C. Engaging tangibles, ponderables and visibles in class.
D. Courses created using backward design.
E. Round tables that each seat three teams of three students.

*Learning objective 1*

*Beichner slide 60 showing failure rate drops significantly across all segments*
5. Readiness Assurance Tests (RATs) are important for promoting team development because
A. They make students accountable for their after-class review of central concepts.
B. Students have a low interest in the outcome of the group and are motivated to engage in a high level of individual effort.
C. The impact of the student interaction on the RAT is immediate and personal.
D. Teams become more cohesive because members know they get information in the subsequent lecture/discussion that they will need on the exam.
E. All of the above.

*Learning objective 1*

Michaelsen pg. 14-16 on the readiness assurance process
Question 6

6. Compared to a traditional course format where the teacher does most of the talking, learning gain is likely higher in a team-based learning format because
A. The readiness assurance process allows the instructor to cover more points in a given unit of time in the following lecture/discussion.  
*B. Students achieve mastery through multiple points of engagement with the material that are built into the TBL approach.  
C. Because better students have less gain to make and their helping of the slower students allows a larger aggregate class learning gain.  
D. Group application activities are what makes the biggest difference in learning gain so even incorporating an out-of-class group project is likely to substantially increase the learning gain even in a lecture-oriented course.  
E. Actually, learning gain in team-based learning is not significantly higher; rather students develop other important cognitive skills such as collaboration, communication, and problem-solving. 

Learning objective 3
Michaelsen pg. 13 (Figure 2) on team learning instructional activity sequence
7. In Robert Beichner’s presentations he makes the point “Don’t waste people’s talents”. What did he mean by that?

A. The STEM pipeline is leaky so that there are only 2.8 million STEM majors graduating today compared to 4 million in 2001.
B. We shouldn’t watch as much television or play as many video games
C. So many fewer people today are attending college than in 1972 because students are not seeing as much value in learning when we have such easy access to information on the internet.
D. Education should be about social interaction and doing real and interesting tasks, not just listening and copying things down.
E. All of the above.

Learning objective 2
Beichner slide 19-31 on wasted potential when we don’t make learning active
7. In Robert Beichner’s presentations he makes the point “Don’t waste people’s talents”. What did he mean by that?
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Learning objective 2
Beichner slide 19-31 on wasted potential when we don’t make learning active
LRQ0 Scores by Team

Score

Team

4.4
3.5
4.6
5.2

iLRQ Score
iLRQ Avg
tLRQ Score
Individual “learning readiness quizzes”

- provide students incentive (and accountability) to do the reading or other pre-class preparation.
- are multiple choice quizzes carefully designed to probe students’ comprehension of 4-12 central concepts at “table of contents level” rather than “index level” of detail.
- occur about six times per 45 hour course, at the beginning of each module or unit.
- prime students for the team quiz that follows since each student has grappled with the question and committed to an answer.
Team “learning readiness quizzes”

- are the same as the individual quizzes only they are taken as a team
- provide students instant feedback (IF-AT form)
- provide an important opportunity for peer-mediated learning
- are a team-building opportunity, where the idea of “smarter together” is reinforced.

Students benefit from frequent and timely feedback on their work
Appeals & Corrective Instruction

• If students believe that the answer their team chose is correct even though it wasn’t the instructor’s choice, they can submit a brief written appeal that consists of
  – Their argument (e.g. “RE: question 4, we believe C is also a correct answer”)
  – Their evidence (e.g. “According to figure 5.6 on page 214 it is possible for a cell to undergo mitosis without immediately undergoing cell division”)

• Instructor, after taking questions on the quiz can choose to give a tailored mini-lecture on the topic(s) of greatest need as revealed by the RAP.
The readiness assurance process

Studies have shown that even at good colleges and universities students sometimes or often skip doing the class reading or other preparations for class. As such, a readiness assurance process at the start of class important for increasing learning during in-class application activities.
The readiness assurance process is as much about motivating and reinforcing learning as it is about assessment.
My path to team-based learning
Why did I leave behind the traditional lecture format for a team-based, active learning course format?
A student rating scores plateau
"If I had asked people what they wanted, they would have said faster horses."

Henry Ford
Change the Game

*Focus on measures of effectiveness*
Shift to a new measure of success, away from student opinion measures only, to an objective measure of \textit{learning gain}.

Cell Biology uses an online 50-item cell biology concept inventory as a pre-test and post-test.

\[
\text{Learning Gain (delta)} = \frac{(\text{Post-test score} - \text{Pre-test score})}{(\text{Total possible} - \text{Pre-test score})}
\]

\[
e.g. \quad \text{Delta (for one student who learned a lot)} = \frac{33 - 17}{50 - 17} = 0.48
\]
Learning Gain (delta) in Cell Biology

Shift to team based, active-learning format

Bar chart showing learning gain (delta) in Cell Biology from 2010 to 2013, with a shift to a team-based, active-learning format.
Learning Gain (delta) in Cell Biology

Traditional lecture format

Active learning format

<table>
<thead>
<tr>
<th>Year</th>
<th>Sum</th>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>2012</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>2013</td>
<td>0.40</td>
<td>0.40</td>
</tr>
</tbody>
</table>
Change the Game

Create transformative experiences:
Focus on shaping professionals, higher functioning people, and connective thinkers
University of Minnesota
Student Developmental Outcomes

1. Responsibility and Accountability
2. Independence and Interdependence
3. Goal Orientation
4. Self Awareness
5. Resilience
6. Appreciation of Differences
7. Tolerance of Ambiguity
University of Minnesota
Student *Learning* Outcomes

1. Can identify, define, and solve problems
2. Can locate and critically evaluate information
3. Have mastered a body of knowledge and a mode of inquiry
4. Understand diverse philosophies and cultures within and across societies
5. Can communicate effectively
6. Understand the role of creativity, innovation, discovery, and expression across disciplines
7. Have acquired skills for effective citizenship and life-long learning
...which brought me to active learning and, in particular, team-based learning
Effective dose of active learning and TBL

TBL is a strategy not a spice
Low impact changes

Some things we try in our classes have low impact:

1) strategies based on misconceptions about what will be effective (they won’t work)

2) badly implemented strategies (they could work but aren’t working)

3) conceptually promising activities done without enough consistency or follow through to realize its potential benefit (they aren’t working as well as they might)
Is team-based learning a spice or a game changer?
1. What would happen if a breeding pair of finches was placed on an island under ideal conditions with no predators and unlimited food so that all individuals survived? Given enough time,
   a. the finch population would stay small because birds only have enough babies to replace themselves.
   b. the finch population would double and then stay relatively stable.
   c. the finch population would increase dramatically.
   d. the finch population would grow slowly and then level off.

2. Finches on the Galapagos Islands require food to eat and water to drink.
   a. When food and water are scarce, some birds may be unable to obtain what they need to survive.
   b. When food and water are limited, the finches will find other food sources, so there is always enough.
   c. When food and water are scarce, the finches all eat and drink less so that all birds survive.
   d. There is always plenty of food and water on the Galapagos Islands to meet the finches' needs.

3. Once a population of finches has lived on a particular island with an unvarying environment for many years,
   a. the population continues to grow rapidly.
   b. the population remains relatively stable, with some fluctuations.
   c. the population dramatically increases and decreases each year.
   d. the population will decrease steadily.

Expectation: more active learning activities would lead to more learning gain

Cohen considered $d=0.2$ a small effect, $d=0.5$ a medium effect, and $d=0.8$ a large effect.
“Active Learning Not Associated with Student Learning in a Random Sample of College Biology Courses”

What?!?

Active learning not associated with student learning in a random sample of college biology courses*

“Active Learning Doesn’t Work”

Average normalized learning gain (Cohen’s $d$) \[ d = \frac{M_E - M_C}{SD} \]

Where $M$ is the mean of the experimental [post-test] ($M_E$) and control groups [pre-test] ($M_C$), and SD is the common standard deviation.

Cohen considered $d=0.2$ a small effect, $d=0.5$ a medium effect, and $d=0.8$ a large effect.
Active learning not associated with student learning in a random sample of college biology courses*

Our study revealed that active learning was not associated with student learning in a broad population of introductory college biology courses.

*These results imply active learning is not a quick or easy fix for the current deficiencies in undergraduate science education. Simply adding clicker questions or a class discussion to a lecture is unlikely to lead to large learning gains.*

Effectively using active learning requires skills, expertise, and classroom norms that are fundamentally different from those used in traditional lectures. Appreciably improving student learning in college science courses throughout the United States will likely require reforming the way we prepare and support instructors and the way we assess student learning in our classrooms.

So adding a few think-pair-share activities, some group work, or clicker questions is often just not enough to see the benefits of active learning approaches.
The authors’ conclusions, distilled

1) *How* active learning is implemented matters

2) *Skill of instructor* in use of active learning matters
The Team-based Learning “Course Scorecard” is one way to make a holistic evaluation of a course’s adoption of TBL practices.

<table>
<thead>
<tr>
<th>Course Scorecard</th>
<th>Optimized For TBL™</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Content Objective</strong></td>
<td></td>
</tr>
<tr>
<td>Cover Content</td>
<td>Focus</td>
</tr>
<tr>
<td>Team Formation</td>
<td></td>
</tr>
<tr>
<td>Student Selected</td>
<td>Selection Method</td>
</tr>
<tr>
<td>Homogenous Teams</td>
<td>Composition</td>
</tr>
<tr>
<td>NOT Transparent</td>
<td>Process</td>
</tr>
<tr>
<td><strong>Orientating Your Students</strong></td>
<td></td>
</tr>
<tr>
<td>No Explanation</td>
<td>Rationales</td>
</tr>
<tr>
<td>Instructor-set</td>
<td>Grade Weights</td>
</tr>
<tr>
<td><strong>Readiness Assurance Process</strong></td>
<td></td>
</tr>
<tr>
<td>Inappropriate Frequency</td>
<td>Frequency</td>
</tr>
</tbody>
</table>
What is this active learning that makes such a difference?

0.20 learning gain

0.40 learning gain
What *is* this active learning that makes such a difference?

- Backward design
- Teams vs. groups
- Effective activities
- Frequent feedback
- Metacognition

Learning gain:
- 0.20
- 0.40
What else do you get for your effort?

• Significantly greater and longer-lasting learning gains by students
• Achievement of higher Blooms learning objectives
• The opportunity to help your students develop professional “soft skills” in your students (e.g. collaborating)
• The chance to change your relation with your students from “source” to “coach/mentor”
• The potential for your course to be truly transformative for your students
An additional way to make a holistic evaluation of a course’s incorporation of best practices...

This article is *highly* recommended
Teaching Practices Inventory

I. Course information provided to students
II. Supporting materials provided to students
III. In-class features and activities
IV. Assignments
V. Feedback, testing, and grading policies
VI. Surveys and ongoing instructional evaluation
VII. Training and guidance of teaching associates
VIII. Collaboration or sharing in teaching

Application activities

the learning is in the doing
Effective TBL activities

- **Significant task** (something done by a worker in the discipline; something that exposes students to credible information that conflicts with their existing information structures; demonstrates concept’s usefulness)
- **Same task** (not divide and conquer here; want to maximize the interest in other teams’ answers)
- **Specific choice** (task’s completion shouldn’t require more time producing the answer than figuring out what the answer is; use of judgment)
- **Simultaneous report** (the big reveal; not sequential, dribbling in of answers; allow immediate comparison & exploration of alternative answers – instant feedback)
Can you get your students to *think* like a biologist, historian, lawyer – whatever workers in your discipline are – to do the *intellectual work* of the discipline?
Some of the activities we do in class

• Case studies (e.g. on hospital-acquired infections and cultural issues in the practice of science)
• Gene and protein annotation (on actual sequences, applying concepts to the particular)
• Making models of eukaryotic genes using envelopes of laminated cards
• Information “treasure hunt”
• Magnets on white boards to make phylogenetic trees
**Team assignments must promote both learning and team development**

Team challenges allow students to work for brief periods (5-10 minutes) in class on a difficult (e.g. application or evaluation) problem or question.

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### Team Challenge

Sketch the design and movement of a protein sequence “AB” that is synthesized at the endoplasmic reticulum, escapes from the Golgi apparatus and then splits in two, half going to the mitochondrion and half to the nucleus? Work at the white board with everyone gathered around; one person should make a paper copy to turn in after 5 minutes.

#### Table 12-3 Some Typical Signal Sequences

<table>
<thead>
<tr>
<th>FUNCTION OF SIGNAL SEQUENCE</th>
<th>EXAMPLE OF SIGNAL SEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import into nucleus</td>
<td>Pro-Pro-Lys-Lys-Lys-Arg-Lys-Val-</td>
</tr>
<tr>
<td>Export from nucleus</td>
<td>Ala-Asp-Ala-Asp-Ala-Gly-Asp-Asp-</td>
</tr>
<tr>
<td>Import into mitochondria</td>
<td>H&lt;sub&gt;N&lt;/sub&gt;-Met-Leu-Ser-Leu-Arg-Glu-Ser-Ile-Arg-Phe-Phe-Lys-Pro-Ala-Thr-Arg-Thr-Leu-Cys-Ser-Ser-Arg-Tyr-Leu-Leu-</td>
</tr>
<tr>
<td>Import into plastid</td>
<td>H&lt;sub&gt;N&lt;/sub&gt;-Met-Val-Ala-Met-Ala-Met-Ala-Ser-Leu-Gln-Ser-Ser-Met-Ser-Ser-Leu-Ser-Leu-Ser-Ser-Asn-Ser-Phe-Leu-Gly-Gln-Pro-Leu-Ser-Pro-Ile-Thr-Leu-Ser-Pro-Phe-Leu-Gly-Gly-Lys-Lys-Ser-Lys-</td>
</tr>
<tr>
<td>Import into peroxisomes</td>
<td>H&lt;sub&gt;N&lt;/sub&gt;-Met-Met-Phe-Val-Ser-Leu-Leu-Leu-Leu-Leu-Arg-Leu-Phe-Ala-Thr-Glu-Ala-Glu-Glu-Leu-Thr-Lys-Glu-Val-Phe-Gln-Lys-Asp-Glu-Leu-COO-</td>
</tr>
<tr>
<td>Return to ER</td>
<td></td>
</tr>
</tbody>
</table>

Some characteristic features of the different classes of signal sequences are highlighted in color. Where they are known to be important for the function of the signal sequence, positively charged amino acids are shown in red and negatively charged amino acids are shown in green. Similarly, important hydrophobic amino acids are shown in white and hydroxylated amino acids are shown in blue. *H<sub>N</sub>* indicates the N-terminus of a protein; *COO* indicates the C-terminus.
An example from a intro business course.

Activity: Choose a location for a new dry cleaning business in town

1. First things first: does it support objectives?
2. Significant task/problem?
3. Specific choice?
4. Same task/problem?
5. Simultaneous report?
6. Completing the circle: assess, survey, feedback
Team assignments – making them work

Impact on learning is the product of individual work, within-team work, and between-team work.

\[ IW \times WTW \times BTW = \text{Impact} \]

\[ 1 \times 0.5 \times 0.5 = 0.25 \]

\[ 1 \times 1 \times 1 = 1 \]
And you *can* take it to the next level with a semester-long team project
Students Propose Genetic Solutions to Societal Problems

Sue Wick, Mark Decker, David Matthes, Robin Wright†

In the Foundations of Biology sequence for entering biological sciences majors at the University of Minnesota, inquiry-based learning is woven throughout the classroom and laboratory. During the first semester lecture and discussion, students work in teams on a Genetic Engineering Proposal in which they propose a gene-based solution to a societal problem of their own choosing. Instructors coach the teams throughout the semester on experimental design and resources, as well as on data analysis, presentation strategies, team work, and research ethics. On the basis of outcomes from the nearly 3000 students who have taken the course over the past 6 years, the project has succeeded in engaging students in the intellectual work of biologists and the experience of science as creative inquiry.

The Genetic Engineering Proposal Project, an IBI prize–winning module, teaches biology students to devise innovative bioproducts or solutions to environmental or health problems.

A team plans their project poster (top); team members at the poster presentations (bottom).

the team settles on a topic that they will jointly pursue for the remainder of the semester (see the top photo). The team must then use primary scientific literature, databases, and, sometimes, interviews with expert researchers to create a compelling argument for the value of the proposed project, to develop an experimental protocol to achieve the end product, and to describe the broader implications of the project, including ethical issues. They must also complete a phylogenetic analysis of their gene of interest or the donor or recipient organisms to address potential methodological problems, environmental impacts, or logical future studies.

Students do not carry out
The project: propose the genetic modification of an organism to solve a significant problem

- Requires students to engage primary literature
- Project divided into manageable subsections
- Instructor feedback and evaluation at every stage
- Peer evaluation of draft and poster presentation
- Integrate many course themes and achieve learning objectives at Bloom’s evaluation and creation levels)
The project is highly integrated into the course

1. The nature of science
2. Principles of evolution
3. Molecules of life
4. Features of cells
5. Gene structure/expressions
6. DNA replication/mutation
7. Gene regulation
8. Population genetics
9. Gene technology I
10. Mitosis and meiosis
11. Gene technology II
12. Speciation
13. Phylogenetics

A. What is science?
B. How does society affect science and vice versa?
C. How do scientists choose questions?
D. How to critique?
E. How to find published articles?
F. How to find genes and promoters?
G. How to choose a vector and make plasmid maps?
H. How to find homologs make seq. alignments?
I. How to make an effective poster?
Students work on complex, integrative projects that requires them to do the work of a biologist (apply, analyze, evaluate, create, collaborate)
Knowledge is Social
A video before lunch

Team-Based Learning: Group Work that Works

https://www.youtube.com/watch?v=kxg5FTGZhZs&t=636s
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VI. Stacking the odds for the success of teams

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VIII. Gathering evidence of engagement, efficacy and transformation

IX. Wrap-up, Q&A and conclusion
The power of teams

group ≠ team

teams > groups ≥ individuals
Groups vs. teams

• Group
  – Low level of individual commitment to the welfare of the group
  – Low level of trust among members of the group

• Team
  – High level of individual commitment to the welfare of the team
  – High level of trust among members of the team

To get a group to become a team you need
- Time interacting together (hence permanent teams & team time)
- Diverse intellectual/social resources
- A challenging task that becomes a common goal
- Frequent feedback on individual and team performance
What is a *team* able to do?

- Inspiring a very high level of individual effort (doing it for the team is more powerful than doing it for the instructor or for a grade)
- Cultivate a willingness to challenge others without fear of giving offense; a high tolerance for honest communication
- Working collaboratively very effectively
- Successfully accomplishing very complex and challenging tasks (which boosts confidence)
Stacking the odds for success of teams

while chance can create a great team, intentional assignment of students to teams based on creating maximal diversity and inter-team equity provides consistently functional teams.
Optimal student teams

• Permanent for the term/semester (to allow time for the building up of trust)
• Diverse (in terms of all dimensions that might affect student performance in the course)
• Composed of 5-7 students (to optimize opportunities for engagement with benefit of diverse perspectives/skill sets)
• Accountable to each other (significant number of points are assigned by team members to each other based on relative effort/contribution)
• Needed for success in the course (to get the work done, successfully compete in inter-team challenges)
Information can be gathered in the week before class starts using a Survey Monkey or Qualtrics tool and questions customized to your course and student population.

3. Where you were seven years ago...
   City/Town: 
   State/Province: 
   Country: 

4. Your first language?

6. Which of the following courses have you taken? (I don’t expect anything beyond the course pre-reqs but it’s good to know what else you might have studied related to this course)
   - [ ] Biology 2002
   - [ ] Intro Biology: Genetics and Evolution (NOT Biol 2002)
   - [ ] Biology 2003
   - [ ] Intro Biology: Cell Biology and Ecology (NOT Biol 2003)
   - [ ] Biochemistry
   - [ ] Genetics
   - [ ] Molecular Biology

7. How many boxes did you check in question #6?
   0-18:
### Team composition – make them diverse

<table>
<thead>
<tr>
<th>Team</th>
<th>Gender</th>
<th>Diverse</th>
<th>Overall Confid.</th>
<th>Team Avg</th>
<th>OneWord</th>
<th>Guild</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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<td>O13</td>
<td>4.7</td>
<td>3.6</td>
<td>Response</td>
<td>0</td>
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<td>1</td>
<td>4.0</td>
<td>3.6</td>
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<td>4.0</td>
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Groups must be properly formed and managed

Diverse teams: First language, gender, honors, int’l status, prior biology experience, self-description, confidence.

<table>
<thead>
<tr>
<th>Caring</th>
<th>Funny</th>
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<td>Jennifer, Minnesota</td>
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<th>Efficient</th>
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<td>Abdullah, Lebanon</td>
<td>Jennifer, Minnesota</td>
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Students must be accountable for the quality of their individual work and their team contributions.

One essential practice is to have students evaluate their own and their teammates' performance on team activities and projects...

The above data is the aggregated responses of all team members of one team for part of one anonymous online survey. This is the summative performance evaluation; a formative one occurs earlier.
Intra-team performance evaluations provides that accountability

Please rate each of your team members, as well as yourself.

1. Assuming the level of effort that you’ve put into team endeavors -- particularly into the team project -- is 100%, how would you estimate the *relative* effort shown by each of your team mates? Note: credit for taking the survey will be reduced if there is no differentiation shown here among team mates. Giving 100% to each team mate, while a noble sentiment, rarely reflects an honest assessment of the others' contributions. Also, if a person listed here has clearly dropped (you haven't seen them in two weeks), you can give them 25% for effort here and minimal comments elsewhere in the survey.

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Same survey, given twice
Formative (week 4 of the semester) – for guidance
Summative (last week of semester) – for (significant) points
How you give points reflects your values

Reflect the value placed on team work: team learning readiness quizzes, team challenges, team unit tests, and team projects – in addition to team maintenance points.

Consider impact of team-based points being 5% vs. 30% of total course points.
Space matters

Does this room feel “made for teamwork”?
What Active Learning Classrooms (ALCs) at U of M look like
From a lecture hall to SCALE-UP classroom
Up to 14 diverse, instructor-assigned & permanent teams of nine

SCALE-UP:  Student Centered Active Learning Environment for Undergraduate Programs
Some examples of active learning classrooms
Besides setting up teams properly, providing them with individual accountability and providing them space to work, what else helps teams work well?

1. They need to have a reason for their existence – another reason for including frequent and substantial work for the team to do.
2. They need to perceive other teams existence as happens when the work of one team is put up against another’s during simultaneous report.
3. They need to be supported and acknowledged.
Transformative course design

TBL is a transformative instructional strategy; It must be fundamental to the course design
Team Challenge, part 1

Find, circle and label all evidence of team-based learning course structure in the syllabus and schedule of a U of M Cell Biology course.
Team Challenge, part 2a

Use the TBL Scorecard to individually evaluate the same course.
Team Challenge, part 2b

Come to consensus as a team as to how fully the course aligns with the TBL learning strategy according to the TBL scorecard, and how it might not (or there isn’t evidence in the syllabus to decide).
How courses get made,
and how instead they perhaps ought to
Traditional Course Design

Plan Learning Experiences and Instruction (often using content description in textbook as guide)

Determine Acceptable Evidence (exams that assess students recall and working capacity with that content)

Identify Desired Results (calibrate “A work” vs “C work” based on bell curve)

Assumptions of “forward design”

Choose texts, plan lectures, find activities
Assumes that content delivery is the goal; activities intended to add spice/variety for students.

Write exams, assignment prompts
Assumes that exams should be on what was covered (“focus on the lecture slides”) and assignment is done in parallel to the class experiences.

See how students perform
Assumes that students performance on exams or assignments reflects their ability and effort in the course.
Backward Design

Identify Desired Results

Determine Acceptable Evidence

Plan Learning Experiences and Instruction


Students will be able to do X, Y & Z (think big)
Backward design

Identify desired results

Determine acceptable evidence

Plan learning experiences and instruction

Assumes that desired results are the goal; activities intended to build up knowledge and skills equal to the desired results.

Assumes that exams should be assess students’ mastery of stated objectives.

Assumes that activities are chosen based on their ability to facilitate the mastery defined the outset.

Team Activity: Backward Design

You want to teach a student in a masters-level class about finding scholarly sources in your discipline. Ideally you want your students to be masters of this skill. You can give 60 minutes of class time to it. Use 15 minutes to put together your idea.

With 1 or 2 others work out the
(a) Results you would want to achieve
(b) Evidence that you would find compelling
(c) Experiences and instruction that would help your students achieve the results.
Team Activity: Backward Design (continued)

Take a photo of your answer and email it to me at dmatthes@umn.edu with this name:

BackwardDesignActivity-initials of participants e.G BackwardDesignActivity-DJM-GSM-WAC

Your answer needs to have these three parts:
(a) Results you would want to achieve
(b) Evidence that you would find compelling
(c) Experiences and instruction that would help your students achieve.
Ideal TBL modular structure

Team-based learning instructional activity sequence
(Repeated for each major instructional unit – 5 to 7 per course)

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<th>Application of Course Concepts</th>
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<td>Individual Study with Reading, Study Guide and Self-tests</td>
<td>Individual Learning Readiness Quiz (iLRQ)</td>
<td>Team Learning Readiness Quiz (tLRQ)</td>
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The TBL work cycle

1. **Individual study:** theory & concepts
2. **Team readiness test:** theory & concepts
3. **Class discussion:** confirming & clarifying theory & concepts
4. **Supportive teaching:** theory & concepts
5. **Team challenge:** Applying theory & concepts
6. **Individual readiness test:** theory & concepts
Instructional Strategy for Foundations of Biology I (Genetics and Evolution)

Monday class
- Learning readiness quiz (Individual)
- Learning readiness quiz (Team)
- Learning readiness quiz debriefing
- Overview & coordination

- Lecture & discussion of key / challenging points
- Team activity: application & evaluation
  **Project time**
- Activity debriefing

Wednesday class
- Overview & coordination
- Project-related team activity:

Friday class
- Foundation skills development related to team project
- Team activity: application & evaluation
  **Project time**
Instructional Strategy for Foundations of Biology I (Genetics and Evolution)

**Before class**
- Study guide
- Reading of text
- Online self-test
- Homework

**Monday class**
- Learning readiness quiz (Individual)
- Learning readiness quiz (Team)
- Learning readiness quiz debriefing
- Overview & coordination

- Lecture & discussion of key / challenging points
- Team activity: application & evaluation
- Activity debriefing

**Wednesday class**
- Overview & coordination
- Lecture & discussion of key / challenging points
- Project-related team activity:
- Team activity: application & evaluation

**Friday class**
- Foundation skills development related to team project
- Team activity: application & evaluation

**After class**
- Reviewing notes
- Reflection
- Project work
- Post-exam analysis
But what about coverage?

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## Foundations of Biology I

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</table>
But doesn’t this take *way* more faculty time??

<table>
<thead>
<tr>
<th>Idea</th>
<th>Before Class</th>
<th>In Class</th>
<th>In Lab</th>
<th>In and Out of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guide</td>
<td>Text</td>
<td>sTest</td>
<td>iLRQ</td>
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</table>
Actually no, it doesn’t take much more time, especially if you have a TA.

Not after the course is developed anyway.

How do you make the transition?

It can seem daunting.
Not *much* more time after the first offering...

- Study guide – once per edition (1-3 pgs/chapter)
- Text – no additional time by faculty
- Self-tests – basic MCQs, often from test bank
- iLRQ (learning readiness quiz) – *important work*
- tLRQ (team LRQ) – iLRQ=tLRQ so no additional
- Lecture – some customization; mostly reducing
- Activities – *important work*
- Lab – unchanged
- Exams – can be the same; often rewritten anyway
- Post-exam analysis – additional TA time if done
- Project – *important work; non-trivial time req’d*
- Reflections – *important but can be only sampled*
A transition plan

1. Decide what your current course objectives really are  (hint: look at your exams and other major assignments, the objectives implicit in them, and the level of achievement your students currently attain).

2. Raise your expectations for how broadly and deeply your students can work with your material. What would amazing look like?

3. Create assessments that have the “head room” to detect such a high level of performance.

4. Test these assessments out in your traditional format course for a couple semesters – extra credit, pre- and post-test.

5. Find, adopt, adapt, create application activities; try them out in your traditional course but be prepared for complaints; they don’t currently have a team supporting them.
The Diverse Sources of Our Inspiration...

SCALE-UP classroom
Beichner
North Carolina State
Robert

Dan Udovic, University of Oregon
Kolb’s Learning Cycle

Traditional course arrangement
Kolb’s Learning Cycle

Active learning course arrangement
What We’ve Aspired to Accomplish

Engage students at higher levels of Benjamin Bloom’s taxonomy of the cognitive domain...

- Remembering
- Understanding
- Applying
- Analyzing
- Evaluating
- Creating

... and support students’ development of important life skills
Achieving this Required "Flipping" the Classroom

Engage students at higher levels of Benjamin Bloom's taxonomy of the cognitive domain...

... and support students' development of important life skills
Learning Outcomes for Foundations

1. Learn foundational biology concepts in an evolutionary context in a deep and lasting way

2. Develop *foundational skills* needed for success in science & future careers

- Problem solving & critical thinking
- Reading the scientific literature
- Data analysis & interpretation
- Laboratory skills & experimental design
- Team work & communication
- Quantitative reasoning
Flipping a course

Inside of class active learning

Traditional format course

Inside of class passive learning

Fully flipped course

Inside of class active learning
Something else important happens...

Inside of class active learning

Watching lecture videos, increased reading done, etc.

Outside of class student effort

Inside of class active learning

Traditional format course

Course transformation

Fully flipped course

Inside of class passive learning

Inside of class passive learning
How do TBL strategies harness the power of highly effective teams for broader, deeper, longer lasting learning gains?
Gathering evidence of engagement, efficacy and transformation

If you don’t track it, you can’t optimize it;
What are you tracking in your class right now?
Some things we can track

- Student performance on homework, writing, quizzes, tests (on student work)
- Student satisfaction (on student ratings forms)
- Peer evaluation of student participation, engagement, effort and contributions
- Change in student’s knowledge or understanding over the semester
- Student ability to do the profession’s work
- Student expressions of transformation
And if we use institutional data we can track even more...
Preliminary Assessment of Foundations

On average students admitted directly from high school who took the Foundations course sequence have done better in relevant upper division courses than those admitted directly from high school who took a lecture-based intro bio course.

<table>
<thead>
<tr>
<th>Intro Biology Course</th>
<th>Biochemistry</th>
<th>Biochem I</th>
<th>Animal Physiology</th>
<th>Animal Behavior</th>
<th>Genetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol1001+1002</td>
<td>Bioc3021</td>
<td>Bioc4331</td>
<td>Biol3211</td>
<td>Biol3411</td>
<td>Biol4003</td>
</tr>
<tr>
<td>Avg. Grade</td>
<td>3.10</td>
<td>3.31</td>
<td>2.90</td>
<td>3.41</td>
<td>3.16</td>
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<tr>
<td>N</td>
<td>76</td>
<td>20</td>
<td>28</td>
<td>17</td>
<td>68</td>
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<tr>
<td>&quot;Foundations&quot;</td>
<td></td>
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<tr>
<td>Biol2002+2003/4</td>
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</tr>
<tr>
<td>Avg. Grade</td>
<td>3.47</td>
<td>3.46</td>
<td>3.36</td>
<td>3.47</td>
<td>3.70</td>
</tr>
<tr>
<td>N</td>
<td>44</td>
<td>8</td>
<td>15</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
</table>
Effect of introductory biology course on performance in BIOL 4003 (Genetics)

Course grade

Frequency (%)

BIOL 1001 + 1002 (lecture)
BIOL 2002 + 2003 (active learning)

$p = 0.0072$
N = 207   Two sections compared, both in the same ALC
One with lecture format      The other: active learning format
**Table 3. Difference of Means Tests of ACT Scores & Grades (FSOS 3101), by Pedagogy**

<table>
<thead>
<tr>
<th></th>
<th>Lecture</th>
<th>Active Learning</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACT</strong></td>
<td>22.74 (0.43)</td>
<td>22.18 (0.47)</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td><strong>Grade</strong></td>
<td>81.80 (0.01)</td>
<td>85.50 (0.01)</td>
<td>3.70***</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>93</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Cell entries are means, standard errors (in parentheses), and the number of cases.  

***p < .001
Expected vs. Actual Grades (FSOS 3101), Lecture vs. Active Learning

- Lecture:
  - Expected: 81.47%
  - Actual: 81.80%

- Active Learning:
  - Expected: 80.96%
  - Actual: 85.50%
A senior-level course in cell biology
Traditional format (2008-10) changed to Active learning format (2011-present)

3 unit course Not paired w/ lab One of seven sections

2 – 75 minute class meeting/week 15 week semester

116 students 95% seniors Avg. attendance = 93%

One graduate student TA helps with logistics and most grading (except project), and offers an optional weekly discussion section.

Format is like Foundations in that ½ the time is spent on projects and much of the rest of the time on team activities punctuated by mini-lectures.
Concept Inventories

a criterion-referenced test designed to evaluate whether a student has an accurate working knowledge of a specific set of concepts

- Statistics
- Physics
- Chemistry
- Biochemistry / Molecular biology
- Natural selection
- Genetics
- Engineering
- Geoscience
What *else* they’ve learned

- How to communicate more effectively about their academic work.
- How to collaborate more effectively on a team.
- How to think through problems in the discipline with creative and diverse approaches.
- How to write a design proposal based on the literature and their first principles thinking.
- How to create and present a scientific poster to a critical audience.
- How to evaluate colleagues and their work in a thoughtful and objective manner.
Agenda

I. Introductions and outcomes: participants and team-based learning (TBL)

II. The readiness assurance process

III. Effective dose of active learning and TBL

IV. Application activities

V. The power of teams

VI. Stacking the odds for the success of teams

VII. Transformative course design

VIII. Gathering evidence of engagement, efficacy and transformation

IX. Wrap-up, Q&A and conclusion
Wrap-up and Q&A

All journeys must come to an end; then we ask questions and tell stories
Test

• Here’s where we would normally, after some passage of time to allow study and use of information, reflection, and memory consolidation, give students an exam, to assess their acquisition of most important (and challenging) concepts, and their ability to apply them as a professional in the field would
Team-Based Learning: Group Work that Works

https://www.youtube.com/watch?v=kxg5FTGZhZs&t=636s
Outcomes we’ll work toward today

1. You can define TBL and describe its essential elements
2. You can explain the concept of effective dose, and why TBL is a strategy not a spice
3. You can evaluate an activity’s suitability for inclusion in a team-based learning course
4. You can describe four ways that teams of students differ from groups of students
5. You can give four ways in which the likelihood of success of a given team can be improved
6. You can describe how to design a TBL-based course and how to transition from a traditional-format
7. You can describe a well-rounded, actionable assessment plan and explain why it matters to have one
8. You commit to reading *Team-based Learning* and to transforming one of your courses to TBL format
Summary - rework

• An active learning course can be – perhaps should be – a much richer learning experience with ambitious goals in terms of content learning and retention, the level at which students master material, and the many additional skills they can develop in a class.

• Students are capable of much more than we usually give them credit for.

• What makes the difference? Intentionality of design, giving and gathering feedback, and using diverse methods to engage & motivate students.
Questions?
Student acceptance of TBL?
A comment from 2008 when I taught cell biology in the traditional format

“The exams seemed unfair, a lot of homework questions does not test anything but memory. I studied a lot for the exam from the lecture and the slides but to find that I am failing due to homework questions from the book does not and did not test my basic understanding of the material presented, since the HW in itself takes hours to finish & the exams the time is very limited.”
Another comment from 2008 when I taught cell biology in the traditional format

“The instructor could have presented the material at a slower pace. He could have also spent more time talking about the homework problems in class (however, I am aware of the time constraint).”
A comment from 2011 when I first taught cell biology in the active learning format

“Okay, this class was by far the worst class I’ve ever taken. It was a total pain. There was way too many assignments, far too much busy work. It was overwhelming. The amount of work I spent on this class was insane. You need to change something. Just a project and less quizzes and work. Look long and hard at this system before you subject students to this type of system (again).”
Another comment from 2011 when I *first* taught cell biology in the active learning format

“Sometimes the deadlines and expectations were unclear. Be more straightforward & clear with instructions and deadlines. The hardest part of the quizzes was figuring what you were looking for”
One last comment from 2011 when I first taught cell biology in the ALC format

“This class has been an unforgettable experience. I have never learned so much in such a short amount of time while feeling like I can apply and retain it. It generated both stable background knowledge and functional understanding. Dr. Matthes really made this course; his interest, expertise and enthusiasm was the heart of the experience”
Comments from 2013 when I most recently taught cell biology in active learning format

“One of the most thoughtful and effective ways to teach. It’s a revolutionary structure and I wish more classes would follow this structure. Exceptional!”

“I loved the structure and projects in this course. They really stimulated my cell biology learning experience”
The numbers on student perceptions from the student ratings of teaching (SFTs)

I have a deeper understanding of the subject matter as a result of this course.
(1 = strongly disagree to 6 = strongly agree)

2009  5.18/6.00  [traditional format]
2011  5.39/6.00  [first time in ALC]
2013  5.70/6.00  [most recent time in ALC]

Compared to other courses at this level, the amount I have learned in this course is more:

2009  52.4%  [traditional format]
2011  59.3%  [first time in ALC]
2013  77.9%  [most recent time in ALC]
Common instructor concerns?
Challenges to Adoption of the Approach

... acknowledge the published evidence supporting a student-centered approach

... try what feels risky – designing a student-centered course and trusting the process

... let go of the misplaced concern for coverage – more time lecturing ≠ more lasting understanding

... work with the rooms we have for now and begin asking for active learning classrooms
Some commonly voiced concerns

• How will I possibly cover the content I’m expected to cover?
• Do I need to change my course so much to get the benefits of active learning? Does classroom shape really matter? I’m already using clickers.
• What will students say? Our students are not as motivated, prepared, skillful. Will my evals drop?
• How will I learn all that I need to about activities and methods, and have the time to make all the activities (etc.) that I need to?
Other instructor concerns

• Looking stupid up there!
• Relying on / having difficulties with technology and no tech support available (esp. since I teach evenings, weekends, etc.)
• Changing my course so much that it actually distracts from learning.
• Once I move to an active learning classroom that I won’t be able to easily switch back
Questions from other instructors?
Some instructor questions

• Where will the time come from?
• Will my student ratings / course evaluations go down?
• Don’t students generally hate group work?
• Isn’t this going to exacerbate grade inflation?
• How do you flexibly choreograph the class on the fly and deal with unplanned questions or issues that arise?
Some more instructor questions

• What are some creative ways to use space and technology that truly make learning different?
• What active learning strategies can or should I include in my teaching?
• How do I get hands-on practice in advance of roll out?
• How long does it take students to learn how to use the environment? How to facilitate this?
• Should I try new exercises at the unit level, then slowly ramp up to a full active / flipped class?
Even more instructor questions

• How do you make a good team activity?
• What is lost when shifting from a lecture to an active learning format?
• Is making an active-learning format class the same as “flipping” a course?
• How do teams get made to work well together?
• What about inter-team interaction?
What challenges should I anticipate?
Some challenges to anticipate

- **Student expectations**: the more you deviate from the traditional course format the more (clearly and often) you need to explain your objectives, the data supporting your methods, etc.

- **Student distraction and your ability to see it**: laptops closed, cell phones silenced or off and put away, reading material not related to this course stowed away. You need their focus and this can be a more distracting environment.
Some challenges to anticipate

• Students will generally come to your course with a preconceived idea that *group work* is either a poor use of time or just painful to do.

• Students will also generally come to your course with a preconceived idea that *in-class activities* are a poor use of class time.

• It will be a noisier, messier, and more logistics-intensive experience than your traditional courses.
Some challenges to anticipate

• Running out of time to convert your course; being only half there is a problem.
• You might need to teach them something about the soft skills you want them to develop (e.g. best practices in collaboration)
• Noise (of conversing students themselves, not just of video you present)
• Letting go of full instructor-control can be difficult
What are common misconceptions about TBL and active learning?
Common misconceptions

• There is more grade inflation in active learning courses than in traditional lecture courses.
• The average scores on my student evaluations will decline if I switch from lecture format.
• I’m doing all I can to motivate my students; what more do they need, singing and dancing?
• Electronics & other gadgets aren’t very important for the solution.
More common misconceptions

• Active learning is good for small classes like you might find at a private liberal arts college but not for the large classes of a public university.

• Active learning is fine for the weaker students but the better students will pay the price.

• I use clickers; I already use active learning.

• My student evaluations are already close to maxed out; why change what I’m doing?
How effective are the active learning classrooms (ALCs)?

What impact do they have on students and instructors?
Impacts of Active Learning Classrooms

- Student-Centered Approach
  - Collaboration
  - Interaction
- What does it change for students?
  - Learning
  - Involvement
  - Risk
  - Community
- What does it change for the instructors?
  - Effectiveness as instructor
  - Relationship with student
Some specific impact of ALCs

Exploratory research into the impact of ALCs began in August 2007. These investigations conducted in collaboration with the Office of Classroom Management, showed that:

• faculty teaching in new learning spaces and students learning in them both had strongly positive attitudes toward the spaces at the end of the term;
• both faculty and students perceived reduced psychological distance between faculty and students, and among students;
• the round tables in the ALCs were singled out as especially important to the impact of the rooms on teaching and learning.
Other specific impact of ALCs

• Both students and faculty rated the ALCs very high in terms of engagement, enrichment, flexibility, effective use, and course-room fit, but the faculty numbers were even more positive than the student responses.

• Both faculty and students were sanguine about students’ ability to focus on a source of information; to identify who is speaking in class; and to follow what is happening in class.

• Students responded positively to the ALCs whether they had prior experience or not; no matter whether they were male or female; no matter whether they were younger or older.

• Science faculty were noticeably more enthusiastic about the ALCs than either their students or their non-science faculty colleagues were.
Team-based Learning Resources

http://www.teambasedlearning.org/
DAVID J MATTHES

David Matthes is an Associate Professor (Teaching) in the Biology Program and Department of Genetics, Cell Biology and Development at University of Minnesota, Twin Cities.

His courses include the award-winning Foundations of Biology course, a senior-level, team-based learning-format section of Cell Biology, a project-based bioinformatic analysis course in which students characterize human genes of unknown function, and a personal genomics course in which students analyze their own genome variations while learning about the connections between the genome and many aspects of the human condition.
Thank you!