# A review of group-based methods for teaching statistics in higher education

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# Overview

- Introduction
- Problem/case-based learning
- Team-based learning
- Example TBL session
- Evidence of effectiveness
- Discussion and conclusion

# Introduction

- Additional detail in: Jones and Palmer, Teaching Mathematics and its Applications, 2022, 41, 69-86 https://doi.org/10.1093/teamat/hrab002

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## A review of group-based methods for teaching statistics in higher education

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- University courses in statistics traditionally use instructional style
  - Passive learning in lectures
  - Active learning in workshops
- American Statistical Association Guidelines for Assessment and Instruction in Statistics Education (GAISE) report (2016) endorses more active approach
  - Statistics education should resemble its practice
  - Relevant statistical research questions and skills such as cooperation, communication, and teamwork
- Collaborative learning often suggested
- We chose to investigate problem- and team-based learning

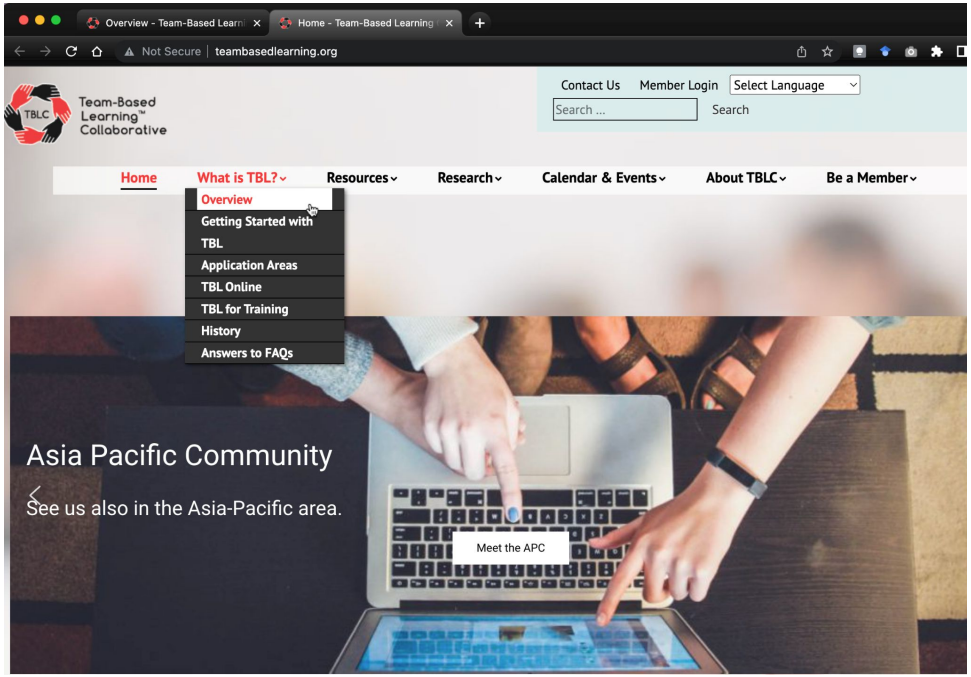
# Problem/case based learning

- Commonly used in Medical/Dental/Law Schools
- Uses problems/scenarios/cases to increase knowledge and understanding
- Aims to teach students to design a set of objectives the accomplishment of which will lead to the development of the solution
- Students then do independent self-directed study
- Return to group to discuss and refine knowledge
- Roles: chair, scribe, others; tutor

- Format of Problem Based Learning sessions
  - Groups meet often with a tutor/facilitator present
  - Tutor can ask questions and prompt to guide discussion towards learning outcomes
  - 1st group meeting
    - Identify what knowledge lacking
    - Set learning objectives/goals
  - Each member then does their research
  - 2nd meeting - after approx. 4 days
    - Discuss and refine what they've found out
- Problem Based Learning assessment
  - Evaluated through surveys - students reflect on learning experiences
  - Tutor guides students through self-assessment of outcomes relative to their goals

# Team-based learning

- http://www.teambasedlearning.org/definition/
  - … evidence based collaborative learning teaching strategy … taught in a 3 step cycle: preparation, in-class readiness assurance testing, and application-focused exercise
- Four principles
  - Groups should be properly formed
    - 5-7 students, not randomly allocated - heterogeneous previous experience
  - Students accountable for their pre-learning and working in teams
  - Team assignments must promote both learning and team development
  - Students receive frequent and immediate feedback



- Format of Team Based Learning sessions
  - Before the session
    - Students complete preparatory materials
  - During the session: in-class readiness assurance testing
    - Individual readiness assurance test (IRAT): 5-20 MCQs
    - Team RAT: take same test as team
    - Both scores count towards the students' grades
  - During the session
    - Working on a problem / in-class application focused exercise
    - Teams arrive at consensus "best" solution out of options provided
    - Teams display choice, educator facilitates classroom discussion

# Example Team Based Learning session

## B. Example statistics TBL session: conditional probability and diagnostic tests

### *B.1* *Learning objectives*

By the end of this section, students should be able to

- Explain the difference between the union of two (or more) events and their intersection.
- Calculate the probability of the union of two (or more) events and the intersection of two (or more) events.
- Distinguish between independent and dependent events.
- Explain intuitively the idea behind conditional probability.
- Use tables and tree diagrams to compute conditional probabilities.
- Explain the rationale behind Bayes' theorem, and use it to compute conditional probabilities.
- Compute probabilities in a range of settings.

### *B.2* *Before the session*

Students work through a directed set of materials, which may include reading, watching instructional videos, quizzes, exercises, among other things.

### *B.3* *During the session: multiple choice quiz*

Students complete a short multiple choice quiz individually, answering a range of questions on probability which might include both theoretical questions such as asking students to apply their judgement on whether two events are independent, through to computing probabilities.

Once the test is complete and submitted, students join their team and answer the same multiple choice quiz. This time each question can be discussed within the team and the group must decide on their joint final answer for each question for submission. Results are available immediately after the team multiple choice quiz, and students can argue their case with the course leader if they think they deserve a higher mark than the one they received. In statistics, this may be because questions or the choice of answers were poorly worded and thus caused confusion.

As the results of the test are available immediately, the course leader can identify any common misconceptions or errors. A very brief lecture follows to clarify these.

### *B.4* *During the session: working on the problem*

An example problem in this case could be the following.

*Down's syndrome is a genetic condition resulting in some level of learning disability, with around one in every 1,000 babies born having the condition. Expectant mothers can opt to take a serum screening test to assess the risk of having a baby with Down's syndrome. The test outcome is either 'positive' or 'negative' for Down's syndrome.*

*As with the majority of medical tests, the test is not 100% accurate. From extensive research, it is known that the test is able to detect Down's syndrome, when the baby has Down's syndrome, in about 85% of cases. Conversely, when the baby does not have Down's syndrome the test identifies this in about 96% of cases.*

*A pregnant woman receives a positive test for Down's syndrome and asks you for advice on how likely the test is to be correct. What are the chances that her baby has Down's syndrome?*

Possible answers: about 85.00%, about 2.08%, about 0.10%, about 0.089%

Correct answer: about 2.08%

This problem requires students to identify the required probability from a text description, translate the given information into appropriate probabilities and manipulate the (indirectly) given probabilities in a non-trivial manner to compute the final probability. The work involved means that it is very difficult to think of a way of splitting the work between group members: each step above depends on information from the previous step.

The three incorrect answers are deliberately given as 'common misconceptions': 85% is the usual prosecutor's fallacy, 0.1% is the prevalence of Down's syndrome without accounting for the additional information from a positive test and 0.089% represents the situation where the calculation of the probability that a test is positive is incorrect (computed without taking the complement of the specificity). It is useful that all answers have a basis in the numbers given here; if not then students would not arrive at that particular answer and so unless they are merely guessing it is of no use.

# Evidence of effectiveness

- PBL in statistics courses Boyle (1999), Hillmer (1996)
- Statistics quite dependent on order of information
  - Deficiencies in understanding of basic concepts may cause difficulties in understanding more complex topics
  - In Team Based Learning there's a danger of "teaching to the test" Nanes (2014)
- Performance on end-of-module assessments
  - Kalain & Kasim (2014) effectiveness dependent upon type of group-based learning
    - Evidence for Team Based Learning
    - No evidence of improvement for Problem Based Learning
  - Karpiak (2011) students performed better under Problem Based Learning
  - Nanes (2014) observed improved grades for Team Based Learning

- Real-world problems
  - Pre-learning for common procedures e.g., hypothesis testing and modelling
  - Problems that do not require handling data may be easier to tackle in class
  - E.g., critical appraisal of a research paper
    - In Problem Based Learning: task around understanding the statistical methods and why used
    - In Team Based Learning: critically appraise use of techniques in context and suggest alternative ways of addressing the research question
  - E.g., consultancy role play
    - Design of an experiment or analysis of collected data
    - Analysis of the data set as task outside of class (In Problem Based Learning: before next group meeting; In Team Based Learning: as pre-work)

- Long-term retention of knowledge
  - Emke et al. (2016) some evidence Team Based Learning group performed better on assessments in short-term but no evidence of difference in the longer term
- Student enjoyment and engagement
  - Evidence suggests improved student engagement with Problem Based Learning and Team Based Learning
  - Students positive about Team Based Learning in maths: Krogstie et al. (2018), Nanes (2014); and statistics: St Clair & Chihara (2012)
  - Maths: some students found ideas more accessible Paterson et al. (2013)
  - Klegeris & Hurren (2011) found Problem Based Learning for a pharmacy course increased attendance
  - Bude et al. (2009) found increased guidance from tutors in Problem Based Learning resulted in better course feedback

- On the other hand
  - Not clear if these/any one approach suits all students
  - Not all students enjoy group learning Haidet (2014)
  - Some students rely on teammates Paterson (2013)
  - Weak students can find the team environment intimidating St Clair & Chihara (2012)
- Teaching space
  - Traditional lecture theatres not great for Problem Based Learning, ok for Team Based Learning
  - Problem Based Learning really needs a classroom per group
- Staff resources
  - Medical schools typically have one tutor per Problem Based Learning group
  - Often just one lecturer per whole module in Team Based Learning

- Creation of groups and student engagement
  - If not done before collaborative learning takes students a while to familiarise with - hence explain structure to them
  - Students engage more as they become more familiar
  - Students should feel confident they can speak to a tutor
  - Groups that stay together have a more positive dynamic Sweet & Michaelsen (2007) and have better student engagement Theobald et al (2017)
  - Groups write own code of conduct

- Possible disadvantages
  - Students might feel group-based learning is glorified self-study
  - Students might worry marks adversely affected by weak teammates
  - Reassure them that appropriate structures are in place mitigate this
- Staff reaction
  - Group-based learning satisfying for staff Jones (1988) - tends to be more interactive
  - Helps to introduce staff to new style of teaching with training/introductory sessions Boud & Feletti (1997), Schwartz et al. (2001)

# Discussion and conclusion

- Used in Medical/Dental/Law Schools
- Examples for potential use in statistics teaching
- Group-based learning can deliver a stronger learning experience
    - Meet needs of employers
    - Easier to apply to areas with an applied/practical component
    - Needs more thought to apply to more mathematical modules
    - Unlike Medical curriculum a Statistics course/module can be adapted section by section over a few years

- Technology can help both students and lecturers
  - Appendix C of paper, e.g. CRAN task view for teaching statistics using R
- Combine peer feedback (TBL) with pre-reading assignments and an initial group discussion (PBL)
- Whether collaborative learning is *the answer* for improved Statistics teaching is unclear
- We recommend emphasis should be on more rounded student education

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