# Exploring the effectiveness of active learning methods in discussion classes of an introductory environmental science course

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## Abstract

*"Tell me and I'll forget; show me and I may remember; involve me and I will understand."* - Chinese Proverb

- I incorporated active learning strategies to teach the discussion sessions of the course Sustainability Science (ESS 002).
- I used class observation, student survey and analysis of final exam scores to explore evidence for improved student learning.
- I observed increased motivational level, development of cooperativeness and increased team spirit among students, and increased satisfaction in their own findings.
- Student survey results indicated students preferred collaborative learning activities.
- Analysis of exam scores indicated smaller gap among student scores where the concept was taught in discussion sessions

## Background

*"Learning which encourages the pupil or student to engage actively with what is being learned through activities such as group discussion, role play, or experimentation, rather than passively receiving and memorizing knowledge or instruction from the teacher"* – Oxford dictionary

- The effectiveness of active learning strategies over traditional methods is generally agreed upon by many educators[3].
- Active learning strategies in science, technology, engineering and mathematics disciplines (STEM) are particularly beneficial to non-majors who often feel they are not good in science[2].
- Active learning has been shown to reduce student achievement gap between underrepresented minority students and nondisadvantaged students[1].
- However, undergraduate learning in STEM disciplines is typically dominated by passive-learning teaching methods.

[1] Haak, D. C., et al. Science *332*, 6034 (2011), 1213–1216.
[2] Kober, N. The National Academies Press, 2015.
[3] Michael, J. Advances in physiology education *30*, 4 (2006), 159–167.

## Course Learning Outcomes

- Sustainability Science (ESS 002) is a three credit hour lower-division course.
- Weekly 50-minute long discussion sessions are a required part of the course and discussion accounts for 10% of course grades.
- The course aims to:
  - Achieve student understanding of the scientific basis of environmental sustainability and the interdependence of humans and the environment.
  - Introduce major environmental challenges facing our generation and approaches to tackling them.
  - Develop student abilities in using simple math to estimate magnitude and trends of sustainability challenges.

## The Students

- There were over 90 registered students but each discussion class had only about 25 students.
- Only 13% of students said they had previously taken another environmental science courses at University level.
- Most of the students said they took the course mainly in order to fulfill credit requirements.
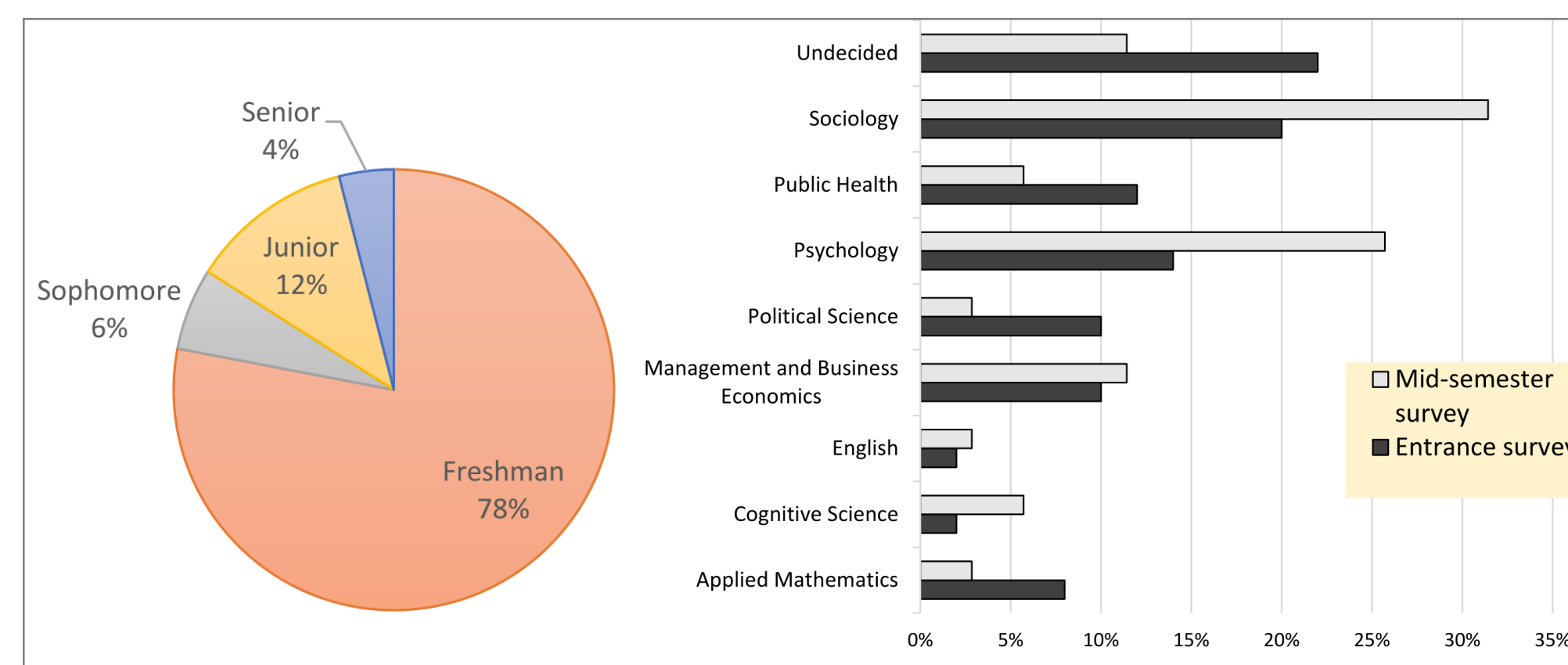


Majority of the students were first-year students and undeclared or non-STEM majors.

## Teaching Methods

- Active learning methods I employed usually involved collaborative learning structures where students worked in small groups to complete group activities.
- Some of the active learning methods implemented with specific examples:

*Active review session game*
- "Stabilization Wedge Game"[4] which is a board where students choose options to solve climate change issues.

*Cooperative groups*
- In small groups, students work on a problem. Groups present their solution to class.

*Interactive lecture*
- Using interactive on-line tool, students compare life-cycle environmental cost of a product.

*Jigsaw discussion*
- In small "expert groups" students discuss section of a scientific article which they then teach to their "home group".

Lecture with self assessment activities
- Students work on an example problem of a concept taught in discussion before moving on to another concept.

- Learning outcome based lesson plans for each session were prepared.
- Direct indirect learning assessments were done for every session. Direct assessment were often an end of class 'minute paper'.

[4] Pacala, S., and Socolow, R. Science 305, 5686 (2004), 968–972.

## Findings and Discussion

- I observed increased motivational level, development of cooperativeness and increased team spirit among students. I also noticed an increased satisfaction among students when they arrive at a solution on their own.
- 78% of students said that they found it easier to learn by doing collaborative group activities. "Wish for even more group activities in the future" was the second most frequent comment on the mid-semester student survey.
- Students scored an average four percent points higher on those questions that were taught in the discussion as opposed to those that were only taught in lecture classes.
- The gap in scores among students was narrower when the questions were those taught in the discussion classes.
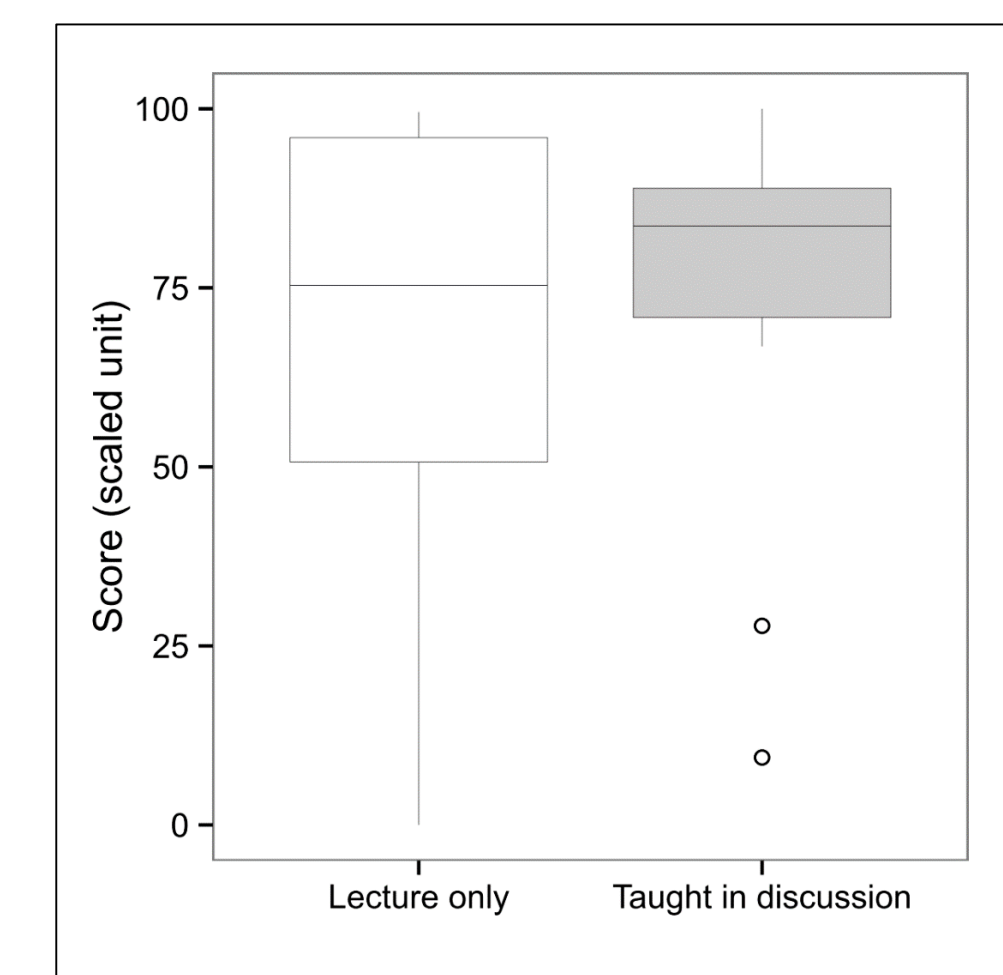


Distribution of final exam scores. Scores grouped based on whether questions were covered in discussion class (i.e. taught with active learning methods) or not. Scores are adjusted to the same scale.

- When the exam questions were grouped based on levels of cognition and levels of knowledge (based on Revised Bloom's Taxonomy), the score distribution was always smaller for questions that were taught in discussion.
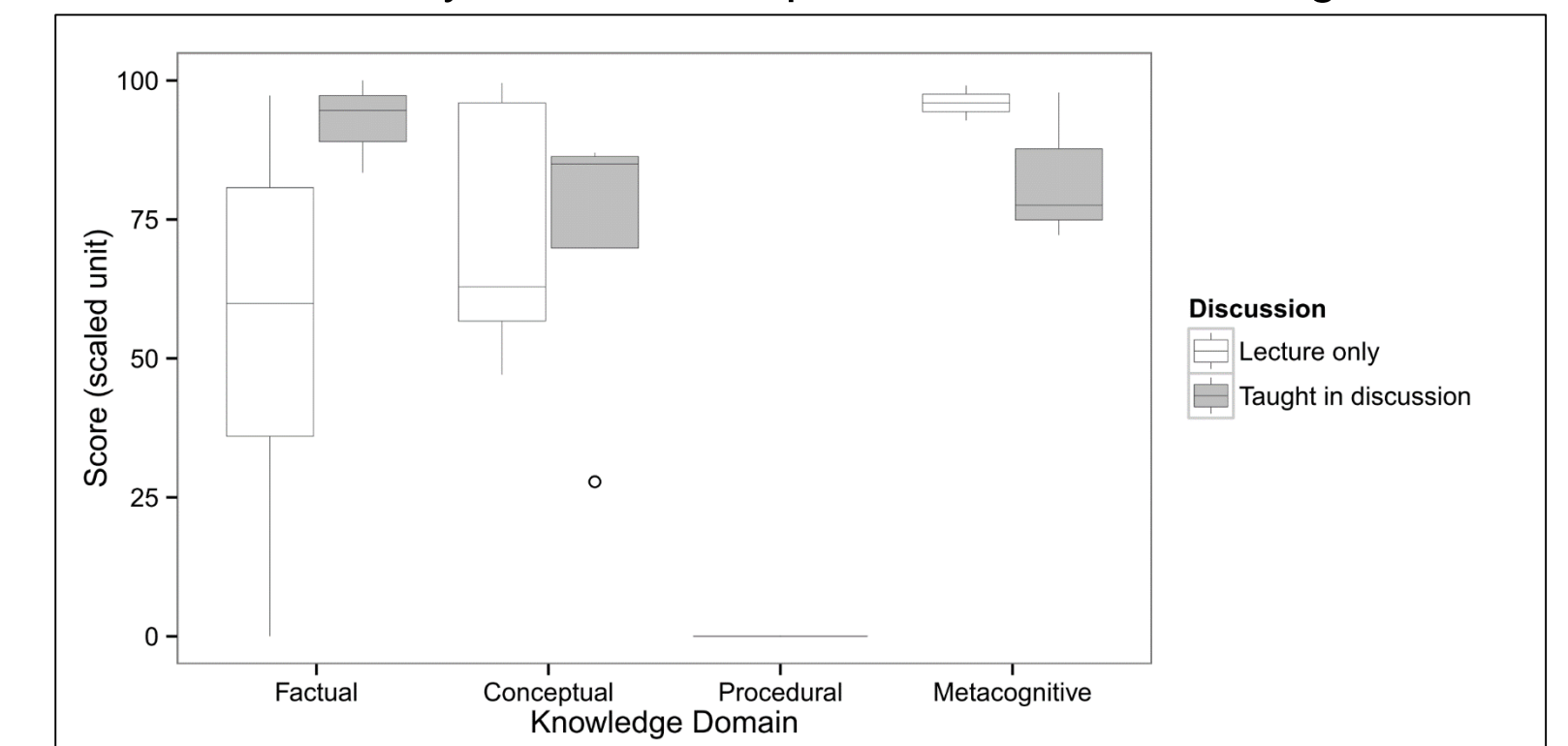


Distribution of final exam scores grouped based on knowledge categories of the Revised Blooms Taxonomy. Questions are grouped based on weather that were covered in discussion classes or not.

## Concluding Remarks

- I observed higher motivational level of students, lively classroom atmosphere, and higher team spirit among students.
- Student survey indicated that students feel they learn better with collaborative learning methods.
- Analysis of exam scores did not suggest active learning methods improved student scores.
- But, there was narrow scores gaps among students, possibly indicating closer learning level among students.