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Value of Student Resources in Materials Science and Biomedical Engineering Courses

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Assessment of Student Responses to Various Resources Offered in Biomedical Engineering and Materials Science Courses

To supplement lectures, various resources are available to students; however, little research has been done to look systematically at which resources studies find most useful and the frequency at which they are used. We have conducted a preliminary study looking at various resources available in an introductory material science course over four semesters using a custom survey called the Student Resource Value Survey (SRVS). More specifically, the SRVS was administered before each test to determine which resources students use to do well on exams. Additionally, over the course of the semester, which resources students used changed. For instance, study resources for exams including the use of homework problems decreased from 81% to 50%, the utilization of teaching assistant for exam studying increased from 25% to 80%, the use of in class Muddiest Points for exam study increased form 28% to 70%, old exams and quizzes only slightly increased for exam study ranging from 78% to 87%, and the use of drop-in tutoring services provided to students at no charge decreased from 25% to 17%. The data suggest that students thought highly of peer interactions by using those resources more than tutoring centers.

To date, no research has been completed looking at courses at the department level or a different discipline. To this end, we adapted the SRVS administered in material science to investigate resource use in thirteen biomedical engineering (BME) courses. Here, we assess the following research question: "From a variety of resources, which do biomedical engineering students feel addresses difficult concept areas, prepares them for examinations, and helps in computer-aided design (CAD) and programming the most and with what frequency?" The resources considered include teaching assistants, classroom notes, prior exams, homework problems, Muddiest Points, office hours, tutoring centers, group study, and the course textbook. Results varied across the four topical areas: exam study, difficult concept areas, CAD software, and math-based programming. When preparing for exams and struggling with a learning concept, the most used and useful resources were: 1) homework problems, 2) class notes and 3) group studying. When working on math-based programming (Matlab and Mathcad) as well as computer-aided design, the most used and useful resources were: 1) group studying, 2) engineering tutoring center, and 3) undergraduate teaching assistants.

Concerning learning concepts and exams in the BME department, homework problems and class notes were considered some of the highest-ranking resources for both frequency and usefulness. When comparing to the pilot study in MSE, both BME and MSE students tend to highly favor peer mentors and old exams as a means of studying for exams at the end of the semester[1]. Because the MSE course only considered exams, we cannot make any comparisons to BME data concerning programming and CAD.

This analysis has highlighted potential resources that are universally beneficial, such as the use of peer work, i.e. group studying, engineering tutoring center, and teaching assistants; however, we see differences by both discipline and topical area thereby highlighting the need to determine important resources on a class-by-class basis as well.

Introduction

One of the first responsibilities of new engineering students is to find useful methods of learning that helps clarify difficult concepts and extends classroom instruction. It is important for students to select appropriate additional resources based on needs. To supplement lectures, various resources are available to students. These resources include expert students who have taken the course before and work either as an undergraduate teaching assistant or undergraduate engineering tutor. Peer-to-peer teaching is viewed as a positive impact in educational understanding[2,3,4]. This seems to be a common trend because students ultimately relate to peers easily[5,6]. In addition, studies have shown that students who visited the drop-in tutoring had higher persistence and slightly higher GPA's then students who infrequently visited[7]. This could suggest that students have better success in undergraduate engineering courses by utilizing peer-to-peer interactions. The authors also consider Muddiest Points that have been highly effective in a BME statistics course[8,9,10]. Furthermore, the authors have considered non-expert student resources. This includes group studying which has seen a shift in engineering students to becoming a highly valuable resource as noted by Krause, et al[1]. Lastly, traditional learning resources were considered such as homework problems, class notes, instructor office hours, book for the course, and old exams[8].

Little research has been done to look systematically at which resources studies find most useful and the frequency at which they are used. Moreover, individual studies have investigated the effectiveness of certain resources but none systematically across an entire department. The authors found from a previous longitudinal study performed by Krause, et al. in a material science course that certain resources are useful throughout the system while others change from the beginning to the end of the semester. To collect student feedback in this preliminary study, a custom survey called the Student Resource Value Survey (SRVS) was employed. More specifically, the SRVS was administered before each test to determine which resources students use to prepare for exams. Over time, study resources for exams including the use of homework problems decreased from 81% to 50%, the utilization of teaching assistant for exam studying increased from 25% to 80%, the use of in class Muddiest Points for exam study increased form 28% to 70%, old exams and quizzes only slightly increased for exam study ranging from 78% to 87%, and the use of drop-in tutoring services provided to students at no charge decreased from 25% to 17%. From these data, it was determined that students in an introductory materials science course thought highly of peer mentors and instructor feedback by using that resources more than tutoring centers[1].

To date, no research has been completed looking systematically at multiple courses of varying format and content areas at the department level. Here, we assess the following research question in 13 biomedical engineering courses: "From a variety of resources, which do Biomedical Engineering students feel addresses: 1) difficult concept areas, 2) preparing them for examinations, 3) helping in computer-aided design (CAD) and 4) required assistance in math-based programming the most and with what frequency are they used?"

The objective of the study is to identify which resources are most useful as well as which resources students use most to address the following: 1) study for an exam, 2) understand a difficult concept, 3) troubleshoot math-based programming (e.g., MATLAB and Mathcad) and 4) improve CAD programming. Identifying key resources will help instructors determine which resources to improve and students identify which resources to target when faced with a certain content challenge.

Materials and Methods

Survey Design

The Resource Assessment Survey (RAS) consists of resources from four categories. The first category is help from other people. The resources in this category are undergraduate teaching assistant, instructor office hours, and the engineering tutoring center. The second category is help from supplemental material. The resources in this category are old exams or quizzes, class notes, homework problems, and the book for the course. The third category is help from material targeting specific common issues. The resource in this category is Muddiest Point feedback. The fourth category is help from group-based activities. The resource in this category is group studying. The survey was administered to thirteen BME courses. There was eight total questions and each question covered nine resources, i.e. "how often did you use this resource for help on exams?" The survey questions may be found in Table 1 of Appendix 1.

Each student was given the survey and asked to rank his/her response on a five point scale with one indicating "never used" and five indicating "always used". A sixth option of "not applicable" was included for courses where the resource was not available or the content not tested (i.e., CAD when studying for exams). Moreover, this study was conducted with IRB approval STUDY00003275.

Survey Administration

Students anonymously participated from 13 courses in biomedical engineering: two freshmen classes, four sophomore classes, and seven junior/senior classes with approximately one hundred BME students per class. The same student may be in several classes. The survey was generated using Qualtrics and students took the survey online at the end of the semester. Excel was used to compile all the results and generate graphs of descriptive statistics from the student responses. The Kruskal-Wallis tests were conducted in Statistical Package for the Social Sciences (SPSS) to look for differences in the frequency and usefulness of resources.

Results

The following graphs display combined results from 60 students regarding the usefulness and how often a particular resource was used in the following four categories: 1) exam preparation (Figures 1 and 2), 2) difficulty learning a particular concept (Figures 3 and 4),

3) troubleshooting programming languages such as MATLAB and Mathcad (Figures 5 and 6), and 4) troubleshooting computer-aided design (CAD) (Figures 7 and 8).

Statistical analysis yielded many significant differences among resources. A chart of all significant comparisons may be found in Appendix 2. Here, we describe the most interesting differences.

Resource Assessment Survey – Exam Preparation Survey Analysis

Figures 1 and 2 show which resources were considered to be the most useful and how often they were used among 60 biomedical engineering students of varying levels across multiple classes when preparing for exams. The least favorable resource for frequency was Muddiest Points and for usefulness it was the book for the course. The most favorable resource for both was homework problems and class notes ($p<0.05$). More specifically, statistical analysis on the frequency of resource use showed that help from homework problems and class notes were statistically higher than Muddiest Points feedback and the book for the course. In addition, in terms of usefulness, class notes was statistically higher than Muddiest Points feedback, and the book for the course. Homework problems were statistically higher than Muddiest Points feedback, and the book for the course. More information about the statistical significance between in-group pairs can be found in Table 3 and 4 of Appendix 2.

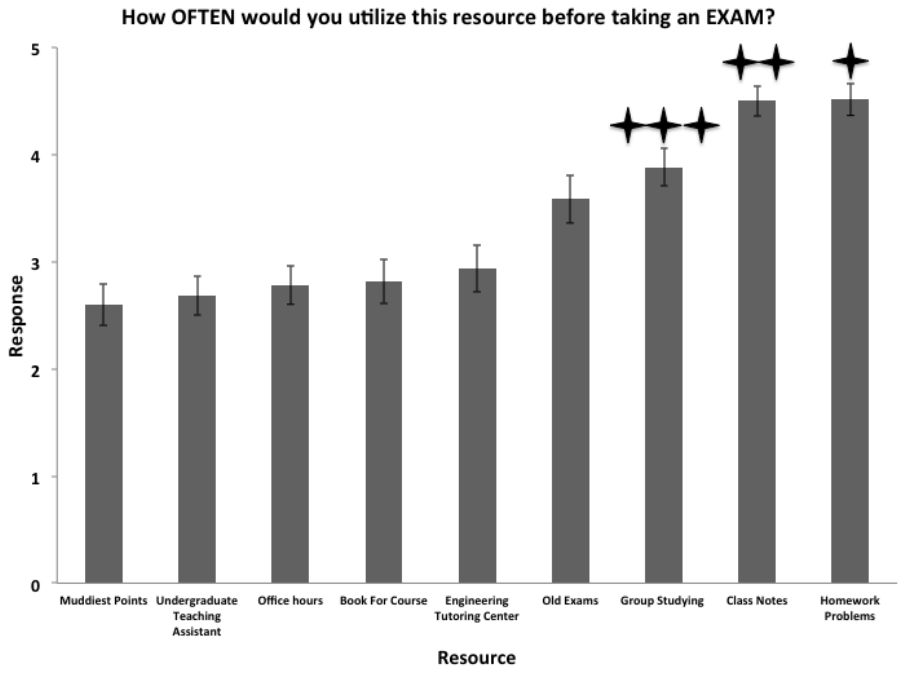

Figure 1. Student Resource Value: Frequency of Resource Use for Exam Preparation: Kruskal Wallis analysis about resource frequency when preparing for exams showed that statistical homework problems ranked highest, followed by then class notes, and group studying (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 3 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

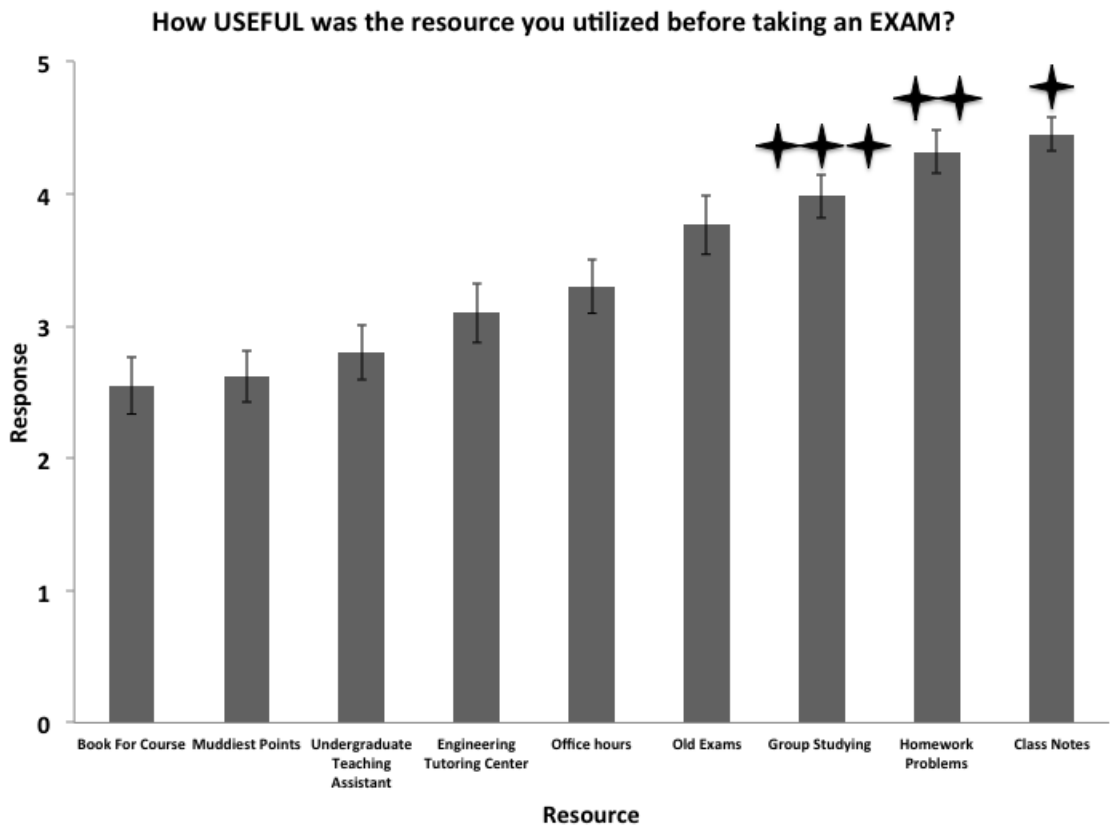

Figure 2. Student Resource Value: Utility of Resource Use for Exam Preparation: Kruskal Wallis analysis about resource usefulness when preparing for exams showed that statistical class notes ranked highest, followed by then homework problems, and group studying (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 4 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

Resource Assessment Survey – Learning Concepts Survey Analysis

Figure 3 and 4 shows which resources were considered to be the useful and how often they were used among 60 biomedical engineering students of varying levels across multiple classes when faced with a difficult concept. The least favorable resource for learning concepts in frequency was Muddiest Points and for usefulness it was the book for the course. The most favorable resource for learning concepts was homework problems, class notes and group studying ($p<0.05$). More specifically, statistical analysis regarding resource frequency showed that that help from class notes was statistically higher then, Muddiest Points feedback, and the book for the course. Homework problems were statistically higher than Muddiest Points feedback, and the book for the course. Group studying was statistically higher then Muddiest Points feedback. In addition, for usefulness class notes were statistically higher than Muddiest Points feedback, and the book for the course. Homework problems were statistically higher than Muddiest Points feedback, and the book for the course. Group studying was statistically higher then Muddiest Points feedback, and the book for the course. More information about the statistical significance between in-group pairs can be found in Table 5 and 6 Appendix 2.

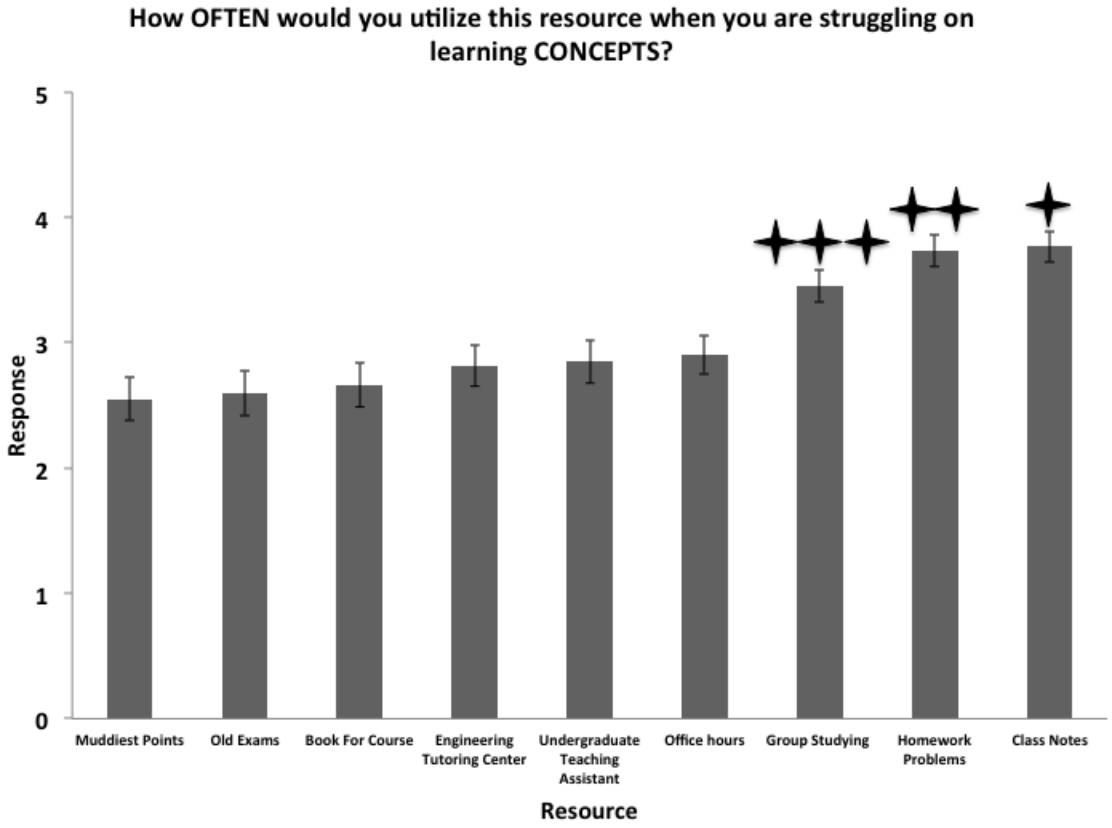

Figure 3. Student Resource Value: Frequency of Resource Use with Learning Concepts: Kruskal Wallis analysis about resource frequency when preparing for learning concepts showed that statistical class notes ranked highest, followed by then homework problems, and group studying (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 5 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

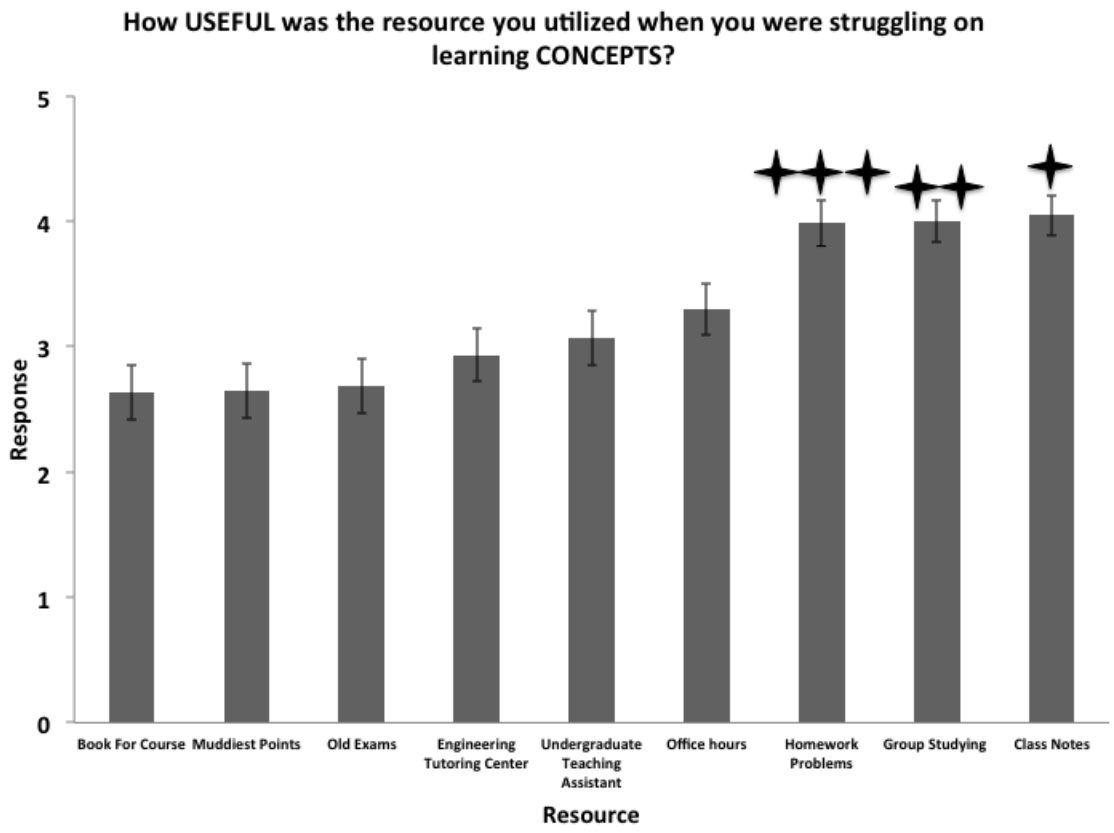

Figure 4. Student Resource Value: Utility of Resource Use with Learning Concepts: Kruskal Wallis analysis about resource usefulness when preparing for learning concepts showed that statistical class notes ranked highest, followed by then group studying, and homework problems (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 6 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

Resource Assessment Survey – MATLAB/Mathcad Survey Analysis

Figure 5 and 6 shows which resources were considered to be the useful among 60 biomedical engineering students of varying levels across multiple classes when working on math-based programming, such as MATLAB and Mathcad. The least favorable resource for MATLAB/Mathcad in frequency and usefulness was the book for the course; while, the most favorable resource for MATLAB/Mathcad was group-studying ($p<0.05$). The top three resources were all peer mentor resources. More specifically, statistical analysis showed that the Engineering Tutoring Center was statistically higher than book for the course ad that group studying was statistically higher then Muddiest Points feedback and book for the course. In addition, in terms of usefulness, statistical analysis showed that the help from undergraduate teaching assistant was statistically higher than old exams and quizzes and the book for the course. Engineering Tutoring Center was statistically higher than help from the book. Group studying was statistically higher than book for the course. More information about the statistical significance between in-group pairs can be found in Table 7 and 8 Appendix 2.

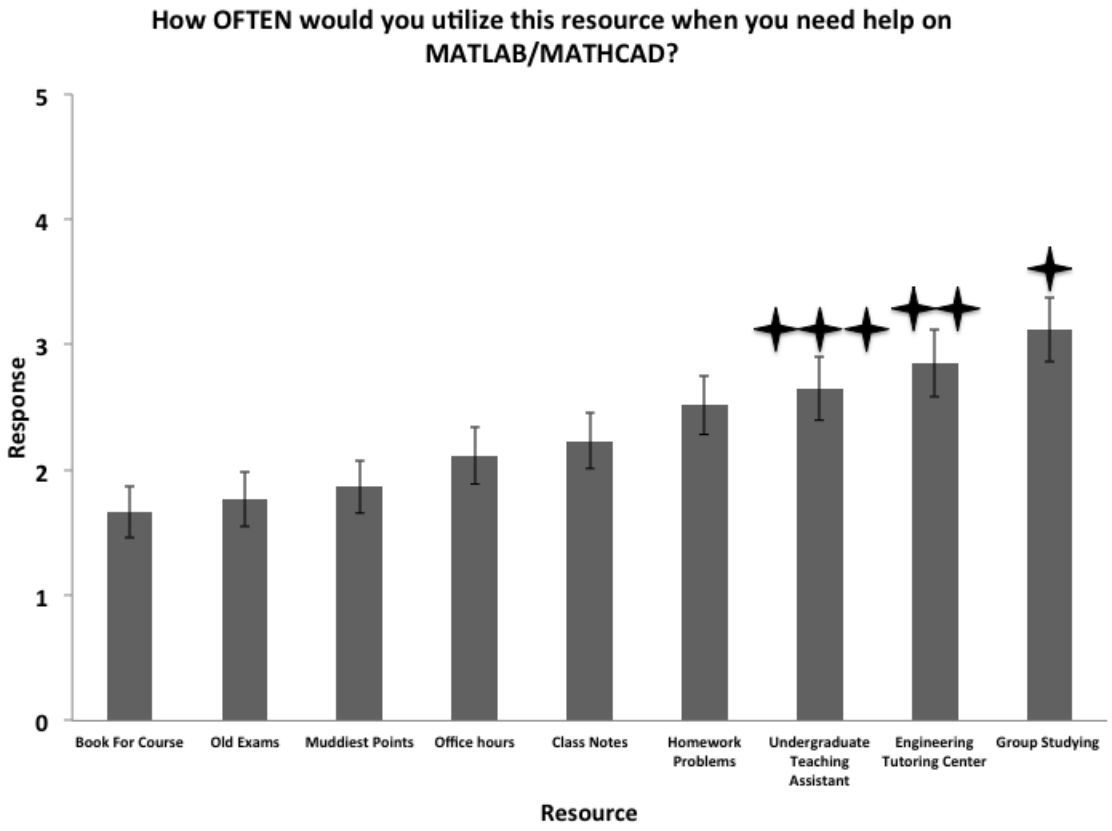

Figure 5. Student Resource Value: Frequency of Resource Use with Math-based Programming: Kruskal Wallis analysis about resource frequency when preparing for Mathlab/Mathcad showed that statistical group studying ranked highest, followed by then Engineering Tutoring Center, and Undergraduate Teaching Assistants (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 7 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

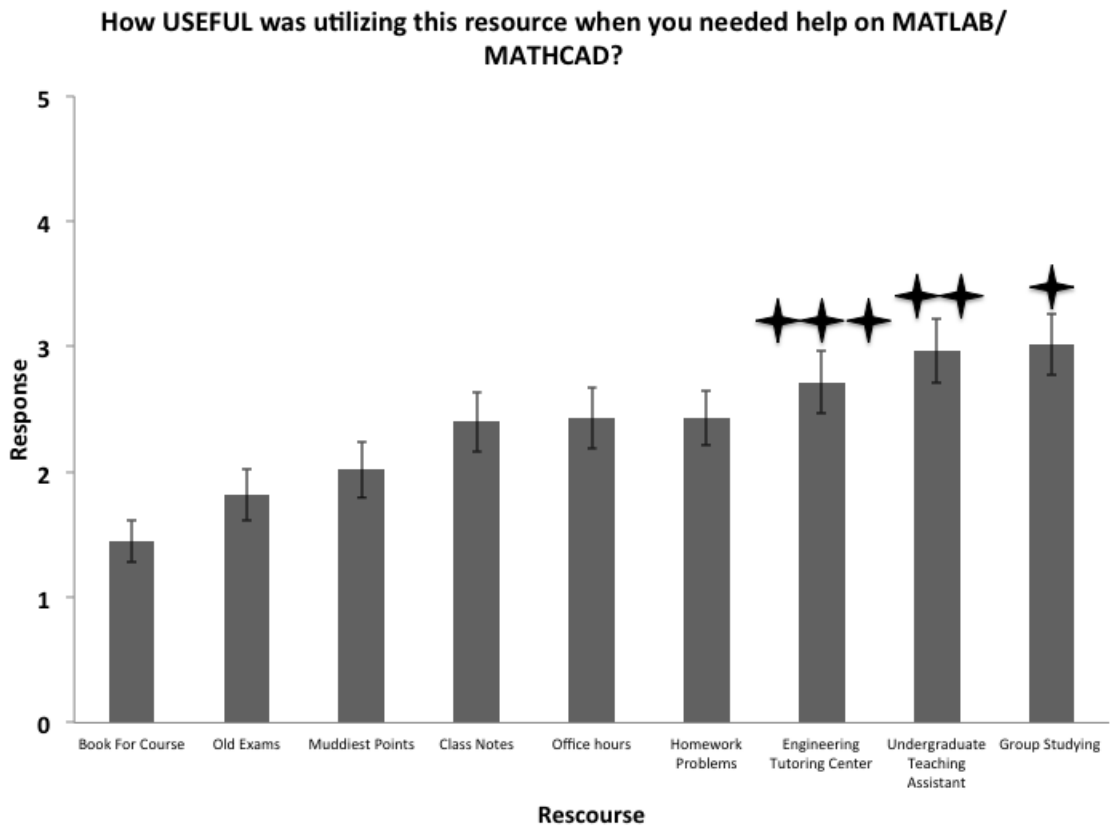

Figure 6. Student Resource Value: Utility of Resource Use with Math-based Programming: : Kruskal Wallis analysis about resource usefulness when preparing for MATLAB/Mathcad showed that statistical group studying ranked highest, followed by then Undergraduate Teaching Assistants, and Engineering Tutoring Center (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 8 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

Resource Assessment Survey – CAD Software Survey Analysis

Interestingly, there was no statistical significance for Figures 7 and 8. However, a trend in Figure 7 suggests that the resource most frequently used for help on CAD software is group studying and the least useful resource is the textbook. In terms of usefulness, Figure 8 suggests that the book for the course may be the least useful and group studying may be the most useful. More information about the statistical significance between in-group pairs can be found in Table 9 and 10 Appendix 2.

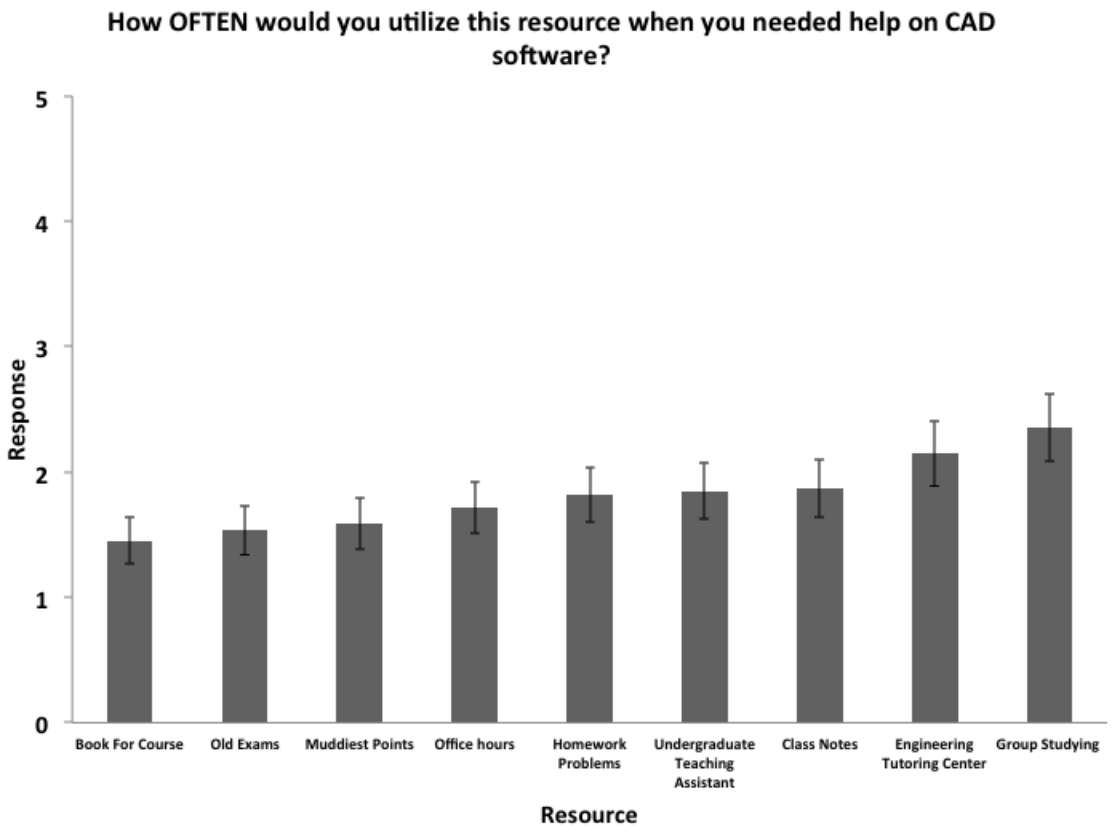

Figure 7. Student Resource Value: Frequency of Resource Use with CAD: Kruskal Wallis analysis about resource frequency when preparing for CAD software showed that statistical group studying ranked highest, followed by then engineering tutoring center, and class notes (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 9 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

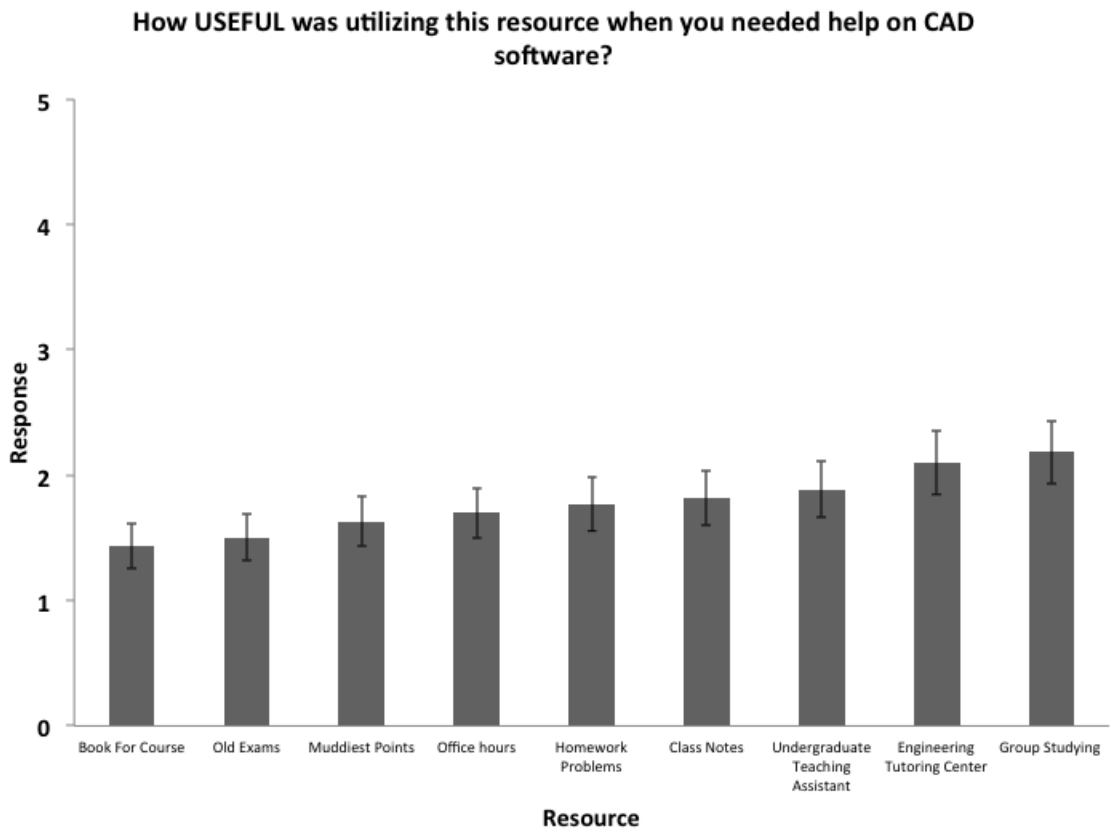

Figure 8. Student Resource Value: Utility of Resource Use with CAD: Kruskal Wallis analysis about resource usefulness when preparing for CAD software showed that statistical group studying ranked highest, followed by then engineering tutoring center, and undergraduate teaching assistant (+, ++, +++ =$p<0.05$, n=60). Individual differences may be found in Table 10 of Appendix 2. The resources were ranked from 1 being the "never" to 5 being "always".

Discussion and Conclusion

This novel study systematically investigated which resources were most useful and the frequency at which students use them in 13 biomedical engineering courses of varying levels. The results from the RAS regarding exam preparation showed that students valued highly homework problems, class notes, and group studying and used these resources the most frequently. This is supported by the work of others in that peer studying is very effective in helping students perform in engineering[11].

The results from the RAS regarding learning concepts showed that most useful resource and the resources used most frequently when encountering a difficult concept were class notes and group studying. The favorable response for group study is supported by the preliminary SRVS research[1]. Students prefer to work with other peers in web-enabled student resources due to shifting students' resource use from traditional resources towards peer mentors and classmates.

The results from the RAS regarding MATLAB/Mathcad, did not show many statistical significance results. Future administrations of the survey to increase endpoint number are required; however, there may be a trend supporting the use of group studying and assistance from the engineering tutoring center and teaching assistant when struggling with math-based programming. This trend is supported by Pollard who found that students are comfortable learning from other students[12]. This preliminary result is different from Krause's study that showed there was a decrease and low percentage of students using the tutoring center[1]. This difference in resource preference highlights the need for investigation of useful resources not only on a course-by-course basis but also on a topic area basis (for example, exam, learning concept, math-based programming, etc.). Lastly, although not statistically significant, the results from the RAS – CAD Software, suggest that students valued the same resources as MATLAB/Mathcad. Hands-on application seem to be the best method when teaching students how to use new computer-based programs[13,14].

In addition, future work will involve surveying additional students in all thirteen BME courses to increase endpoint number. Furthermore, additional analysis will be conducted to look for differences not only due to major but class format or year. At this stage, end point numbers are too low to make meaningful conclusions regarding resources on a class-by-class or student-year basis.

Additionally, future students will include achievement analysis (i.e., final grades) to see if students using the most favorable resources often have high achievement levels. Statistics tracking capabilities in Blackboard and YouTube, among others, will be investigated to confirm student reporting of use matches actual use. We will also include confidential identifiers in order to determine if the same students are surveyed multiple times for different classes.

It is important to note that previous studies have found evidence that in challenging classes such as engineering classes, that there is no correlation between achievement and attitude/opinion[15,16,17]. Though this may be true, student opinion drives student action and therefore, results from the current study will allow professors to select which evidence-based practice/resource to devote time and resources to develop. In other words, professors may choose to develop resources students are most inclined to use and remove the use of resources that are costly and not often used, such as textbooks. Use of evidence-based supplemental resources promotes redundancy of material and therefore supports overall learning[18].

There are both similarities and difference among the resources biomedical engineering and material science students thought were useful and were used most often. In biomedical engineering, when struggling with difficult learning concepts or preparing for exams, the following resources were most important: 1) homework problems, 2) class notes, and 3) group studying; whereas, materials sciences students preferred to use the following: 1) Muddiest Point feedback and 2) group studying. Also, there are similarities and differences within biomedical engineering depending on topical area. The favored resources for math-based programming and CAD software assignments were as follows:

1) undergraduate teaching assistant, 2) engineering tutoring center and 3) group studying. This shift may be due to the lack of available conventional resources for programming and software-based assignments. Future studies will investigate longitudinally differences in the frequency and type of resource on a class-by-class basis as well as provide individualized feedback to course instructors and future students. Additional studies will investigate the root cause for differences between and within majors, including whether the courses were required or elective and the manner by which each resource was implemented. That is to say, different instructors create and implement resources differently (for example, Muddiest Point feedback.)

Universally favored resources in fourteen different classes in two different engineering departments in differing topical areas include: 1) undergraduate teaching assistants, 2) engineering tutoring centers, and 3) group studying. This highlights the need for group-based, interactive activities and assignments.

In summary, although there are universally favored resources, there are differences depending on course type and assignment category (learning concept vs. programming/software assignment). Therefore, it is important to determine and develop the most appropriate resource for the student need.

Acknowledgements

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Appendix 1. Resource Assessment Survey

Table 1. Resource Assessment Survey Questions

How OFTEN would you utilize this resource before taking an exam?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How USEFUL was the resource you utilized before taking an exam?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How OFTEN would you utilize this resource when you are struggling on learning concepts?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How USEFUL was the resource you utilized when you were struggling on learning concepts?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A

Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How OFTEN would you utilize this resource when you need help on Matlab/Mathcad?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How USEFUL was utilizing this resource when you needed help on Matlab/Mathcad?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How OFTEN would you utilize this resource when you needed help on CAD software?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
How USEFUL was utilizing this resource when you needed help on CAD software?	
Help from Undergraduate Teaching Assistant	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from instructor during office hours	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the Engineering Tutoring Center	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from old exams or quizzes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from class notes	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from assigned homework problems	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from group studying	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from Muddiest Points feedback	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A
Help from the book for the course	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ N/A

Appendix 2. Statistical Analysis

Post Hoc analyses were performed using Langley, R. *Practical statistics simply explained* p220 with a written Matlab code to perform all possible combinations.

$$K = \frac{\Delta(Rank\ Total) - 0.8}{N * \sqrt{N}} \qquad (1)$$

The Rank Total is simply the mean rank number multiplied by the sample size. All this information is output from SPSS. One group is compared to another group and from Equation 1 a K value is calculated and compared to Table 1 (Langley, 1971). There were 10 resources from which students rated each question, thus meaning there was a total of 10 groups. The written Matlab code runs through all possible combinations of the 10 groups. The output from Matlab is shown in Appendix Tables 3-10.

Table 1. **K value table for determining significance**. For groups of 10 and an alpha of 0.05 the K value needs to be 12.97 (Langley, 1971).

Total number of groups in the analysis	When comparing any groups with each other in pairs
	K Needs to be equal to or greater than the table value, for it to be significant significant at the level indicated by p
	p = 0.05
3	2.89
4	4.22
5	5.6
6	7.01
7	8.46
8	9.94
9	11.43
10	12.97

Table 2. Number which resource corresponds to.

Help from Undergraduate Teaching Assistant	1
Help from instructor during office hours	2
Help from the Engineering Tutoring Center	3
Help from old exams or quizzes	4
Help from class notes	5
Help from assigned homework problems	6
Help from group studying	7
Help from Muddiest Points feedback	8
Help from the book for the course	9

Table 3. **MATLAB output for the Post Hoc data for "how often?" and "exams".** **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance.

How OFTEN would you utilize this resource before taking an EXAM?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	**1**	**1**	**1**	**1**	0	0
2	0	0	0	**1**	**1**	**1**	**1**	0	0
3	0	0	0	**1**	**1**	**1**	**1**	0	0
4	0	0	0	0	0	0	0	**1**	0
5	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	0	0	**1**	**1**
7	0	0	0	0	0	0	0	**1**	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 4. **MATLAB output for the Post Hoc data for "how useful?" and "exams".** **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance.

How USEFUL was the resource you utilized before taking an EXAM?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	**1**	**1**	**1**	**1**	0	0
2	0	0	0	0	**1**	**1**	0	0	0
3	0	0	0	0	**1**	**1**	0	0	0
4	0	0	0	0	0	0	0	**1**	**1**
5	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	0	0	**1**	**1**
7	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 5. **MATLAB output for the Post Hoc data for "how often?" and "learning concepts"**. **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance.

How OFTEN would you utilize this resource when you are struggling on learning CONCEPTS?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	0	**1**	**1**	0	0	0
2	0	0	0	0	**1**	**1**	0	0	0
3	0	0	0	0	**1**	**1**	0	0	0
4	0	0	0	0	**1**	**1**	**1**	0	0
5	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	0	0	**1**	**1**
7	0	0	0	0	0	0	0	**1**	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 6. **Matlab output for the Post Hoc data for "how useful?" and "learning concepts"**. **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance.

How USEFUL was the resource you utilized when you were struggling on learning CONCEPTS?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	0	**1**	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	**1**	**1**	**1**	0	0
4	0	0	0	0	**1**	**1**	**1**	0	0
5	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	0	0	**1**	**1**
7	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 7. **MATLAB output for the Post Hoc data for "how often?" and "MATLAB/Mathcad"**. **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance.

How OFTEN would you utilize this resource when you need help on MATLAB/MATHCAD?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	**1**
4	0	0	0	0	0	0	**1**	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 8. **MATLAB output for the Post Hoc data for "how useful?" and "MATLAB/Mathcad"**. **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance.

How USEFUL was utilizing this resource when you needed help on MATLAB/MATHCAD?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	**1**	0	0	0	0	**1**
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	**1**
4	0	0	0	0	0	0	**1**	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	**1**
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 9. **MATLAB output for the Post Hoc data for "how often?" and "learning concepts"**. **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance. In this case they are all 0.

How OFTEN would you utilize this resource before taking an EXAM?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

Table 10. **MATLAB output for the Post Hoc data for "how useful?" and "learning concepts"**. **1** indicates there was statistical significance between those groups and 0 indicates there was no statistical significance. In this case they are all 0.

How USEFUL was utilizing this resource when you needed help on Learning Concepts?									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0