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Active Learning: Does It Really Matter?

Dr. Kleio Avrithi, Marian University

Dr. Avrithi is an assistant professor at Marian University. She earned a BS in Civil Engineering, an MS in Structural Engineering both from the National Technical University of Athens, an MS in Mechanical Engineering from the University of Illinois at Urbana-Champaign, and a Ph.D. in Civil Engineering from the University of Maryland, College Park. Her research interests include uncertainty and risk quantification for design, optimization, resilience, systems design, and engineering education. She is member of ASCE, ASEE, ASME, and ASTM.

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Abstract

Active learning is defined by classroom activities that engage students in the learning process. There are numerous studies excelling the impact of active learning in different fields, and particularly in engineering and sciences, such as improving the students' performance and their critical thinking, as well as increasing the likelihood of their not failing or withdrawing from a class. The paper explores the advantages and difficulties in implementing active learning in core engineering courses. As a case study, a Statics course is examined with two interdisciplinary groups of roughly twenty students each. The first group, designated as "active," is engaged in five activities that encourage active learning. The second group, designated as "passive," is exposed to traditional lecture-based teaching. An end-of-semester survey examines how the students perceive their learning on different topics. Learning is then assessed by considering students' performance on their final exam. Research results show that the "active" group of students perceives their level of knowledge attainment better and clearly appreciates the importance of the taught material more. Moreover, these students seem to better enjoy the course and appreciate the instructor's efforts.

Introduction

Active learning is a teaching method that includes classroom activities, which engage students in the learning process. Such activities may include group work, peer discussions, case-based learning, peer teaching, and interactive polls. Active learning emphasizes student engagement and participation, in opposition to passive learning, a lecture-based learning method, where students sit and listen and are expected to absorb the communicated information.

A main advantage of the lecture-based teaching is that the teacher can present a significant amount of information in a shorter time and explicitly share their knowledge and expertise on a subject [1, 2]. However, the lecture approach does not work well with students of different learning styles and who can get overwhelmed with the amount of information presented during lecture.

Active learning can overcome this difficulty by having students participate in learning and think critically. For example, students working in teams can learn together by sharing their knowledge and experiences. Engineering core courses require less technical depth, but at the same time require that a great volume of fundamental topics is covered. Moreover, core courses have usually more students, making active learning challenging to implement.

Statics and Active Learning

Statics is a sophomore course that provides fundamental engineering knowledge on solving equilibrium problems. The course is prerequisite to several other fundamental engineering courses, e.g., mechanics of materials, dynamics, etc. The literature is rich with methods used to make the statics material easier to understand, e.g., studying worked examples [3], performing hands-on in class activities, and keeping students involved in the learning process [4], having a visual representation of the completed student work [5], doing a series of projects combining different learning strategies [6], and using software [7, 8].

In this study, we examine two groups, a “passive” and an “active” with 20 and 18 students, respectively. “Passive” refers to the control group where teaching is based traditionally on just lectures and where quizzes and tests are used to check student progress. “Active” refers to the group that was taught by the same instructor exactly the same material as the “passive” group but this group is additionally exposed to five active learning projects, as Table 1 shows. All projects needed critical thinking with projects 1, 3, and 4 requiring craftmanship as well. For all projects, students worked in teams of about five people. Due to class time limitations, for some projects work was partly done in class and partly outside class. The teams were formed by the students themselves to better match their schedules.

Figure 1 shows the students’ major in each group and Fig. 2 their self-reported grade point average (GPA). It can be seen that the “passive” group has mostly mechanical engineering students, while the “active” group has a more balanced interdisciplinary student body. Based on the reported GPA, students in the “passive” group have a higher average GPA. In Figure 1, “Physics” refers to an engineering physics major.

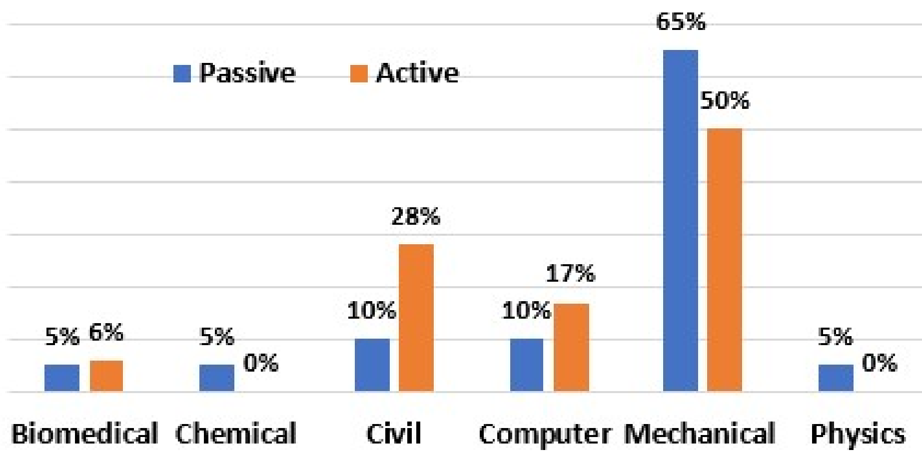

Figure 1. Students’ major for the “passive” and “active” groups.

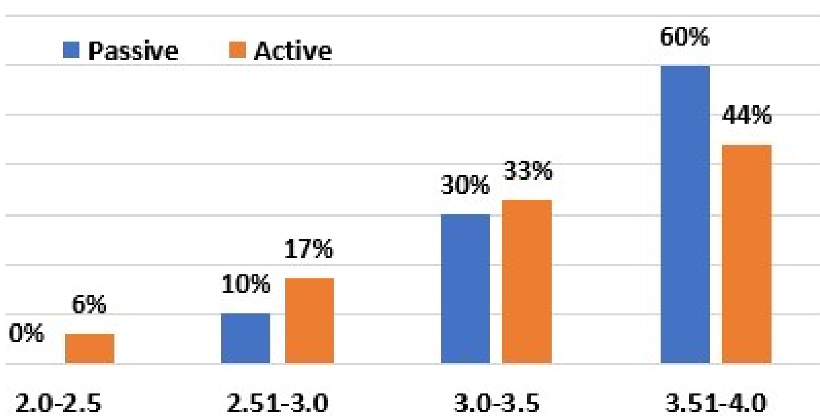

Figure 2. Students’ GPA for the “passive” and “active” groups.

Table 1. Active learning topics and projects.

a/a	Topic	Project	Reference
1	Direction angles	Construct a given 3-D vector with straws and clear tape and show the direction angles.	N/A
2	Types of supports for structures	Take pictures of supports on campus and explain the type and function of these supports	N/A
3	Structure with constraints	Build an observation tower by minimizing the footing area and maximizing the observation area.	[9]
4	Truss bridge	Build a toothpick bridge under constraints maximizing the sustained weight over self-weight ratio	N/A
5	Cable forces	Balloon turbine project.	[9]

Note: N/A refers to activities created by the course instructor

Student Survey Results

Students were asked at the end of the course to self-evaluate their learning in a 5-point Likert scale ranging from 1 "poor" to 5 "excellent." Figures 3 to 7 show the results for both groups and for the specific survey question.

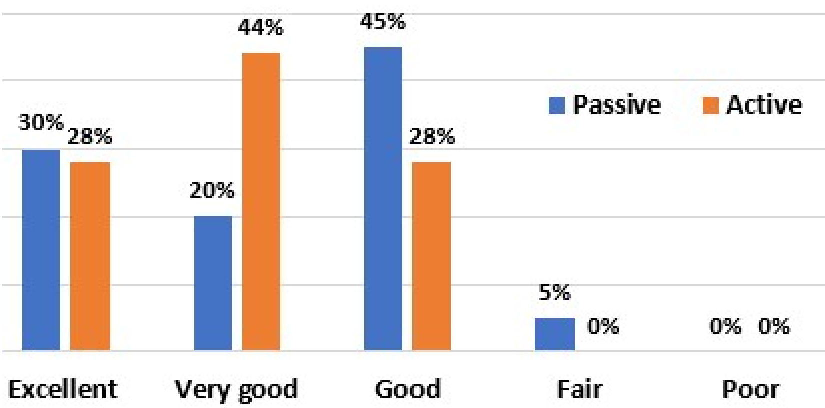

Figure 3. Rate your understanding of direction angles.

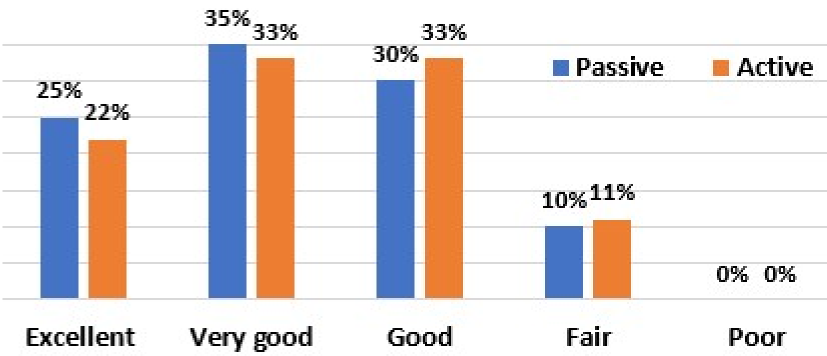

Figure 4. Rate your understanding of different types of supports for structures.

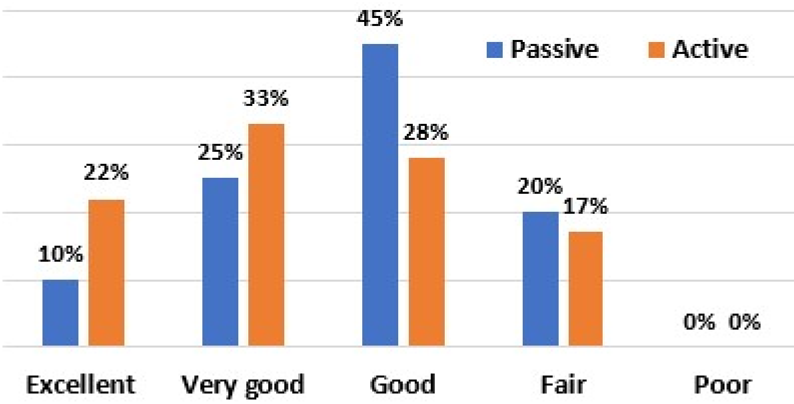

Figure 5. Rate your understanding of how trusses work.

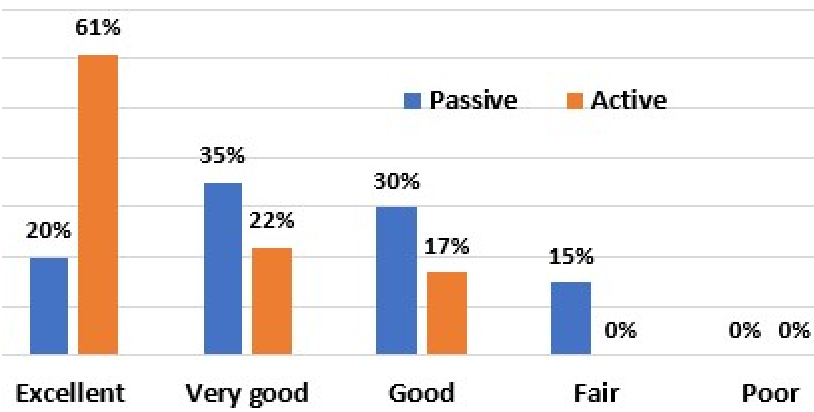

Figure 6. Rate your understanding of the importance of statics in engineering.

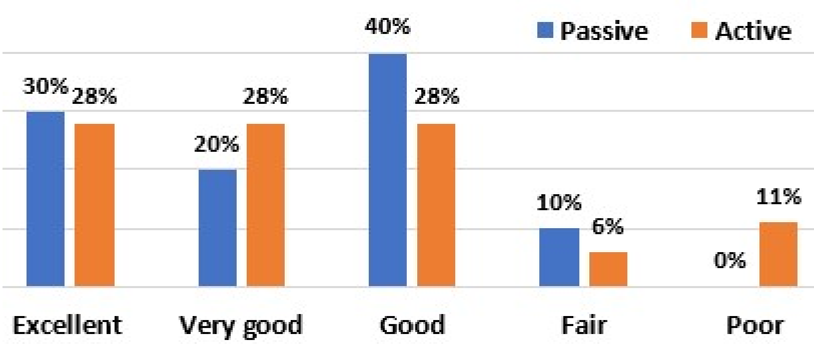

Figure 7. Rate you understanding of equilibrium of rigid bodies.

Considering the information in Figs. 3 through 7, Table 2 presents the mean and standard deviation of the student's perception of learning the different statics topics.

Table 2. Mean and standard deviation of the students' survey questions.

Topic	Passive Student Survey		Active Student Survey	
	Mean	St. Dev.	Mean	St. Dev.
Rate your understanding of direction angles.	3.75	0.97	4.00	0.77
Rate your understanding of different types of supports for structures.	3.75	0.97	3.67	0.97
Rate your understanding of how trusses work.	3.25	0.91	3.61	1.04
Rate your understanding of importance of statics in engineering.	3.60	0.99	4.44	0.78
Rate you understanding of equilibrium of rigid bodies.	3.70	1.03	3.56	1.29

For the student survey answers to knowledge questions, we performed a *t*-test with a level of significance $a = 0.05$ and examined the null hypothesis of the mean value of the "active" group being equal to that of the "passive" group. The results are as follows:

- For the understanding of direction angles, the null hypothesis holds with p = 0.381 implying no significant difference between the mean values.
- For the understanding of different type of supports, the null hypothesis holds with p = 0.793 implying no significant difference between the mean values.
- For the understanding of how trusses work, the null hypothesis holds with p = 0. 264 implying no significant difference between the mean value values.
- For the understanding of importance of statics in engineering, the null hypothesis is rejected with p = 0.006 implying that the two means are different and with the "active" group having a higher mean value.
- For the understanding of equilibrium of rigid bodies, the null hypothesis holds with p = 0.708 implying no significant difference between the mean values.

Final Exam Evaluation Results

Students from both groups were given the same final exam problems testing, among other topics, their knowledge on direction angles, trusses, support types, and equilibrium. The instructor graded the work in a 5-point Likert scale as "excellent" equivalent to 5, "very good" equivalent to 4, "good" equivalent to 3, "fair" equivalent to 2, and "poor" equivalent to 1. Although the exam problems were complex with several questions, the evaluation addresses only the specific topic of interest. The topic of types of supports and equilibrium was assessed cumulatively based on two problems of the final exam. Table 3 shows the average grade based on the final exam evaluation results conducted by the instructor.

Table 3. Mean average grades for the "passive" and "active" groups from the final exam

Topic	Passive Final Exam		Active Final Exam	
	Mean	St. Dev.	Mean	St. Dev.
Direction angles	3.05	1.66	4.11	1.18
Types of supports/Equilibrium	3.81	1.36	4.0	1.28
How trusses work	3.43	1.43	3.61	1.61

For the final exam results, we performed a *t*-test with a level of significance of $a = 0.05$ and examined the null hypothesis of the mean value of the "active" group being equal to that of the "passive" group. The results are as follows:

- For the direction angles, the null hypothesis is rejected with $p = 0.026$ showing that the two means are different and with the "active" group having a higher mean value.
- For the type of supports/equilibrium, the null hypothesis holds with $p = 0.656$ implying no significant difference between the mean values.
- For how trusses work, the null hypothesis holds with $p = 0.183$ implying no significant difference between the mean values.

According to Tables 2 and 3 and for the "active" group, the instructor's evaluation of the final exam's questions matches the perception that the students have for their gained knowledge. Students in the "passive" group seem to have a higher knowledge perception than the instructor's evaluation especially as it concerns their understanding about the direction angles and how trusses work.

Official Course Evaluations

Official evaluations conducted by the university at the end of the semester with a survey participation of 70% for both groups, clearly showed greater satisfaction for the instructor and the course by the students of the "active" group. Qualitative comments of the "active" group of students included high satisfaction for the teaching methods and excitement about the performed extra activities. Students of the passive group complained about the lack of variety in teaching methods and gave significant lower grade for both the instructor and the course.

According to the instructor's understanding, the performed activities kept all the students of the active group engaged in the course, while several students from the passive group remained uninterested in the course materials.

Conclusions

The positive effects of active learning on teaching effectiveness are well-known. This study confirmed that active learning actually matters to students themselves and that the students engaged in active learning perceive better the level of gained knowledge. The two examined groups of students had the same instructor and were taught the same material. However, the "active" group had five activities with some parts performed in class and those, which needed excessively more time, completed outside class. The "active" group of students understood better the importance of the taught material in the engineering work. Moreover, the "active" group, performed statistically significantly better in the final exam on the direction angles problem. The active learning activities on how trusses work, types of supports, and equilibrium had statistically no significant impact on students learning. Students from the "active" group remained enthusiastic about the instructor and the taught material the whole semester. On the other hand, several students from the "passive" group did not enjoy the course. Future work will incorporate flipped class principles [10] to allow time for more activities in the classroom.

Acknowledgment

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