
AC 2012-3581: A PEER-TUTOR'S PERSPECTIVE ON PEER-TUTORING IN THERMODYNAMICS

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Abstract

The purpose of this study was to examine the effects of peer tutoring on student performance in a Mechanical Engineering Thermodynamics course and to provide insight into the peer tutoring experience from a variety of perspectives. A Senior-level undergraduate student was recruited to host weekly group study sessions in addition to daily open tutoring hours. This tutor worked with two of the Mechanical Engineering professors who were teaching the Thermodynamics courses over several terms in order to discuss the performance of the students and other general observations regarding the learning experience. Students were surveyed as to their perspective and grades were analyzed at the end of each term in order to quantize the results that were observed. What was found indicates that students who attended the weekly study sessions tended to have a greater comprehension of the material and confidence in their abilities.

Introduction

Peer tutoring has been repeatedly demonstrated to be an effective resource for improving student learning when used as a supplement to the traditional lecture format. Additionally, peer tutoring has been shown to positively impact self-confidence, student retention, and interest in the subject¹. The reason for these benefits is attributed to the fact that cooperative learning encourages a higher level of reasoning in which students are more successful in generating new ideas and solutions than during individualistic thinking².

There are a variety of methods in which peer tutoring has been implemented. The term peer-tutoring is typically used when describing the cooperative learning of two or more individuals in the same age group; another form of peer-tutoring, however, can be done in cross-age groups, where an older student may advise other students who are several years younger. An additional distinction between methods of tutoring is whether it is structured uni-directionally or bi-directionally. Unidirectional peer-tutoring is the most commonly observed in structured tutoring programs, where a trained tutor assists other students. Bi-directional or reciprocal tutoring is often observed when students study in small groups. In this method of tutoring, each student takes turns in the role of tutor or tutee so that they may share ideas and individual expertise on the subject matter, and consequently both parties benefit from the interaction.

At the author's university, one of the resources offered by the Student Academic Resource Center (SARC) is a free peer-tutoring program. Students who have reached sophomore status with a 3.0 GPA minimum may sign up to tutor courses in which they achieved an A-letter grade. The hours that the tutors are scheduled to work act as "office hours" during which they remain available to assist students on a one-on-one basis in the subjects they are qualified to tutor.

Additionally, some of the peer-tutors host study sessions in the evenings, during which time they devote a two-hour block to a single subject; these study sessions tend to have several students in attendance.

The approach used in this case varied over a three-term period, providing insight into which aspects of the peer-tutoring process led to different observable effects on the students' performance. Additionally, the professor(s) teaching the same class each term varied, allowing for insight into how the professor may influence the structure and content of the tutoring sessions.

During the first term, a single peer tutor was employed by the university's SARC to provide learning assistance to engineering students taking MECH-320: Thermodynamics. The tutor's schedule was posted, however the professor made no commitment to the process, not even going out of the way to mention in class that a peer tutor was available for consultation. As could be expected, students did not find their way to the tutor, and their performance was unaffected.

During the second term, the same tutor posted the tutor schedule in the SARC as had been done previously. Additionally, a weekly Thermodynamics study session was made available with weekly email reminders sent to all students registered in the course. The professor (Prof A) actively promoted the tutor's availability at least once per week. Prof A also developed worksheets which were used in-class and which became the basis for the study sessions run by the peer tutor. Recommended homework problems and solutions were also provided as a resource for the tutor to reference. The results from this approach were much more successful in engaging students and understanding how students prioritize their work load, as described later in the paper.

During the third term, the same tutor posted the tutor schedule and hosted weekly study sessions, with weekly email reminders that were sent to all students. In this third term, two different professors were teaching the course. One of the professors (Prof C) made no commitment to the process, and despite the emails, only two of his students sparsely attended during the term. The other professor (Prof B) promoted the tutor several times during the term, as well as provided homework problems and solutions which were consistently assigned and graded throughout the term. A more consistent response was seen from this professor's students, providing further insight into the minds of the students.

This paper will review the tutoring experience from the perspectives of the peer tutor, the students involved in the study sessions, and the professors teaching the Thermodynamics courses. The ultimate goal of these tutoring exercises was to identify ways to effectively improve student outcomes without expending additional resources.

Results from the peer tutor's perspective

The peer tutor selected for this study was uniquely qualified for the position due to her experience studying the subject of Thermodynamics. During her college career, she has studied Thermodynamics in CHEM-361: Physical Chemistry, MECH-320: Thermodynamics, and PHYS-452: Thermodynamics & Statistical Physics. This extensive and well-rounded background allowed her to share diverse views on the subject matter to students currently enrolled in MECH-320: Thermodynamics.

Based on her observations, the peer tutor believes that there were four key influencing factors which affected the structure and outcomes of the peer-led study sessions: how the class was structured, how the content was presented, the teacher-student social dynamic, and the learning atmosphere.

Consequences of Class Structuring

One of the most dramatic things perceived by the tutor was how the student level of participation and modeling of the tutoring sessions were affected by the level of encouragement from the professors and the manner in which they structured their class. It appears that if the professor did not invest him- or herself into the tutoring system, the students did not invest themselves into the system either. Furthermore, the objectives set out by the professor dictate how much effort the students apply to their educational success.

Figure 1 identifies the number of each professor's students in attendance at the weekly study sessions.

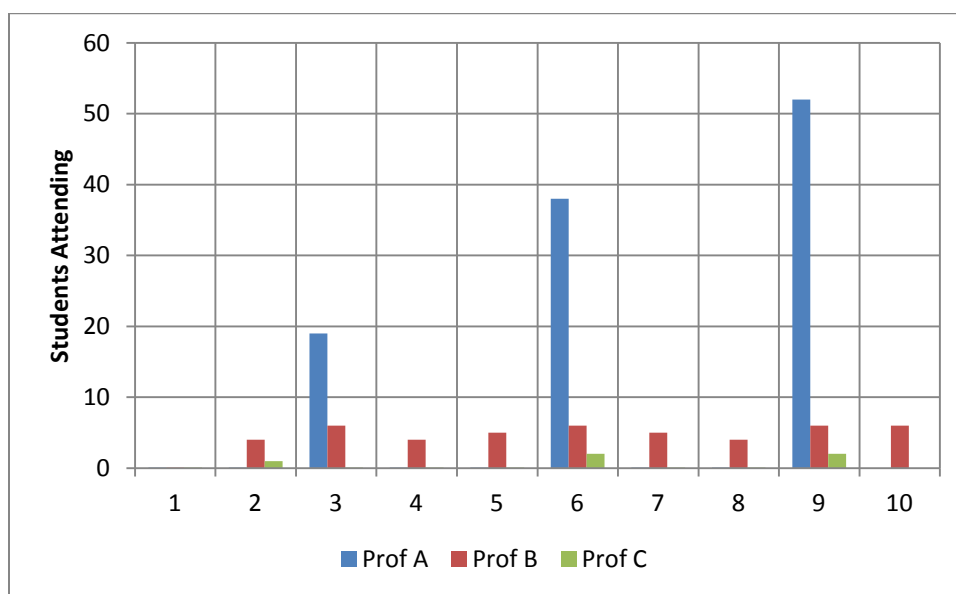


Figure 1 Number of students attending the weekly study sessions; three different professors

In the second term, Prof A based his grades entirely on the students' performance in three exams. Even though the students had been assigned recommended homework assignments at the conclusion of each lecture, and the tutor was available every week, there was zero attendance during the weekly study sessions except for those sessions offered just prior to exams; at these pre-exam sessions, a significant percentage of the class attended, with the overall numbers growing at each subsequent exam review. In the post-term survey, the students attributed this behavior was a means to balance their priorities between Thermodynamics and their other courses; when there were no impending examinations, they had no incentive to take time away from other courses or personal time to attend the study sessions.

However, during the third term, Prof B collected weekly homework assignments for grading in addition to his exams. Because of the importance placed on these weekly assignments, there was regular attendance at the weekly study sessions. This again demonstrates students' motivation to benefit their performance in a time-effective manner. It should be noted again that Prof C did not encourage his students to participate in the study sessions, and this lack of involvement is reflected in the attendance.

Consequences of Content

Thermodynamics is considered to be a fundamental subject in the Mechanical Engineering curriculum. As such, it requires a thorough understanding of the abstract concept of energy. While prerequisite courses rely heavily on Newtonian mechanics which are easily visualized, concepts involving energy are intangible and consequently much more difficult for many students to comprehend. One of the most common strategies employed by the tutor to help students make sense of this new material is to relate these new concepts to more familiar concepts by way of using analogies. This learning tool is effective because it takes advantage of constructivist learning theories, in which people learn new material by means of adapting their preexisting mental framework to accommodate new knowledge.

Another point that is repeatedly stressed to the students that come in for peer tutoring is that the internet is a phenomenal resource for aiding in one's education. In addition to various guides, forums, and applets, the most important feature is that this content was all put online by *different* people. It is common knowledge that everyone learns differently, so it follows that no two students sitting in the same lecture will experience the same benefits. Ultimately, learning is optimized when the material is presented in a manner in which each individual student can relate; the internet acts as a gateway for numerous ways of viewing the same concepts and solving varied problems. Engineers think and teach like engineers, chemists think and teach like chemists, and physicists think and teach like physicists. Because of the tutor's successful background in each of the aforementioned areas, she was able to present Thermodynamic concepts from multiple perspectives and help guide students to resources with the potential of

being the most beneficial to their particular learning style, based on what “clicked” best with them.

Consequences of the Teacher-Student Social Dynamic

In addition to purely academic concerns, there are social concerns that must be acknowledged regarding how the student perceives themselves to be viewed by others. Some students are uncomfortable coming to peers for fear of looking “stupid” or being judged, whereas others would rather have the option available to seek out another student’s assistance as opposed to admitting to the professor responsible for their grade that they don’t actually know what’s going on. Additionally, many feel that if they did not understand the material as given by the professor in lecture, that they would not gain anything from having it repeated to them during the professor’s office hours. Many professors that have been teaching in their field for years do not necessarily remember what it was like to struggle to understand the material. Peers not only have a better appreciation for current academic struggles, but often use different language when conversing among themselves; as such, peer tutors are capable of explaining these abstract concepts in a different manner than would be used in a formal lecture.

Consequences of the Peer-Tutoring Atmosphere

One of the more striking differences between lectures and peer-tutoring is the atmosphere in which the learning takes place. Whereas a lecture is fairly structured and professor-led due to a need to cover material, the peer-tutoring sessions are typically aimed toward a more open discussion, a freedom possible due to the smaller group size and supplementary nature. Study sessions typically began with a short review of the material that the students had recently covered in order to get their minds focused back on the subject and remind them of the new material they had covered in lecture. Most of the time was spent working through problems that students had specifically requested. The nature of the sessions allowed the tutor to spend as much time and go into as much detail – both theoretical and mathematical – as the students needed. Some students will always work faster or slower than others, require more or less explanation of theory or guidance as to the mathematics, etc. Just as this is true for problems in lecture, it is also true for problems in the study sessions, but because tutoring sessions are more intimate, the tutor was capable of tailoring her responses better to those in attendance.

Another benefit of the more relaxed atmosphere is that students may “tune in” to what the tutor is doing at any point in time or work quietly with others, knowing that the tutor is there to field questions when they encounter problems. By encouraging students to work through problems in small groups, they are able to advise each other on methods they found successful in solving various problems, thereby gaining the benefits of reciprocal peer tutoring. While students were

working in these small groups, the tutor encouraged them to attempt answering each others' questions while remaining available to ensure that they did not become "off-track."

Results from the students' perspective

In order to gauge the student response to this peer tutoring system, student surveys were conducted at the end of the academic term for Prof A's students. Unfortunately, survey data from Prof B's and Prof C's classes was not available.

As shown in Table 1 very few students took advantage of the one-on-one tutoring services available to them. Only a small fraction of students showed up multiple times. The data shown was from surveys of Prof. A's students, but the trend is similar for Prof. B's students.

Table 1 Frequency of student attendance for one-on-one tutoring hours. (Self reported)

Sessions Attended	No. Students	Percent of Surveyed
0 times	32	60%
1-2 times	12	23%
3-4 times	7	13%
5 or more times	2	4%

Table 2 shows that students are highly motivated to attend only as many study sessions as could provide immediate benefit of participating in the review, but prioritized other academic or personal activities when there were no upcoming exams. Note again that Prof B's students demonstrated fairly regular attendance patterns for the weekly study sessions due to the weekly graded homework assignments.

Table 2 Frequency of student attendance for weekly study session. (Self reported.)

Sessions Attended	No. Students	Percent of Surveyed
0 times	13	25%
1 time	12	23%
2 times	17	32%
3 times	11	21%
4+ times	0	0%

Table 3 shows the students response to the helpfulness of the pre-exam study sessions. The student response is extremely favorable, with 75% of those participating feeling as though they had benefitted from the experience.

Table 3 Student response to the helpfulness of the weekly study sessions.

Response	No. Students	Percent of Surveyed
Very much helped.	26	49%
Somewhat helped.	13	25%
Somewhat didn't help.	3	6%
Not useful at all.	6	11%
Unanswered	5	9%

Students were also encouraged to submit open responses along with the survey; some of the comments regarding the peer tutoring experience included:

- It was a great time to get help on problems I was stuck on or just to see a different way of doing the problem.
- It was nice to have an upper classman to go to who knew plenty about the course and who I trusted knew what they were talking about.
- I found [the study sessions] very helpful in the beginning when not as many students were present and we tried new questions that were not covered in class.
- [The tutor's] student-level understanding helped her relate the subject to the students in a different, yet helpful light.
- [The tutor] taught very similarly to [Prof A] using the same notation making it easy to understand
- Going in to the session I felt like I didn't understand much but leaving I was confident and I got a 91 on the second test.

Although the primary focus of this study was on the peer tutoring experience, the lessons learned regarding the effectiveness of review worksheets were important and worth discussion. As was noted previously, many students tend to prioritize doing what is required over anything else; specifically, students often will not make the time to do homework unless they will receive credit for it. The worksheets used during the second term were designed to test the students' abilities in certain key subject matters so that they could gauge their preparedness for the exam. The professor allowed two-hours of class time for the students to devote to these worksheets in self-selected groups while the professor provided coaching. As can be seen in Table 4, the student response to these worksheets was overwhelmingly positive.

Table 4 Student response to the helpfulness of the pre-exam worksheets.

They were very helpful.	49	92%
They were somewhat helpful.	4	8%
They were somewhat not helpful.	0	0%
They were not helpful.	0	0%

Results from the professors' perspective

One way to gauge the success of the peer tutoring program is simply to count the number of students that are taking advantage of the opportunity. The number of students taking advantage of the regular office hours of the peer tutor, as self-reported by the students in the student survey (See Figure 1), is very disappointing. However, the students became more highly motivated in the days leading up to the exams. Figure 1 shows the attendance at the peer-tutor lead review sessions, which occurred just prior to the exams. Not surprisingly the number of students that attended was directly related to the professor's promotion of the benefits of attending.

Professors A and B, were both actively encouraging their students to attend. In Professor A's case, he was also providing data to demonstrate how the scores of the students that attended were being improved. Students obviously received the message, as the attendance soared for each subsequent review session.

The other obvious metric for determining the value of the peer tutor is to measure improvements in students' exam scores. Figure 2 begins to demonstrate the improvement of students that attended the pre-exam review sessions for Prof A. The bar chart shows clear improvement for students that attended the review in exams 2 and 3, but not apparently so for exam 1. The theory for this, was that there were a number of 'non-serious' students that hoped to improve their test scores 'magically' by simply attending the session, rather than investing purposeful effort in their homework.

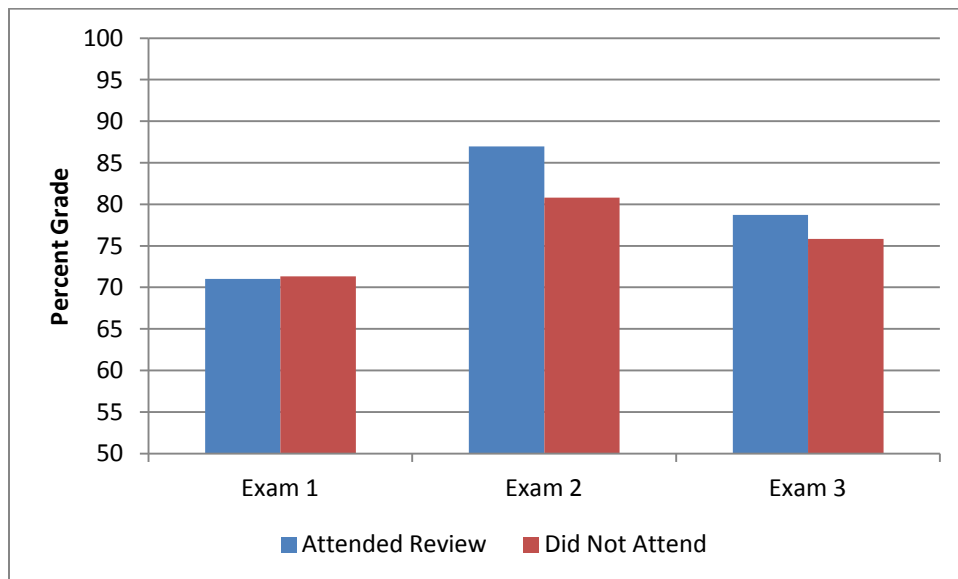


Figure 2 Student exam scores for Prof A

In Figure 3 an attempt was made to remove these 'non-serious' students from the data set. This was done by removing any student who did not achieve a minimum score of forty (40) percent on the exam. After this modification for each exam the students that attended the review

sessions was about five (5) percentage points higher for both Exam 1 and 2, and one (1) percentage point higher for Exam 3.

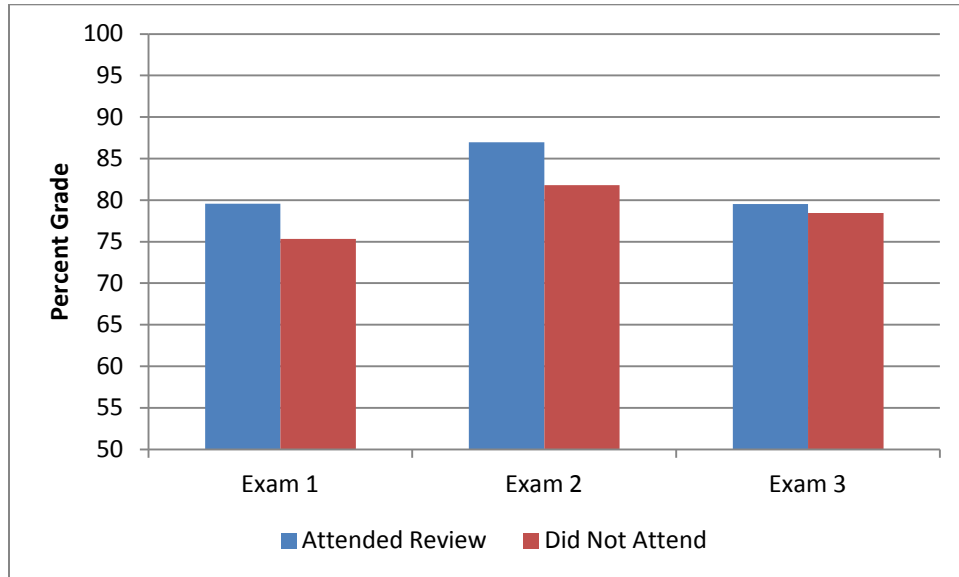


Figure 3 Improvements for ‘serious’ students (minimum grade of 40%) for Prof A

Figure 4 shows the effects on the final grades. The 11 students (out of 87 total) that attended all three of the review sessions averaged significantly higher final score (83.4%) than the 25 students that did not attend any review sessions (73.5%); this is an improvement of nearly ten percentage points in overall score. Students that attended one and two sessions received correspondingly improved scores.

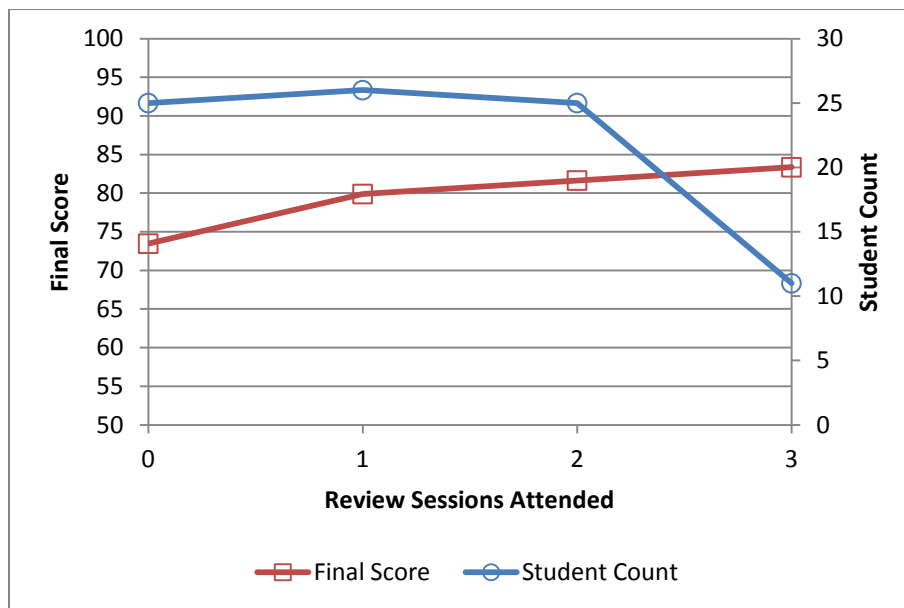


Figure 4 Course final score as a function of the number of review sessions attended. For Prof. A.

It can be argued that the improved scores did not come from the peer-tutoring itself, but because better students were more likely to attend the peer tutor review sessions. This is disputed by the distribution of the scores in Figure 5. All groups (those that attended zero times to those that attended 3 times) have a significant number of high performing students; not just the group that attended 3 times. What is also clear in the data is that students that attended only one or less were much more likely to fail the course (50% or lower).

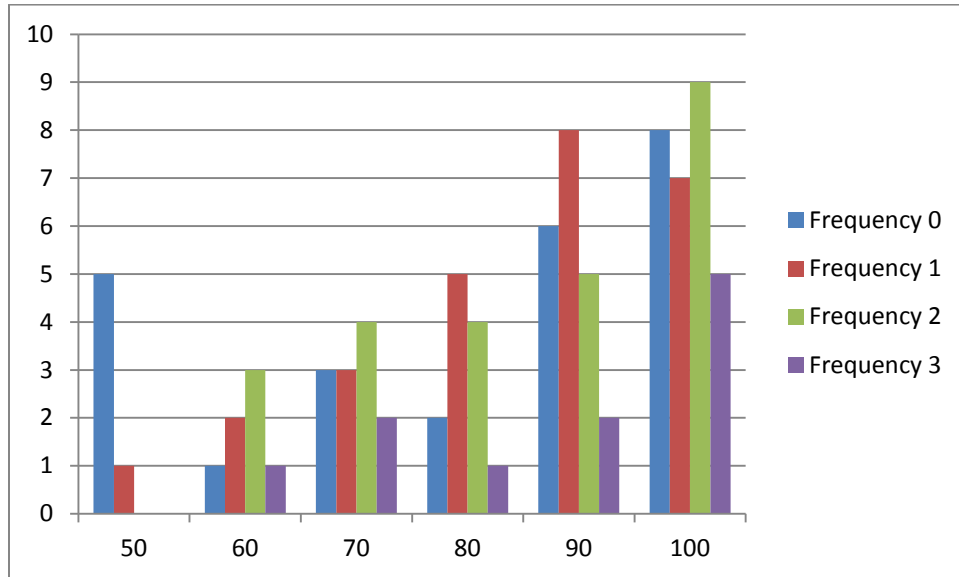


Figure 5 Distribution of scores for various groups. Prof. A.

The results for Prof A seemed to show that there was a definite benefit for participating in the pre-exam study sessions.

Prof. B results, based on using weekly study sessions, demonstrated a similar benefit. Figure 6 demonstrates the improvement in average test scores, the final exam score, and the final course grade for those students attending the weekly tutoring sessions. Students who demonstrated no serious effort on the final exam were omitted. As is shown, the scores of students attending the tutoring sessions were four to six percentage points higher for the student group which participated in the weekly study sessions.

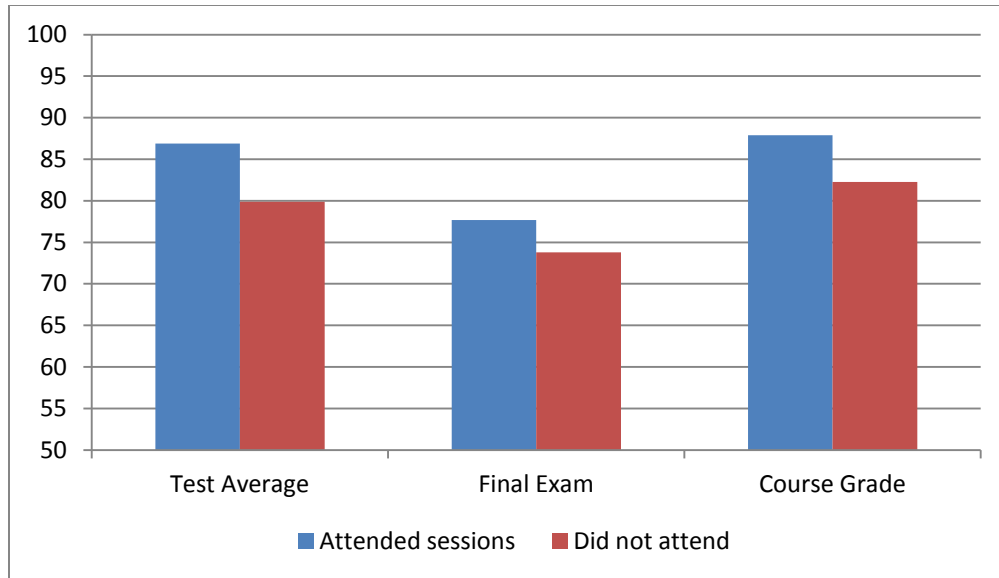


Figure 6 Test average score, final exam scores, and overall course grades. Prof. B.

Figure 7 shows the effect of the number of tutoring sessions on the final grade achieved in the course for Prof. B. Those students who attended at least one tutoring session scored about 5% better than those who did not attend any sessions. Interestingly, this data set showed a relatively flat improvement with the number of sessions attended, until the number became high.

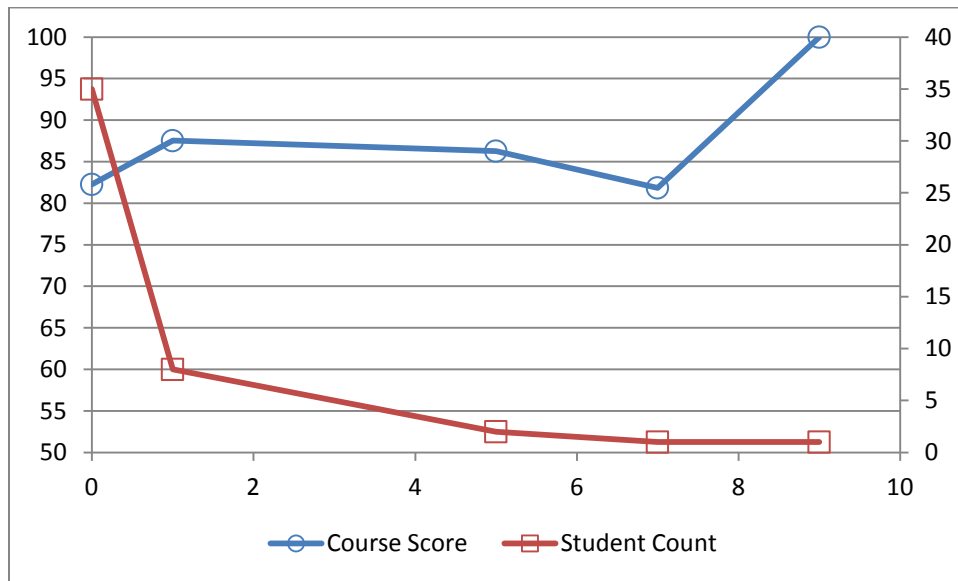


Figure 7 Course final score as a function of the number of tutoring sessions attended.

Sometimes, it has been argued that the best students will attend tutoring sessions; therefore the grade improvement is due to the student and not the tutoring. As shown in Figure 8, this is not true. Many of the best students did not attend any tutoring sessions. Although, it is important to note that no students who attended at least one session received less than 70 in the course.

Analyzing this data in conjunction with that of the previous figure shows that many of the best students did not attend any sessions. This lends credence to the observation that average and poorer students will gain the most from attending these sessions.

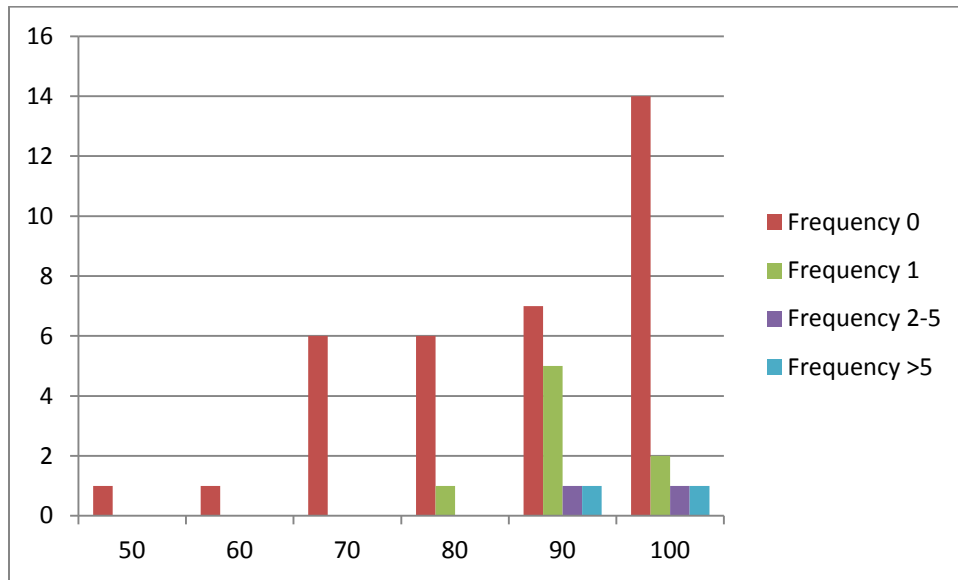


Figure 8 Distribution of scores for various groups. Prof. B.

Conclusions & Recommendations

During the course of this study, it was verified that peer tutoring is indeed an effective means of improving student learning when employed in such a way that the students are motivated to take advantage of the opportunity. Students are attracted to the study sessions because it simply requires them to show up during a pre-designated time, unlike the open tutor hours in which they must initiate the interaction. Additionally it was found that the size of the group significantly impacted the students' perceived outcome; while many were unattracted to the one-on-one scenario, too many students in attendance at the sessions took away from individualized attention and began to resemble a lecture. Ideally, the tutor found that groups of around a dozen students displayed the best group dynamic. This group size permitted several small sub-groups to form in which students were capable of participating in reciprocal peer tutoring amongst themselves, and the peer tutor was still capable of providing individual assistance to each student without becoming overwhelmed.

Even with the tutoring services available to students, it is the instrumental support of the professors that ensures the success of the program. Students will choose to participate only if the benefits of the time-cost are made apparent to them. By promoting the advantages of meeting with qualified tutors and providing incentive to the students to attend, the tutoring system may

prosper. Examples of effective incentives could include homework assistance, review sheets, old test problems, or extra credit opportunities.

In addition to providing resources to their students, it is also important for professors to provide material for their tutors to reference to avoid stalling or confusion when they are attempting to answer questions. The pre-exam review worksheets worked ideally for introducing students to the format of the upcoming exam, and providing worked problems to serve as a framework and reference for the tutor to solve problems in a method consistent with that used by the professor.

The student survey indicates that many students recognize the significant benefits associated with attending group study sessions led by a peer tutor. Seventy-five percent of the students participating in the survey attended one or more of the study sessions offered throughout the term, and seventy-five percent of the same group indicated that it was a valuable experience, increasing their understanding and confidence in the material.

The professors involved in this study found that there was measurable improvement in student performance among those students that attended the study sessions. Exam scores and final course scores improved by five to 10 percentage points. Encouraged by these results, the professors will be continuing to use this approach.

Ultimately, it is essential to keep in mind the fact that every student has unique learning styles. The more supplementary learning opportunities made available to students, combined with proper motivation, helps ensure enhanced overall performance and comprehension.

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