A Systematic Assessment of the Benefits of Active Learning in Undergraduate Aerodynamics

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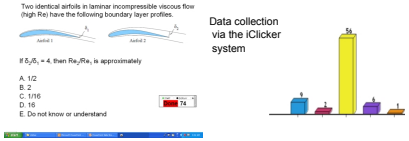
Abstract

This work studies the effectiveness of one non-traditional lecture approach, based on in-class concept questions, on the performance of students in a core undergraduate Aerodynamics course. The motivation for this investigation comes from existing research showing the benefits of having students actively engaged in the learning process, for example through responding to concept questions and participating in follow-up discussions. The effectiveness of the approach is studied over two consecutive terms by varying the amount of time spent on concept questions in each term. Performance is assessed using four standardized quizzes and the final course grade. Student information pertaining to gender, ethnicity, and prerequisite grade were included in the study. No statistical significance was found in the relationship between quiz performance and any of the independent variables. Only performance in the prerequisite class was found to be strongly correlated to the final course grade. Suggestions are made for improvements to the methods in a follow up study.

Methods

- Target class: two terms of undergraduate Aerodynamics (AE 325), a core course in aerospace engineering.
- Same instructor and GSI both terms.
- Concept questions constituted active learning component



Data collection via the iClicker system

- Term-to-term difference: amount of time spent on concept questions during each lecture (80 minutes total):
  - 15 minutes of concept questions in Fall 2010
  - 25 minutes of concept questions in Winter 2011

  Remainder of time was a standard whiteboard lecture.
- Kept a lecture log of concept questions and topics covered
- Standardized performance assessment between terms:

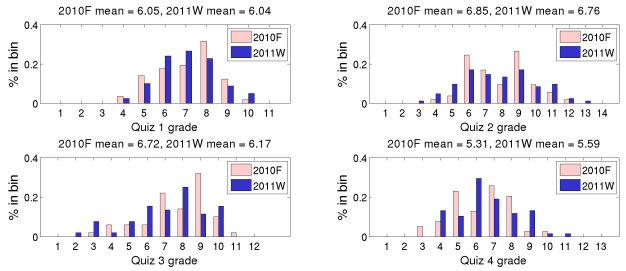
  multiple choice quizzes (not counted towards final grades).
- Additional variables for statistical analysis: final course grade, gender, ethnicity, prerequisite grade (in Aero 225)
- Statistical analysis in SPSS (type IV sum of squares) using repeated measures and univariate models

Results

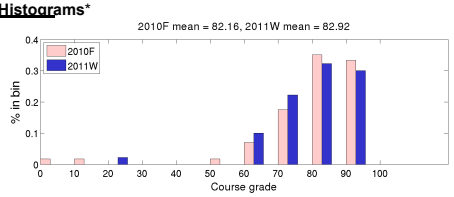
Sample Summary: 147 students

- 132 male, 14 female, 1 no data, 57 in Fall 2010, 90 in Winter 2011
- 98 White, 25 Asian, 10 other, 14 no data

Standardized Quiz Histograms



Course Grade Histograms*



2011W course grades do not include final exam (not available at time of printing)

Statistical Analysis

Repeated measures: effects on quiz (2,3,4) scores

Source	Significance	Partial Eta Squared	Observed Power
quiz_1	0.283	0.020	0.187
course_grade	0.190	0.029	0.257
ae225_grade	0.724	0.002	0.064
gender	0.486	0.008	0.106
race	0.648	0.027	0.157
term	0.802	0.001	0.057
gender * race	0.763	0.002	0.060
gender * term	.	0.000	.
race * term	0.236	0.069	0.366
gender*race*term	.	0.000	.

Univariate model: effects on final course grade

Source	Significance	Partial Eta Squared	Observed Power
ae225_grade	0.000	0.326	0.999
quiz_1	0.637	0.004	0.075
quiz_2	0.287	0.020	0.185
quiz_3	0.034	0.076	0.570
quiz_4	0.450	0.010	0.116
gender	0.506	0.008	0.101
race	0.566	0.035	0.186
term	0.618	0.004	0.078
gender * race	0.349	0.015	0.153
gender * term	.	0.000	.
race * term	0.149	0.089	.455
gender*race*term	.	0.000	.

Discussion

Nomenclature

- *Significance*: Probability that the experimental results are due to chance (and were not caused by a relationship between the indicated variables). By convention, significance < 0.05 is required to reject the null hypothesis.
- *Observed Power*: Probability of correctly rejecting the null hypothesis. Again by convention, power > 0.8 is desired.
- *Partial Eta Squared*: Normalized measure of a predictor variable's "predictive contribution" to the dependent variable: i.e., a relative measure of effect size.

Repeated measures model (effects on quiz scores)

- No independent variable has a statistically significant impact.
- Insufficient data to estimate significance and power for gender*term and gender*race*term interactions.

Univariate model (effects on the final course grade)

- Only Aero 225 (prerequisite) grade has a statistically significant effect on the Aero 325 final grade.
- Large value of partial eta squared for the Aero 225 grade variable suggests a strong correlation.

Conclusion

- Lack of statistical significance in the repeated measures model means that we cannot draw conclusions on the benefits of concept-question-based active learning from this study.
- Only prerequisite performance was found to be a statistically significant and strongly-correlated predictor of the course grade.
- Qualitative assessment: class was more engaged and asked more well-formulated questions following concept questions.
- Assessment techniques need to improve to obtain statistical significance.
- Future work:
  - Improve wording of standardized quizzes
  - Include quiz grades in course grades to incentivize performance – would need to mitigate possibility of honor code violations since the same quiz should ideally be used in both terms.
  - Perform a control study without concept questions

Acknowledgments

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