Increased Student Engagement in Problem Solving Courses in Engineering through Active Learning

Dr. Puttagounder Dhanasekaran Swaminathan, University of Minnesota, Duluth

Dr PS (Puttagounder Dhanasekaran Swaminathan) has PhD degree in mechanical engineering from Wichita State University, Wichita, KS. He is currently working as an assistant professor, at University of Minnesota, Duluth. He has taught, CAD/CAM, FEA, Machine design, Statics, Strength of Materials, and various courses on materials and materials selection, for both undergraduate and graduate programs. He also authored and co-authored a text book chapter and research papers on machining of composites. He has a diverse industrial experience for 27 years, in design, research and manufacturing of electro mechanical systems, such as design of various types of gear and gear boxes, antennas and light and heavy fabricated structures, for communication, TV telecast, natural disasters management and Telemedicine application. Dr PS, designed and manufactured various types of antenna's weighing from 200 pounds to 100,000 pounds. He was also actively involved in configuring the antenna controls and selection of motor and motor controllers. Dr PS, has advised more than 40 senior/capstone projects. One of his project won the national award from Airforce Research Laboratory in spring 2017. Project was on "Design of the Load Carrying Vehicle (LCV)"- The project solution is a fully electric, autonomous, all terrain, load carrying vehicle.

Dr. Ping Zhao, University of Minnesota Duluth

Dr. Ping Zhao is currently an Assistant Professor at Department of Mechanical and Industrial Engineering in University of Minnesota Duluth. Her research focuses on smart materials and devices, advanced materials and composites, and Micro/nanomechanics, etc.

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[a] PS Dhanasekaran, [a] Ping Zhao
[a] Department of Mechanical and Industrial Engineering, University of Minnesota Duluth,1305 Ordean Ct. VKH 105, Duluth, MN 55812, USA
Email: pdhanase@d.umn.edu, zhaop@d.umn.edu

Abstract

Increased student engagement in classroom activities is gaining significant importance in higher education. Active learning is one of the latest teaching techniques that engage students in the learning procedure. While active learning has become an axiom in STEM education, overwhelming research in active learning demonstrates its effectiveness in promoting student engagement, learning, motivation and retention. It has been observed, that the active learning techniques have been one of the vital tools for instructors to stimulate student engagement. In short, active learning is any activity that engages students in a classroom, and demands students to do significant learning activities and analyze what they are doing, rather than simply focusing on traditional lecture. Student engagement in classroom via review, discussion, application and practice, demonstrated that the students learn more than in traditional classrooms. In-class reading and writing exercises also, improve student engagement in learning process even in large size classes.

To improve student engagement in the class size of up to 40, in senior mechanical engineering courses, such as machine design. Every student was provided with similar problem having different variables to solve. The instructor was solving a similar problem on whiteboard with dissimilar variables than students. This demands for active discussion with their peers, teams and with the instructor kept the whole class engaged. Traditional classroom teaching versus active learning, student engagement outcome measured through in class work submission.

1. Introduction

In the past, there has been a high level of curiosity for new method of teaching at college level education [1]. Among various teaching methods, such as cooperative learning, problem based learning and active learning, high volume of research established that, active learning edge over other instructional methods [2].

Cooperative learning is an another category of active learning, wherein students work as a small groups of three to four, instead of working alone or two. Cooperative-learning techniques commonly used for a multipart job, such as research projects or huge problems, which involves many steps. Problem-based learning is one of the instructional technique, where the appropriate problems announced at start of the teaching sequence. It is at all times active, but not essentially cooperative learning [3], [4].

Active learning is similar to any other teaching style that occupies students in the processes of learning, and necessitates students to think and perform their learning activities such a way that

supports their learning [1]. Active involvement, either in the form of discussion, review, practice or applying, enhances student learning [5]. Active Learning, it is any kind of activity where students are actively engaged in understanding of ideas, facts and skills [6]. Active learning techniques play a vital role for instructors to stimulate student engagement with both discipline and material learning. The notion of student engagement is fetching more importance than a just educational oratory [1]. The increased amount of research on active learning establishes that active learning is very effective and important in STEM education to promote student learning, engagement, motivation and retention [6]. Active learning technique also encourages, in-class reading and writing which improves student engagement and learning and also benefit students to think intensely about topic and to participate in class discussion, addition to exploration, clarification and analysis [6], [7].

To improve student engagement in engineering courses such as machine design in a class size up to 40, via active learning, where more problems to solve. Individual problems with different variables provided to all the students in the class, as an option to solve the problem with the instructor, who is solving a similar problem on whiteboard. This in-class, work collected at the end of the class helps, to evaluate student engagement and learning. This method of solving problems with different variables kept the class active via discussions, with their peer, teams and with the instructor. The higher amount of student engagement could be measured against the traditional instructional method, as shown in assessment.

2. In-Class Problem Solving

Introduction of active learning to senior level mechanical engineering courses such as machine design was greatly helpful for students, to learn and to keep them active in classroom, rather than simply writing down from a lecture or copying from the whiteboard. Typically, every student in the class and the instructor choose similar problem with different variables to solve, as can be seen in example problem provided below and sample calculations are shown in Table1.

Problem statement:

Select a suitable ball bearing, to carry a radial load of 1700 lb and a thrust load of 700 lb. The bearing inner race rotates at 1150 rpm, and require a design life of 18000 hours.

Instructor works with above given input

Students to pick random numbers from below given range

Radial load R = 1750 to 2200 lb
Thrust load T = 550 to 690 lb
Speed = 1150, 1500, 1750 rpm
Design life = 19000 to 25000 hours
Common data to collect from textbook
Since inner race rotates V = 1
Radial factor X = 0.56 (for combined load application)
Trust factor Y = 1.5 (average to start with)

Equivalent load P = VXR + YT
Ld= Design Life hrs * Speed in rpm * 60 (min/h)
Dynamic Load rating C = P * (Ld/ 10000000)⅓

Table 1. Sample calculation for the given problem

	R in lb	T in lb	RPM	Design Life hrs.	P in lb	Ld in Rev	C
Instructor	1700	700	1150	18000	2002	1.24E+09	21520
Student 1	2200	550	1750	19000	2057	2E+09	25895
Student 2	1790	690	1500	25000	2037.4	2.25E+09	26697
Student 3	1810	570	1750	23000	1868.6	2.42E+09	25070
Student 4	1860	600	1500	21000	1941.6	1.89E+09	24006
Student 5	1910	630	1150	20500	2014.6	1.41E+09	22615
Student 6	1930	625	1500	22000	2018.3	1.98E+09	25344
Student 7	1770	675	1150	24000	2003.7	1.66E+09	23706
Student 8	1835	650	1750	20000	2002.6	2.1E+09	25645
Student 9	1975	590	1150	22750	1991	1.57E+09	23139
Student 10	2100	635	1500	19750	2128.5	1.78E+09	25784

In class problems solved as discussed above, since every student has to solve the problem with different variables, a discussion initiated for each step to understand. Almost every student was active in the classroom by the way of discussion, selection of data and calculations. Students can discuss with their peer, team and with the instructor as needed. Sufficient time was provided for every step and the instructor made sure that, entire class completes that particular step before moving on to next level of calculation. However, this method takes more time than traditional way of solving the problem. Students were active and shown good progress in learning. Although this was an option for the students to choose different variables and work with the instructor, students realized that this method helps to learn quicker and need less time to prepare for the exams. Student engagement measured through practice problem submitted at the end of the class. The accepted submissions were only from the students, who choose different variables than the instructor. As shown in the last column of Table 1, every student arrives at his or her own C – dynamic load rating for selection of bearing.

3. Assessment

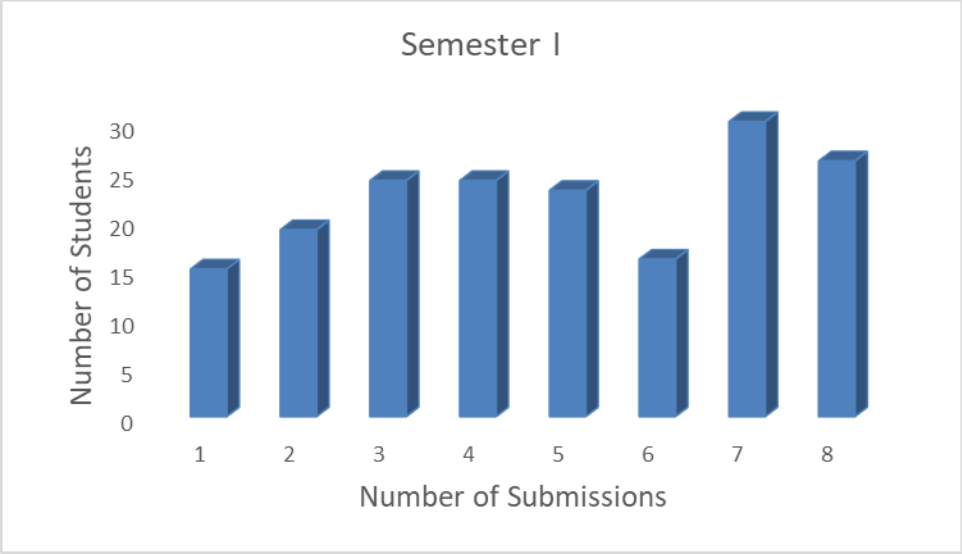
Problems solved by the students collected for measuring engagement and learning, submission limited to the students those who followed different variable to solve as explained above. Student engagement for three semesters presented and compared in this paper, as shown in Table 2, the percentage of student engagement and number of students who submitted the class work for all three semesters. First-semester traditional classroom teaching, students follow the lecture and take down the notes. Second and third semester taught through active learning and noted continual improvement in student engagement and learning. The percentage of engagement was computed using number of submissions versus total number of students registered for the class.

Table 2. Comparison of student engagement for three semesters

Details of in Class Submission						
Submission #	Traditional classroom Semester 1 (Total # of students 31)		Active Learning Semester II (Total # of students 30)		Active Learning Semester III (Total # of students 42)	
	# of Student Submission	% of Student Engagement	# of Student Submission	% of Student Engagement	# of Student Submission	% of Student Engagement
1	15	48.4	26	86.7	36	85.7
2	19	61.3	27	90.0	34	81.0
3	24	77.4	26	86.7	36	85.7
4	24	77.4	25	83.3	35	83.3
5	23	74.2	27	90.0	35	83.3
6	16	51.6	16	53.3	40	95.2
7	30	96.8	28	93.3	39	92.9
8	26	83.9	23	76.7	39	92.9
Average		71.4		82.5		87.5

3.1 Semester I - Traditional classroom teaching

Traditional classroom teaching, an average of 71.4% of the student engagement measured. However, there was no evidence to provide that, how much students could learn from the lecturers while listening and writing down the notes. Since there was no discussion in the class except occasional questions to the instructor, engagement as shown in Table 2, and Figure 1.



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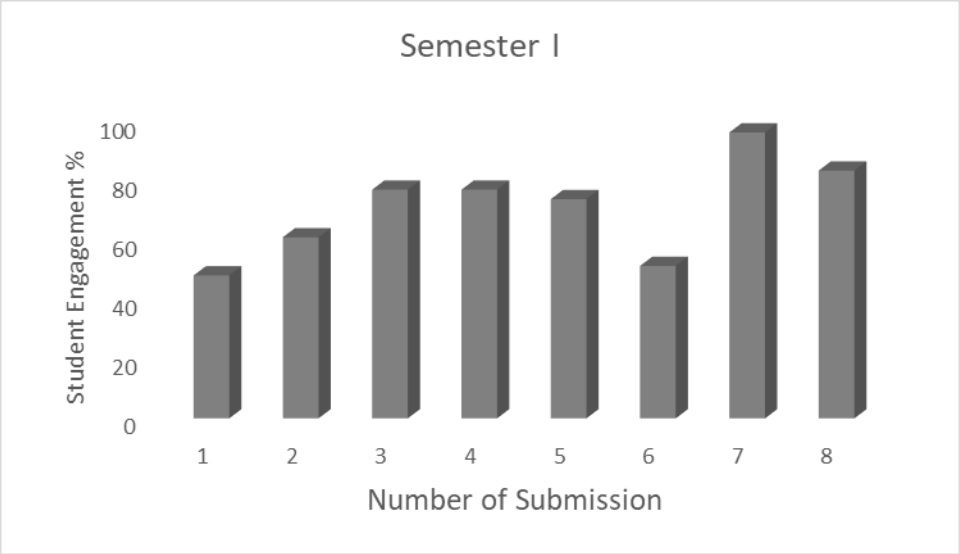

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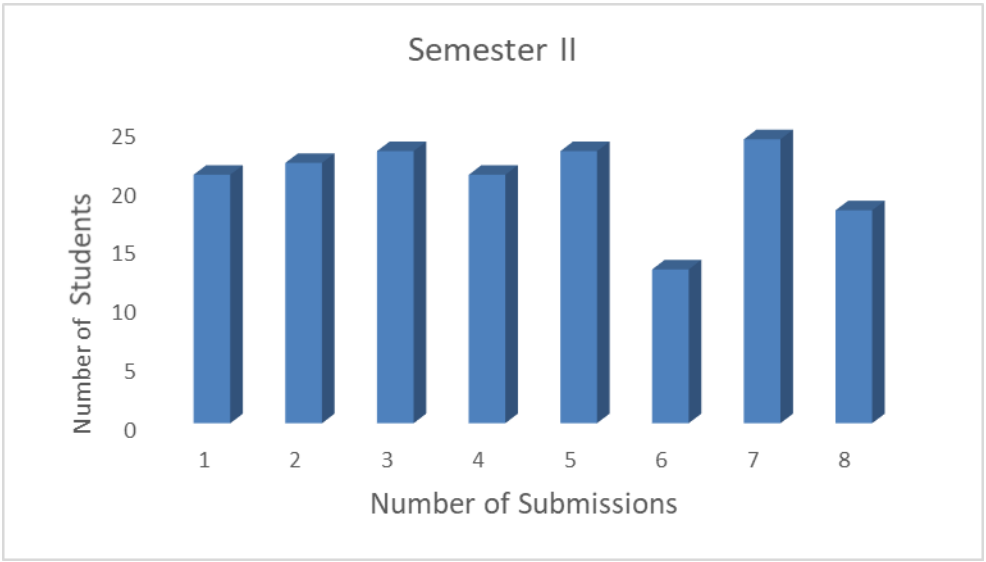
Figure 1. In-Class Work Submission for Semester I-Traditional classroom teaching (a) Number of Students Submission, (b) Student engagement percentage

3.2 Semester II – Active Learning

Introduction of active learning, showed a considerable increase in student engagement up to 82.5 % as shown in Table 2, and Figure 2, against 71.4 % in traditional classroom teaching. Students' active participation established that, they learn in classroom via their discussion and exchange of questions with peers, teams and the instructor, while solving problems. Students volunteered to participate actively, since there was enough time between each steps, before moving on to next step.



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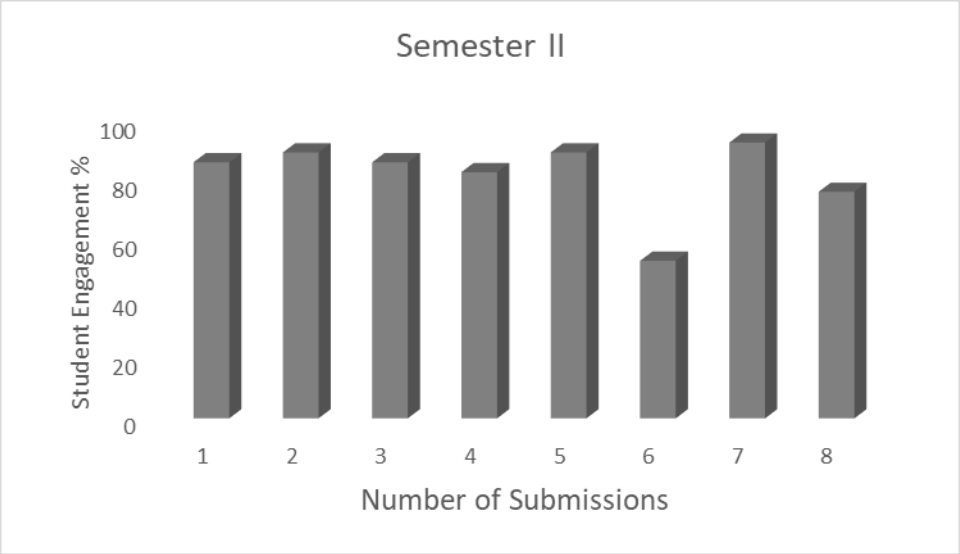

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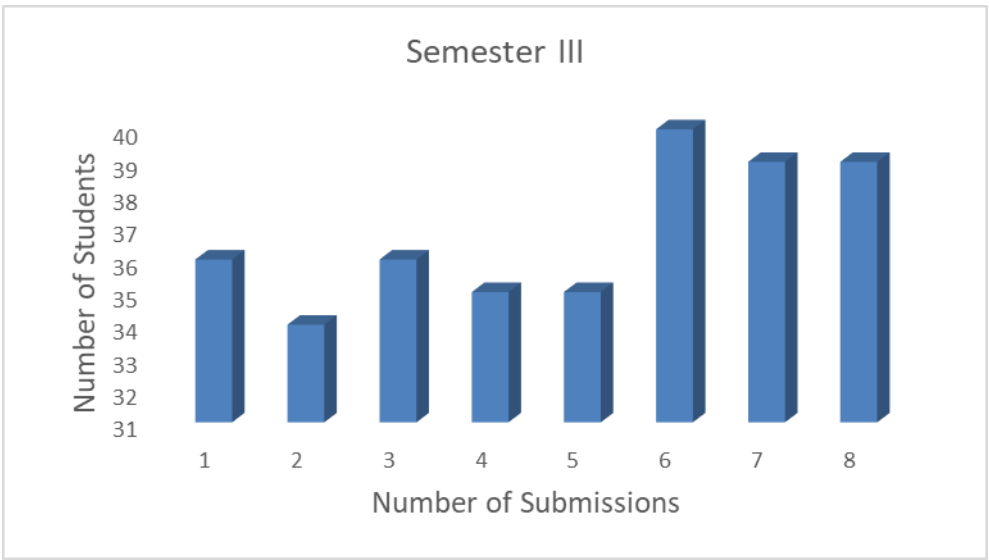
Figure 2. In-Class Work Submission for Semester II- Active learning (a) Number of Students Submission, (b) Student engagement percentage

3.3 Semester III – Active Learning

Student engagement for semester III, as shown in Table 2, and Figure 3, raised up to 87.5 % compare to 71.4 % traditional classroom engagement and 82.5 % engagement in pervious semester active learning. Almost every student actively took part to answer or ask a questions, the instructor was only a facilitator or involve when students had no answer to some question. The discussion at every step clearly established their understanding and learning of the material.



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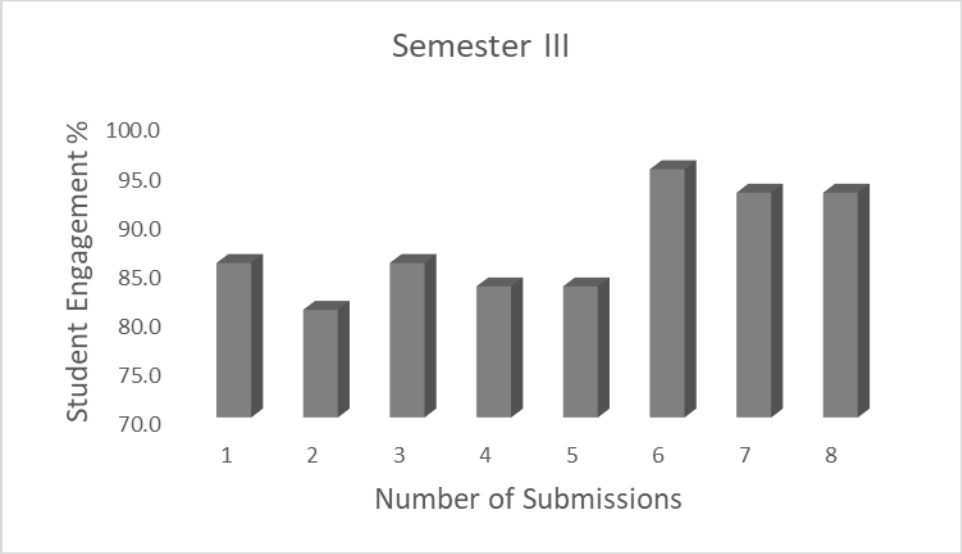

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Figure 3. In-Class Work Submission for Semester III- Active learning ((a) Number of Students Submission, (b) Student engagement percentage

4. Conclusion

Solving machine design problems through active learning takes more time than teaching through traditional method, due to the selection of many values such as interpolating plots or selection of data from the tables or material properties. Since every student, have different variables to solve, adequate time was provided to complete each step of the calculation. Assessment establishes that raise in student engagement and learning is significant. Student engagement calculated for the total class registration against the actual number of students present for that day. Actual engagement will be little higher, if the student engagement is computed against the actual number of student present in the class. However, it is evident that student engagement and learning improved, using above method to solve problems through active learning. As a future work, authors plan to establish a method to measure and present the increased effectiveness of active learning in such courses.

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