Integrating Team-Based Learning Across Disciplines: Ideas and Challenges

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Team-Based Learning

Photo courtesy of the Center for Instructional Technology, Duke University
Team-Based Learning

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sequence repeated as needed for mastery of learning outcomes →

student mastery of learning outcomes

Duke UNIVERSITY
Learning unit

Typical TBL Module

Readiness Assurance
1 to 1.5 hours

Application Activities
2 to 5 Class Periods

- Readings
- iRAT
- tRAT
- Appeals
- Mini-lecture

Duke University
TBL at Duke

- Support for innovative teaching
- Center for Instructional Technology
- 17 Faculty Fellows
- Met for intense summer workshops (5), continued in Fall

Photo courtesy of the Center for Instructional Technology, Duke University
Level: Undergraduate

Primary learning outcomes:
- Overview/Survey
- Focus on Restoration Plan
- Apply the principles of restoration ecology through the development of a detailed restoration plan

Students: 16 students
- 4 teams of 4 students

5 modules:
- Learning objectives
- Readiness Assessment
- Applications
Student buy-in
In which scenario could a developer purchase mitigation credits to offset wetland loss?

a. A mitigation bank exists in the same watershed as the development activity.

b. A mitigation bank exists in the same state as the development activity.

c. Never. A developer is always responsible for creating its own mitigation credits.

d. Only when an in-lieu fee sponsor provides an opportunity to protect or restore a wetland in the same watershed as the development activity.
Duke Forest has plans to close the popular trail to the New Hope Creek Rhododendron Bluffs.

What are the three most important stakeholder groups to engage early in this process?
Biggest challenges

‣ How can I write multiple choice questions that test a student’s knowledge/understanding?

‣ How do I know when I should provide a mini-lecture to clear up confusion?

‣ How can I balance TBL techniques with other innovative strategies?
Measures of success

- Student grades
- Course evaluations
- My own energy level
- Student feedback

“I had a cohesive group with great team chemistry. We were also diverse enough to bring a variety of perspectives to different ideas/problems/concepts, which provided a more comprehensive understanding of them.”
Level: Introductory undergraduate
- No calculus required

Primary learning outcomes:
- Critique data-based claims and evaluate data-based decisions
- Acquire a conceptual understanding of the unified nature of statistical inference.
- Use statistical software to summarize data, visualize, and perform data analysis

Students: 120 undergraduates
- 29 teams of 4-5 students
- Mostly social sciences first-year and sophomores

Textbook: OpenIntro Statistics

Meetings: 75 minutes twice/week (with me) + 75 minutes once/week lab (with TAs)
Forming teams

- Before class / first day of class:
  - **Survey:** previous stats/math/CS exposure, major, year, why they’re taking the class, hobbies/interests
  - **Pretest:** Comprehensive Assessment of Outcomes in a First Statistics course (CAOS)
    - Conceptual questions assessing statistical reasoning
    - [https://apps3.cehd.umn.edu/artist/caos.html](https://apps3.cehd.umn.edu/artist/caos.html)

- **Team composition:** 4-5 students, heterogeneous with respect to preparation, homogenous with respect to major/interests/etc.

- Teams formed from Day 1, drop/add period introduces challenges
Readiness assessments

- **Preparation:**
  - Guided reading from text (learning objectives)
  - 4-5 videos/unit, each 3-10 minutes

- **Format:**
  - First take individually using clickers (i>clicker2 with self-paced polling capability)
  - Then re-take in teams using scratch off sheets

- **Feedback:** Lecture focusing on questions most missed on individual RA
Which of the following is false? Hint: It might be useful to sketch the distributions.

a. The Z score for the median of a left skewed distribution is most likely negative.

b. The Z score for the median of a symmetric distribution is approximately 0.

c. Z scores are defined for observations from distributions of any shape and skew.

d. Calculating percentiles based on the Z table is only appropriate for observations that come from (nearly) normal distributions.

Use the Z score to determine the percentile score of a data point if the distribution is normal (using technology or normal probability tables), or to assess whether or not the particular observation would be considered unusual (regardless of the shape of the distribution).

Depending on the shape of the distribution determine whether the median would have a negative, positive, or 0 Z score.
Computing labs

- **Hands on experience** with data analysis using modern statistical software (R/RStudio)
  - New to almost all students
- **Lab reports**: completed in teams
  - "Author" role rotates
  - All members engage in discussion
  - Need attend lab session to get credit
- **Initial challenge**: pacing, mostly resolved via peer evaluations
- **Benefits**:
  - Conceptual discussions instead of just copying/pasting code
  - Students help each other, much easier for the TA to effectively help 25 students at a time
Benefits, challenges, lessons learned

**Benefits:**
- Active learning and peer instruction → engagement with the material and with each other in a meaningful way
- Learning units and objectives → organization and clear links between main concepts
- Developing team dynamics early on → end-of-semester team project completed with minimal issues
- Peer evaluations → detect and triage problems early on

**Challenges:** with respect to implementing TBL in a large class
- Application activities difficult to implement efficiently without additional instructors (TAs) in the room
- Classroom configuration is not conducive to team based activities
- Peer evaluations and team formation are quite time consuming

**Lessons learned:**
- A hybrid course works best for my class – some time spent lecturing
- Tweaking TBL guidelines as it fits the course is OK – AAs not graded
Student feedback

‣ "[...] we have discussed the problem set questions in ways that force us to explain our reasoning (and therefore actually learn the material). Though we may each grasp the material to different extents prior to the readiness assessments, our discussions have involved each member’s participation and have resulted in great scores. [...]"

‣ "[...] it helps us get the collaborative educational process without being overwhelmed by how many kids are in the class while still feeling like you’re getting individual attention and education."

Advanced Optics

- **Level:** Upper level graduate
  - Highly mathematical: calculus, complex analysis, differential equations

- **Primary learning outcomes:**
  - System-level analysis of optical systems
  - Design optical systems appropriate for tasks
  - Read and analyze current primary literature

- **Students:** 9 physics and electrical engineering students
  - 1 first-year and 5 year 3 or above graduate students, and 2 juniors

- **Textbook:** Fundamentals of Photonics

- **Meetings:** 75 minutes twice / week
Selecting teams

- **Survey** on Sakai before the first class
  - Asked one question about student background, including past course, research, industry experience.
  - Other questions on department affiliation, grad/ugrad, other course using the same textbook, apprehension about the course.

- **Teams**: 2 teams of 4, 1 team of 5 → 3 groups of 3
Decades ago, a picture in a newspaper consisted of a series of fine, regularly spaced dots each with a different gray scales. Imagine making a transparency from such a figure and placing it at the input of a 4-f imaging system. The dots can be removed from the output image by using a mask in the Fourier plane of the system that is of the form of

a. A small opaque dot on the optical axis and transparent elsewhere.
b. A narrow optical slit oriented vertically.
c. A narrow optical slid oriented horizontally.
d. A small hole centered on the optical axis.
Application Activity

- Short AA on day of RAT
- 2-3 AAs on remaining 3 days of learning unit
- Write on large sticky-note paper, post on wall, discuss
- Eventually photographed with phone for posting, grading
- Sample application activities:

  **Unit 1 - Application Activity 1A (~25 mins)**
  In Saleh & Teich exercises 3.1-1 - 3.1-5, methods for determining Gaussian beam parameters are discussed. Determine which method is best from an experimental point of view.

  **Unit 1 - Application Activity C (~25 mins)**
  Devise a method for taking a TEM$_{00}$ Hermite-Gaussian mode from a laser and turning it into an approximation of a plane wave. Make sure to discuss and analyze your criteria for success.
\[ \lambda = 1.55 \text{\textmu m} \]

\[ D_\lambda \left( -\frac{\lambda_0^2}{c} \right) = D_r \Rightarrow D_r = \left( \frac{-\left(1.55 \times 10^{-6}\right)}{3 \times 10^{-8} \text{m/s}} \right) \left( 18 \times 10^{-12} \frac{s}{\text{m} \cdot \text{m}} \right) \]

\[ = -1.41 \times 10^{-25} \text{ s}^2/\text{m} \]

(a) How far do we need to go to increase width by 2? 
\[ \tau = \tau_0 \sqrt{1 + \left( \frac{2z_0}{z} \right)^2} \cdot \left( \frac{z}{z_0} \right)^2 = 3 \]

(b) What is \( z_0 \)?
\[ z_0 = \frac{\pi \tau_0^2}{D_r} \]

1. 1 ps: \( \frac{\pi \times 10^{-15}}{1.41 \times 10^{-25}} = 37.8 \text{ m} \)
2. 25 ps: \( 2.36 \text{ km} \)
3. 100 ps: \( 377.87 \text{ km} \)

(c) What is losses?
\[ \tau = \frac{T}{10} \]

1. 1 ps: \( 0.2 \times (0.0378) = 0.00756 \Rightarrow T = 0.9983 \)
2. 25 ps: \( 0.2 \times 2.36 \text{ km} = 4.724 \Rightarrow T = 0.337 \)
3. 100 ps: \( 0.2 \times 377.87 \text{ km} = 75.57 \Rightarrow T = 2.97 \times 10^{-8} \]

Work is fine, but you made the mistake of using a full-width-at-half-maximum of the intensity waveform to be equal to \( \tau \), which it is not. Careful!
Score: 11/12
Lessons learned, challenges

- Most in-tune with student learning than any other teaching method
- Surprised about student difficulty with basic materials that they “learned” in previous courses
- Course is definitely active! Usually lots of discussion

- Collaborative space is important
- Don’t be rigid in following TBL guidelines (grade only a subset of AAs)
- Don’t try to start course too quickly
- TA/additional faculty support is likely important for a lots of students
- Flexibility is key, as in any teaching

- Backward design of a course is a good thing!
- Writing learning objectives is painful (for me) but effective
Student feedback

- Mid-semester feedback – are you willing to change?
- Final evaluations:
  - “TBL did help me in my learning. It forced me to learn new things, or I would not be able to catch up [with] my team members.”
  - “Lots of thinking after & before classes [be]cause there is a quiz at the beginning of each learning unit, which motivated me to learn a lot.”
  - “Good interaction.”
  - “TBL is a great way to teach a course. The assignments were fair and helpful, but it was class time where I actually learned the most.”
- Lower course difficulty rating than is typical for me (?!)
- From Prof. Laurie Patton, Dean of Arts & Sciences and Prof. Lee Baker, Associate Vice Provost for Undergraduate Education (2/12/13):
  - “During the fall semester 2012 in the categories of Quality of Course and/or Intellectual Stimulation, your course evaluations were among the top 5% of all undergraduate instructors at Duke for a small class (less than 20 students).”
If you are interested in TBL, what is your major concern?

- Teaching is not necessarily discipline specific
- Community, collaboration, innovation
- University support
- Value added to being on campus in a changing higher education environment