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Introduction of active-learning elements to physics lectures: preliminary results

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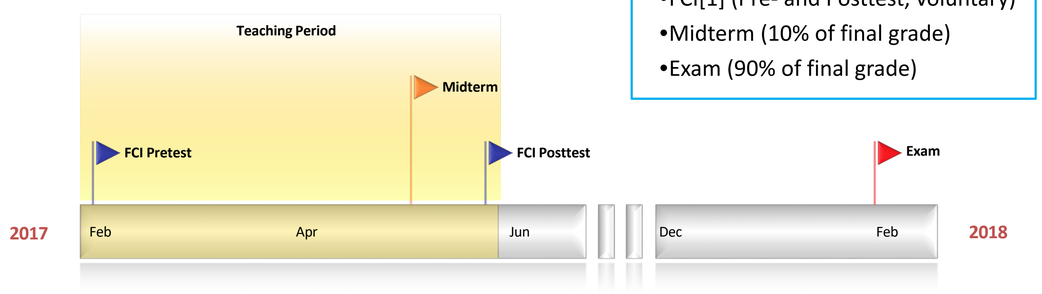
Project Outline

During the spring semester 2017 we have divided a non-physics student cohort into two parallel teaching settings, one focusing on conceptual understanding (SCALE-UP) and one focusing on content delivery (LECTURE).

This presentation provides preliminary findings on the students' performance in the SCALE-UP setting compared to the LECTURE setting.

Teaching:
- 13 weeks x 3h (SCALE-UP/LECTURE)
- 13 weeks x 1h (exercise session)

Assessments:
- FCI[1] (Pre- and Posttest, voluntary)
- Midterm (10% of final grade)
- Exam (90% of final grade)



SCALE-UP offers a highly collaborative, hands-on, computer-rich, interactive learning environment.[2] In the SCALE-UP setting the students worked through activities in small groups of 3-4 students each. Before each class students started learning about a topic by doing assigned readings and online exercises via MasteringPhysics. In class, the student groups did activities that helped them understand the basic concepts from the reading, and applied these concepts in experiments and problems.

LECTURE provides a structured framework for content delivery and addresses a large number of students. Apart from communicating enthusiasm for the topic, the lecturer tailors the material to the students' needs.[3] The LECTURE setting included 40 demonstrations. 37 conceptual clicker questions with peer instruction [4] were used in order to engage students interactively and to get instant feedback of their level of understanding.

Both settings were supplemented by weekly **exercise sessions**, where numerical problems were discussed together with teaching assistants.

Essential key figures

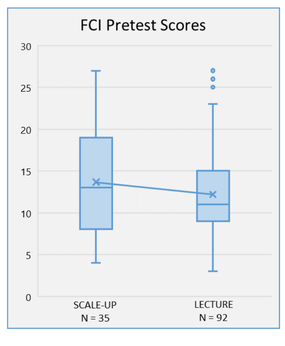
	SCALE-UP	LECTURE
Instructors	1 Full Professor + 3 TAs	1 Full Professor + 16 TAs
Students	52	318
Room infrastructure	9 tables, each with 6 seats	amphitheater with 372 seats

Special boundary conditions

- both main instructors were awarded for excellent teaching and had long-term experience in their respective teaching setting
- the SCALE-UP setting was limited by 54 seats, students were free to choose the teaching setting at the beginning and were allowed to revoke their choice during the semester
- the weekly exercise classes were identical for all students and covered the same numerical problems that all students were invited to solve as a homework
- for all students the attendance, the homework and all assignments were optional
- the midterm was optional and can be counted for 10% of the final grade if ameliorating the result of the final exam in Jan/Feb 2018

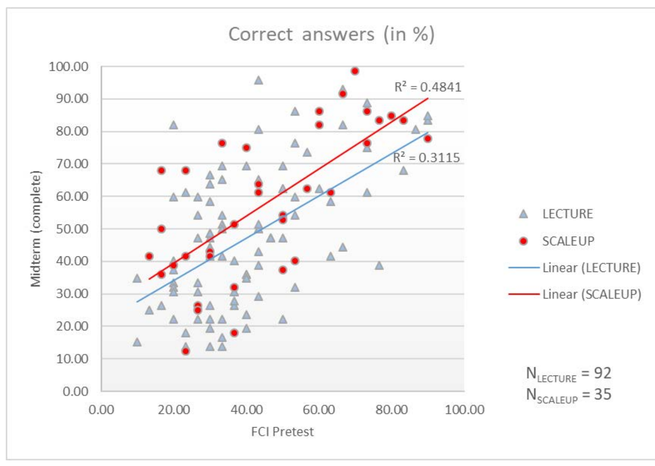
Initial group differences?

As the students were not assigned randomly to the two settings SCALE-UP and LECTURE, it might be argued that only the best students have joined SCALE-UP. Based on the FCI-Pretest there was no statistically significant difference in the mean scores between the two settings: $t(52) = -1.18$, $p = .243$, $d = .26$. Thus, we can assume that students in both groups shared the same pre-knowledge.

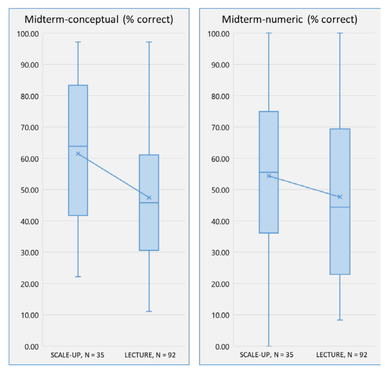


Students' Performance in the Midterm Test

An optional midterm exam was administered to the students in week 10. It covered 3 conceptual and 3 numeric problems, each one with a maximal credit of 12 points.



Distributions of paired results

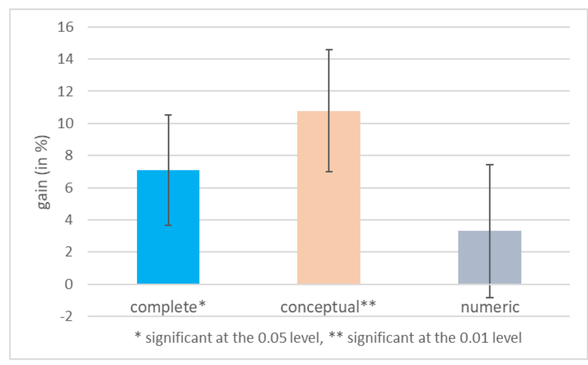


There was a correlation between the results of the FCI Pretest and the overall results of the midterm exam: $r_{LECTURE} = .558$, $p < .001$ and $r_{SCALE\text{-}UP} = .696$, $p < .001$.

For this reason we opted for an ANCOVA analysis in comparing the results of the midterm exam while holding the effects of the FCI Pretest constant.

Mean performance gain of the SCALE-UP group, from ANCOVA (in % of correct answers)

Midterm	Gain (in %)	Std. Err.	Conf. Interval
complete	7.10	3.44	[0.29, 13.90]
conceptual	10.78	3.80	[3.28, 18,32]
numeric	3.31	4.14	[-4.89, 11.51]



There was a significant positive effect of the SCALE-UP setting on the complete and on the conceptual midterm performance after controlling for the effect of the FCI Pretest achievements: $F_{complete}(1,124) = 4.26$, $p = .041$ and $F_{conceptual}(1,124) = 8.07$, $p = .005$.

The performance in numeric problems, however, remained unaffected and students in both settings obtained similar results: $F_{numeric}(1,124) = 0.64$, $p = .426$.

The results from a t-test analysis without a covariate were similar.

Summary

A student cohort was divided into two parallel teaching settings, a traditional LECTURE and a highly interactive flipped class (SCALE-UP).

The students' performance was measured according to the results of a midterm exam.

- **The SCALE-UP students performed significantly better on conceptual problems.**
- **SCALE-UP and LECTURE students showed similar results for numeric problems.**

References

[1] Hestenes, D. , Wells, M. & G. Swackhamer, (1992). Force concept inventory. *The Physics Teacher, 30*,141-158.

[2] Beichner, R., et al. (2007). Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) project. In E. F. Redish and P. J. Cooney (Eds.), *PER-Based Reform in University Physics, Vol. 1.* College Park, MD.

[3] Exley, K. & R. Dennick (2004). *Giving a lecture: from presenting to teaching*. London: Routledge.

[4] Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69(9),* 970-977.