

Faculty Facilitated Study Group: Improving Students' Academic Performance in Engineering Courses

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Abstract

Many colleges and universities offer peer facilitated study groups (FSG) for various courses, which have proven to be an effective way to help students stay engaged in their program study and improve their academic performance. At Wentworth Institute of Technology (WIT), FSGs are offered for some generic courses such as Engineering Calculus, Physics, etc., which are required of all engineering students. However not many FSGs are offered for engineering courses due to the low enrollment numbers in each subject.

Engineering Statics and Engineering Thermodynamics are the two fundamental courses in the Mechanical Engineering program, which are the foundation and prerequisites for other more advanced courses. Many students have difficulties in either Statics or Thermodynamics, or both. The authors have had experience as the only moderators hosting study groups to help students in engineering statics and engineering thermodynamics courses. Due to the increasing number of enrollment in the Mechanical Engineering program, student teaching assistants (TAs) are hired to help run the study group. In these arrangements, the faculty-lead facilitated study groups for Statics and Thermodynamics have one faculty and two TAs, and each FSG is a weekly study session open to all students who want to be involved in small peer group learning environment, get help for their homework, and improve their understanding of course materials. TAs are recommended by the teaching faculty in the related subject areas, and those chosen all have previously completed the course with an earned grade of B+ and above.

The paper presents our findings in running the faculty driven peer FSGs for Statics and Thermodynamics. Of all eligible students who registered for these courses, more than 20% of the students participated in the FSGs. Post FSG survey data show 85% of respondents believed that their grades improved, and 57% believed that their grades improved more than half a letter grade. Students felt that they became part of a learning community, and had a space where they were comfortable asking questions. Other benefits were also obvious based on survey data: performed better on exams, understood the course materials better, kept up with the course more effectively. The TAs benefitted from participating in the FSGs as well. Survey responses from them indicated that the FSG experience improved their teaching and communication skills, and reinforced their understanding of the course materials. In conclusion, our observations and survey results show that students who attended FSGs regularly gained a deeper understanding of the materials and achieved a better grade as part of the participants' academic performance.

Introduction

Group studying has become more and more popular in today's teamwork-focused higher education environment. Through meta-analysis of outcome research in undergraduate STEM education, Springer, et.al.¹ show that various forms of small group learning are effective in promoting greater academic achievement and increased persistence through STEM courses and programs. The group studying environment offers students the opportunity to engage in a more in-depth discussion with peers, sharing information and knowledge about a course they are

collectively enrolled in. Another factor typically involved in group studying is peer tutoring. Peer tutoring consists of students teaching other students of the same or different age, either in a one-on-one setting or involving one tutor working with two or more students at the same time. Power and Dunphy² define the peer tutoring environment as a safe and non-threatening interactive learning situation, which typically nurtures more favorable attitude towards learning.

Peer facilitated study group (FSG) is another form of small group learning environment. It provides extra help for students who encounter difficulties in certain courses. It differs from regular classroom experience in that it provides a comfortable and relaxed environment for students to share their thoughts and work collaboratively. Normally teaching assistants (TAs) are involved in FSG. The objective of the FSG is to help students initiate their own learning by focusing on study techniques tailored to the specific course, and centering around discussing and clarifying concepts.

Many colleges and universities offer peer facilitated study group (FSG) for various courses³⁻⁵, which has proven to be an effective way to help students stay engaged in their study of difficult subjects. At Wentworth Institute of Technology (WIT), FSGs are offered for some generic courses such as Calculus and Physics, which are required of all engineering students. However not many FSGs are offered for engineering courses due to the low enrollment numbers in each subject. Furthermore, instructors of the course hold regular meetings with TAs for most FSGs, however, teaching faculty are not directly involved in leading FSGs to help the students. We believe that instructors should play an important role in running more effective FSGs. Hence in our faculty-driven FSGs, instructors and student TAs work together in all the FSG sessions, which provide students the most benefit in a group-learning environment. These pilot FSG programs have shown two primary benefits: i) Students gain confidence in transferring the hands-on learning skills towards future study endeavors. ii) TAs gain a hands-on experience to improve their teaching and communication skills, further enhancing their understanding of the materials.

The rest of the paper is organized in four sections as follows: literatures related to peer facilitated study and study group are reviewed, before the detailed set-up of the FSG for Engineering Statics and Thermodynamics is discussed. Next, data from participant surveys are presented and discussed, followed by the concluding remarks which are drawn based on the data analysis results.

Background and Literature Review

Students have different levels of motivation, different attitudes towards teaching and learning, and different responses to specific classroom environments and instructional practices⁶. In order to help students attain academic success through mastering the subject materials, many colleges provide supplemental instruction services. For example, peer tutoring and facilitated study group and other in-person small-group study sessions have been introduced as part of the on-campus teaching and learning assistance services. Research on the effectiveness of the many different types and formats of peer tutoring at various colleges and universities has been reviewed by Topping⁷, advocating for implementing peer tutoring and other small-group study methods in "high-risk" subjects, i.e. subjects that typically pose a greater challenge in passing, such as statics and thermodynamics in mechanical engineering. Zhao and Kuh⁵ examine the relationships

between participating in learning communities and student engagement in a range of educationally purposeful activities of first-year and senior students from 365 four-year institutions. The findings indicate that participating in a learning community is positively linked to engagement as well as student self-reported outcomes and overall satisfaction with college. Peer tutoring is also variously known as supplemental instruction (SI), Peer Assisted Learning, among other references - a type of academic support intervention popular in higher education. It provides a positive learning community for students. Relatedly, FSG is designed to have upper classmen facilitate peer learning among undergraduates studying a challenging subject/course. Shapiro et. al.⁸ report that students participating in learning communities are more engaged overall, have higher persistence rates, and produce greater gains in intellectual and social development compared with peers who do not participate in learning communities. Meta-analysis reported in Springer, et. al.¹ shows that various forms of small-group learning are effective in promoting greater academic achievement, more favorable attitudes toward learning, and increased persistence through STEM courses and programs. A recent survey conducted by Dawson et. al.⁹ presents a systematic review of the literature regarding the effectiveness of supplemental instructions. Their findings are consistent with claims validated by the US Department of Education in the 1990s that participation in Supplemental Instruction is correlated with higher mean grades, lower failure and withdrawal rates, and higher retention and graduation rates.

FSGs have been employed in a variety of STEM courses¹⁰⁻¹¹, as well as some fundamental courses in engineering¹². Their effectiveness has been shown to result in students feeling more positive towards study and learning, achieving improved course grades, feeling greater self-confidence towards future academic success, and consequently resulting in a marked improvement in retention in their chosen program of study.

Faculty-driven Facilitated Study Groups

There is a wide variety of on-campus resources at our institute to assist students in their pursuit of academic success. The Center for Academic Excellence (CAE), formally known as the Learning Center, offers free tutoring services to our students experiencing academic challenges in many targeted areas of mathematics, physical sciences, and fundamental engineering, which are tailored to their respective majors. One of the services available at the CAE is the Facilitated Study Group (FSG), which is organized on site to allow student drop-ins according to a fixed set of schedules for a given set of subjects. These courses are mostly concentrated in mathematics and physics. Led by faculty volunteers and upper-classmen tutors, these sessions primarily engage small groups of students not much beyond assisting them to finish their homework assignments. For those mathematics and physics courses, which are required of all engineering students, having steady participants is not a problem. However, for engineering courses, since the subjects are only offered to students in certain majors, the total number of students is much fewer than the common mathematics and physics courses. With the number of enrollment increases, the one-on-one tutoring offered by CAE could no longer meet the students' needs.

Starting in the fall semester of 2014, with financial support of CAE, we were able to establish two pilot FSGs in Thermodynamics and Engineering Statics, in an effort to target sophomores majoring in mechanical engineering, who predictably would struggle in these two fundamental

engineering subjects. There are three major components of FSGs reported herein: Faculty, TAs and Participants.

- Faculty: Faculty are volunteers who are willing to help students and are currently teaching one or more sections of the target course, so they are familiar with the progress of the course, and aware of the problems that students face.
- Student Teaching Assistants (TAs): Upperclassmen of superior academic performance in these courses are recruited to serve as teaching assistants, in addition to us being the faculty lead in these sessions. Many students have part time jobs, and are reluctant to spend time helping fellow students in this capacity. Financial incentives were offered in the form of hourly compensation higher than a work-study student rate, in order to attract the best candidates to work for the FSGs.
- Participants: Recruiting students to participate in the FSG remains a challenge. We noticed that even though faculty had regular office hours, they were greatly underused because most of the times not many students would come to ask questions and seek help. They would rather ask questions of their peers. To achieve greater publicity, students in multiple sections of these two classes were notified by us, and our colleagues during class hours (for maximum awareness), in addition to the traditional means of CAE bulletin-board style notices posted across the campus.

Meeting hours were set up such that most of the students would encounter no conflict within their weekly schedules. Both Statics and Thermodynamics FSGs would meet in a designated classroom, over a period of three hours. Teaching Assistants would be present throughout the allocated time period, while faculty would be present for any type of consultation for the duration of the first one and half hours. Participation of the students was quite flexible, however the majority of students would join the sessions and stay well over the first one-hour period. Indeed, most frequently students who came to these sessions needed help with their homework assignments, however we hoped to run these sessions differently than the usual drop-in tutoring sessions. Firstly, we were active instructors of the subjects, so we did have a good sense about the students' weaknesses in grasping of certain topical materials while the semester was on-going. This type of insight allowed us to expand the discussions over a particular homework problem to covering key concepts and strategies needed for tackling similar problems. Connections between topics and concepts under scrutiny and those encountered in future follow-up courses, such as Fluid Mechanics, Heat Transfer, Mechanics of Materials, were also highlighted wherever appropriate. It is well understood that having students repeatedly recognize the underlying common thread through the logical progression of the curriculum, motivates them to stay engaged with their chosen major, which in turn improves retention. Secondly, we wanted to have both small-group discussions, encouraging students to interact among themselves and TAs, as well as one-on-one help sessions with the faculty present, thusly creating a varied, less structured, more relaxing environment to learn and progress (students' feedback survey results indicated as much this positive effect).

At the end of the semester, a survey was conducted of all participants to collect their feedbacks, in order to assess and examine the value of these newly configured FSGs. Some of the survey questions are highlighted as follows:

- Background info: Race, Gender, etc.
- How did you find out about FSG?
- Did you participate in FSG before?
- Which benefits did you gain from participating?
- How do you think attending has impacted your course grade?
- What is the grade you expected to receive in the course?

Presentation of Participants' Survey Data

Student attendance was taken during each FSG session, and CAE conducted on our behalf a series of anonymous questionnaire-based surveys of all the participants. They are summarized here for Fall 2014, when the FSGs were launched, covering both the Statics and Thermodynamics sessions, all participants are Mechanical Engineering majors. In Fall 2015, only Statics FSGs were offered, since Thermodynamics was moved to the Spring semester to accommodate a course sequence change.

There were more than 30 students that participated in each FSG. In Fall 2014, there were 37 students that attended Engineering Statics FSG, and 30 students the thermodynamics FSG. There were 34 students that attended Statics FSG in Fall 2015. Data discussed in this section are averages over these three FSG sessions.

Most respondents expressed a fairly high degree of satisfaction with their overall experience in these FSG sessions. Some highlights of the data (shown in Figures 1 and 2) are summarized below:

- Most respondents (over 82%) found out about these FSG sessions through their instructors. When they participated, they would attend the sessions at least a majority of the times. Furthermore, more than half of these students were repeat attendees. We recognize that it is important to publicize FSGs widely for student recruitment, and that teaching faculty's informing the students is rather crucial to promote participation and improve attendance.
- Faculty leads' real-time familiarity with the subject matter was highly valued by the students. Over 88% of respondents agreed that session leaders in most or all of the sessions were knowledgeable about the subjects in question.
- Exposing the students to different perspectives over subjects covered by the homework assignment and prior class discussions left a significant impression on the participants. Over 87% respondents answered affirmative in most and/or all sessions they attended.

- Personal attention to students struggling on various topics was crucial in promoting students sense of belonging in a relaxed, non-judgmental environment. Majority of participant (65%) felt more comfortable asking questions.
- Participant self-reported the following (shown in Figure 2):
 - Performing better on exams (79%)
 - Feeling more confident in their academic abilities (65%)
 - Having learned how to study more effectively (44%)
 - Majority of them thought that FSGs helped them improve their course grade by up to a half letter grade or more (83%)
 - Understanding better course materials (92%)
 - Keeping up with course more effectively (79%)
- Participants were mostly a self-selecting group, based on their professed expected course grade. Majority of them (over 63%) expected a B and above letter grade. It can be argued that these participants in fact were already quite motivated to do well in these classes.

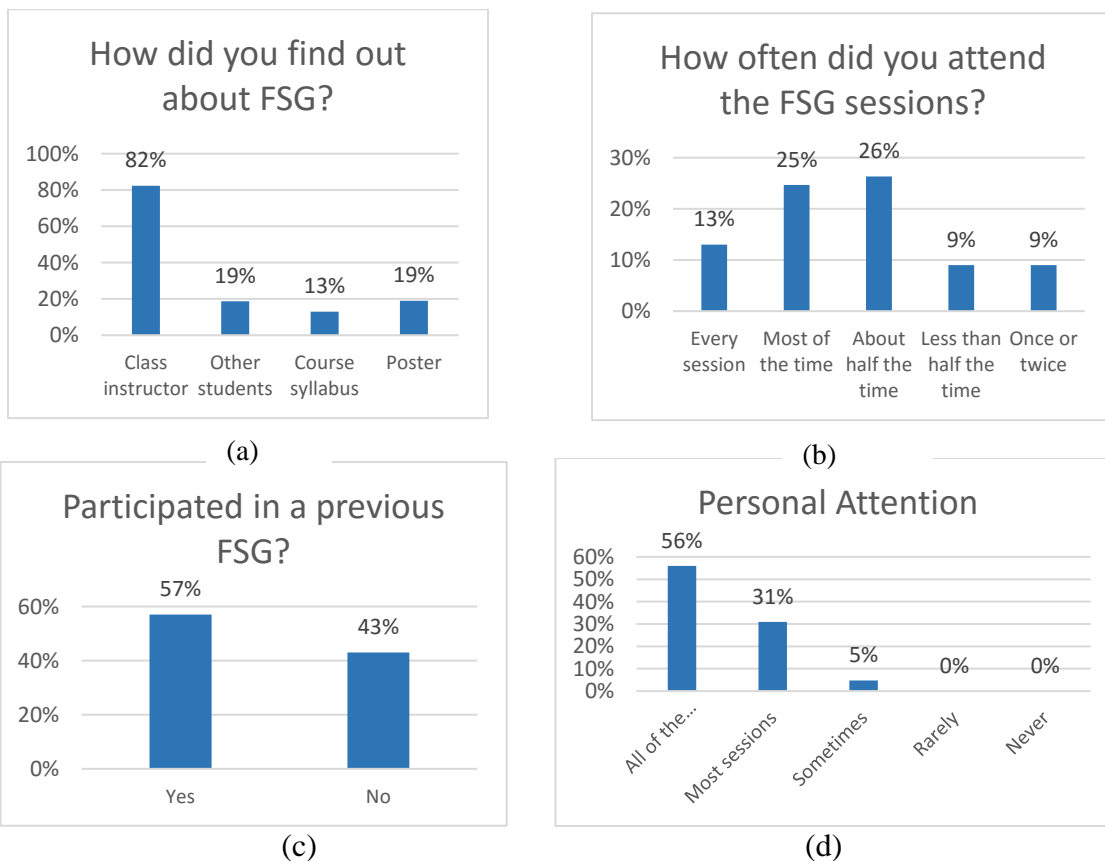


Figure 1. Selected Survey Results

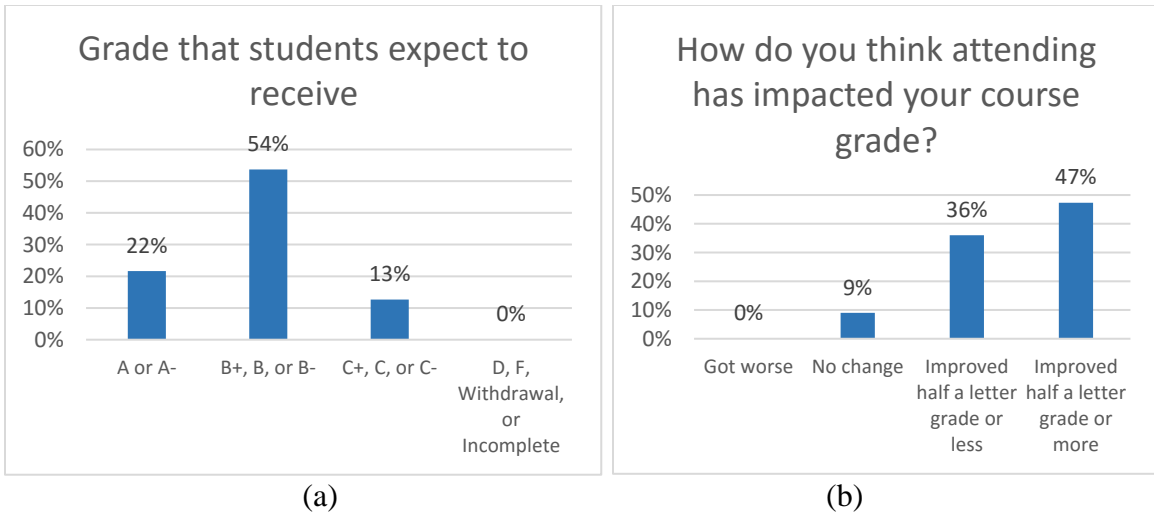


Figure 2. Survey Results – Grade

It is worth pointing out that these highlighted results indicate a contrasting difference from those reported by Malm et. al.¹³. Their studies focus on first year engineering students in a calculus class and the studies tend to show that "weaker" students benefit more from FSGs, while the results for "average" and "strong" students are not as clear.

It is however clear that not only student participants enjoyed many benefits, having gone through our faculty-driven FSGs. The TAs also benefitted from the FSGs. They reported through the survey results that their teaching and communication skills were improved and their understanding of the materials was further enhanced.

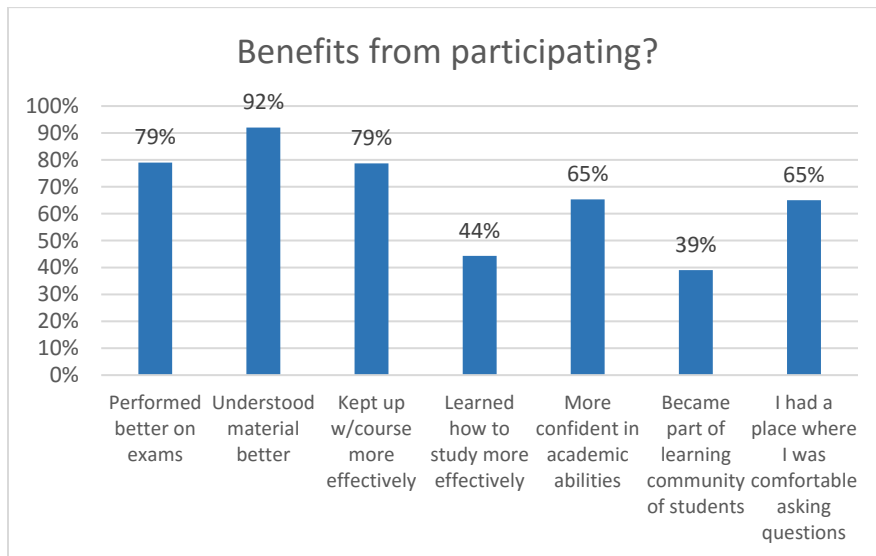


Figure 3. Survey result – Benefits from Participating in FSGs

To further examine the benefit of faculty-driven FSGs on student course performance, we compared the eventual average grade of students who participated in the FSGs and those of their non-participating peers from the same cohort. Figure 4 shows that in Statics classes where sufficient sample is available - of the 32 students in two sections of Statics classes, 16 students participated in the FSG, there is a 5.7% improvement of their average final grade on a percentage scale. However, in Thermodynamics the grade comparison is inconclusive, since there are not enough data of this nature available to show much statistical significance one way or the other. After completing these FSGs, the authors received many inquiries and requests from students in mechanical engineering asking for such type of FSGs for other subjects, such as Mechanics of Materials, Fluid Mechanics, etc. There is a strong indication that faculty-lead FSGs can be a potentially rather effective means to help students succeed in studying engineering-focus subjects.

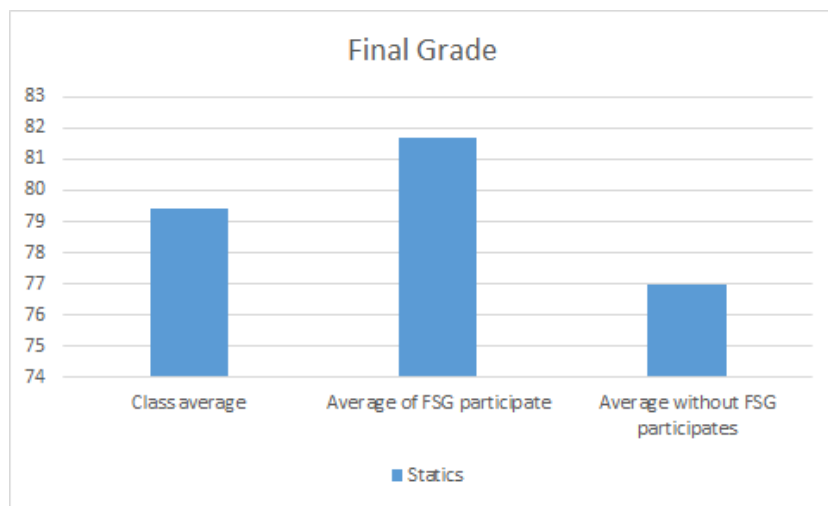


Figure 4. Average grades of FSG participants versus those of their non-participating peers

Summary

Faculty-lead Facilitated Study Groups are offered for two fundamental Mechanical Engineering courses (Statics and Thermodynamics). Of all eligible students who registered for these courses, there are 37 and 34 students that participated respectively in Statics FSGs in Fall 2014 and Fall 2015, and 30 students in Thermodynamics FSG in Fall 2014.

Post FSG survey data show that 83% of respondents believed that their grades improved, and 47% believed that their grades improved by at least one letter grade. Students felt that they became part of a learning community, and had a place where they were comfortable asking questions. The other benefits were also evident: performed better on exams, understood the course materials better, kept up with the course more effectively. The TAs also benefitted from the FSGs. They felt they improved their teaching and communication skills, and further reinforced their understanding of the course materials. In conclusion, our observation and survey results show that students who attended FSGs regularly gained a deeper understanding of the materials and achieved a better grade.

Future studies in this area may focus on tracking the same group of students of diverse academic aptitude through a sequence of mechanical engineering courses while participating in our FSGs. Proper assessment of their academic performance will undoubtedly shed more light on the effectiveness of this supplemental instruction method. Furthermore, as faculty of an institution that is primarily devoted to undergraduate education, we recognize that the willingness and commitment of the teaching faculty to be involved in these activities are also important. Instructor-student interactions, supported by enthusiastic faculty beyond the regular lecture settings, are an integral part towards the sustainment of such successful instructional practices. Future study components can indeed include examination of faculty attitude towards these practices and how their willing participation correlates with FSG successes. It also remains an on-going effort as to how a more diverse profile of participants can be recruited in order to broaden the positive impact of FSGs, and thusly improve their academic performance and their continued engagement in their chosen field of study.

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