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ETH zürich

Flipping large university courses: how do student learning gains improve compared to lectures

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Conference Paper

1. Motivation

In the past, all ETH introductory physics lectures have been reformed and supplemented by active learning elements such as Peer Instruction [1]. A different approach consists of breaking up large lectures into smaller classes and shifting to highly interactive flipped learning settings. Studio Physics and SCALE-UP are well-documented implementations of this approach [2]. Running multiple parallel classes, however, implies substantial investment efforts (rooms, faculty) [3] and it is advisable to gain insights on expected learning improvements before deciding on either reformed lectures or small interactive class settings. A comparative study of student achievements between these two different settings is needed in order to guide pedagogical decisions going forward.

Research questions concerning SCALE-UP:

- What are the students' short-term and medium-term performance gains?
- Do students develop a different learning behavior and do their attitudes towards the learning goals change?

2. Method

In a one-year undergraduate physics course, we divided the student cohort into two parallel teaching settings (figure 1, table 1).

	SCALE-UP	LECTURE
Instructors	1 full professor + 3 TAs	1 full professor + 16 TAs
Students	52	318
Sample size*	35	133
Room infrastructure	9 tables, each with 6 seats	amphitheater with 372 seats
Main in-class activities	peer instruction, group problems, hands-on experiments	lecturing, classroom demonstrations, peer instruction

Table 1: Essential key figures of the two settings.

*Throughout the performance analysis, we are only considering students who took part in all assessments. As a result, we had to reduce the overall population to 35 students in the SCALE-UP setting and to 133 students in the lecture setting.

We compared students' performance and evaluation data in both settings and could identify immediate and medium-term differences (figure 2).

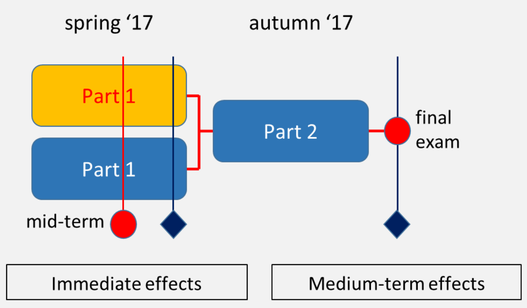


Figure 2: Data collection.

Mid-term and final exam included conceptual and numerical questions. The final exam had a part with topics from the split intervention (Part1) and another part with the topics that were covered without a parallel setting (Part2).

Elimination of confounders

- Teacher effect: in their respective teaching setting, both main instructors were awarded for excellent teaching and had long-term experience.
- Initial performance differences: students in both groups manifested similar pre-knowledge in physics and had equal performance results in mathematics.

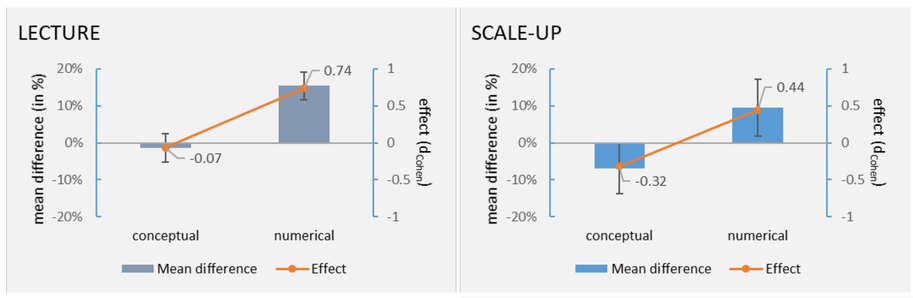
Distinction between conceptual and numerical performance

The mid-term and final exams included conceptual and numerical questions. In the mid-term exam, 50% of the points could be achieved by conceptual multiple-choice questions, whereas the ratio in the final exam was 40%.

Figure 1: Pictures from the LECTURE (above) and the SCALE-UP class (below).

3. Performance results

We can directly compare the performance recorded in the mid-term to the Part1 results in the final exam, both covering the same topics. The mean difference is calculated by $M_{Part1} - M_{mid\text{-}term}$. Figure 3 shows the results of dependent t-tests.



Error bars correspond to the 95% confidence intervals.
Effect sizes of d=0.2 are considered to be small, whereas d=0.5 is related to a medium effect and d=0.8 to a large effect.

Figure 3: Longitudinal performance differences for the LECTURE and the SCALE-UP students.

For each of the assessments we analyzed the performance gains of the SCALE-UP students by calculating: $M_{SCALE\text{-}UP} - M_{LECTURE}$. Figure 4 shows the results of independent t-tests.

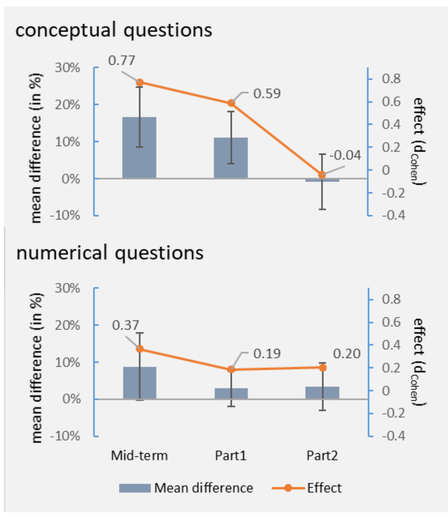


Figure 4: Performance gains of the SCALE-UP students in the different assessments.

4. Evaluation results

Two survey sets addressed questions on the learning behavior and the level of intellectual challenge. By analyzing the 280 responses, we are able to identify the following findings:

- SCALE-UP students did not invest more overall study time, even though they had to come prepared to class.
- SCALE-UP students manifested an increased level of self-confidence in their own learning achievements.

5. Gender

The gender distribution was similar in both settings with twice as much female as male students. The SCALE-UP setting offered marginally better performance results for male students.

6. Conclusions

- A single active learning intervention of one semester (14 weeks) is too short for students to sustain substantial performance gains (figure 3).
- Even though students enjoyed the flipped class very much, their performance gains were much lower than those reported from the (mainly U.S.) literature (figure 4).
- Curricular constraints such as contact hours and assessment conditions should be considered and adapted when shifting to a flipped class setting.
- Female students won't profit from a shift to the flipped class.

References

[1] S.V. Chasteen et al. (2011) A Thoughtful Approach to Instruction: Course Transformation for the Rest of Us *J. College Sci. Teach* **40.4** 24-30

[2] R.J. Beichner (2014) History and Evolution of Active Learning Spaces *New Directions for Teaching and Learning* **137** 9-16

[3] E. Brewe et al. (2018) Costs of success: Financial implications of implementation of active learning in introductory physics courses for students and administrators *Phys. Rev. Phys. Educ. Res.* **14** 010109