Paper ID #27817

Do support sheets actually support students? A content analysis of student support sheets for exams

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Do support sheets actually support students? A content analysis of student support sheets for exams

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Abstract

In science and engineering courses, instructors often administer multiple examinations as major assessments of students' learning. Some instructors allow students to use a page of notes, sometimes called "cheat sheet," "crib sheet," or "support sheet" to aid them during the exam. In this case, the professor called it a "support sheet" in order to emphasize the to the students the usefulness she sees in constructing them. Anecdotal evidence has shown that students' performance on course material retention and performance on exams increases if the student constructs a support sheet. What exactly students record on the support sheets varies between each student. Students may feel daunted on deciding what to record on the support sheet.

The aim of this study is to determine if there exists a relationship between what is recorded on the support sheet and the students' performance on the exam and in the course for an undergraduate mechanics of materials class. Through this study, we want to find any commonalities on support sheet material across all students using content analysis. The results of this study may show which categories recorded correspond with the highest performance. In addition, we will investigate students' organization of the support sheet and whether this effects performance. The data set collected is comprised of over 200 support sheets from a final exam in an undergraduate mechanics of material course. For this study, a subset of 30 support sheets are used as a preliminary analysis. The instructor made creating a support sheet and turning it in with the final mandatory. The final exam was cumulative, and students could record anything that they believed may aid them during the exam, limited to one page, front and back. The data was analyzed by grouping the support sheets by categories, for example, if the support sheet is comprised mostly of equations, conceptual topics, examples, or combination of the three. We also considered the density and organization of the support sheets. Each category will be compared to the students' performance. Moreover, we will also investigate the frequency of these categories across all support sheets.

This paper would likely interest instructors and students alike. Instructors will be able to determine if allowing students to include a support sheet is beneficial, and specifically inform students what information has been shown to be useful to include. Students will have a better idea of how to construct a support sheet that will be beneficial to their performance.

1 Introduction

Instructors can control the access students have to pertinent information during examinations. In closed book examinations, students are entirely reliant on their memory to recall information they need, and instructors may or may not provide relevant equations. In the 1950s educationalists began to explore the possibility of alternative approaches to what information students have access to during an exam. One such suggestion by Kalish[9] as to have open book examinations, that is, "the student is allowed to make use of any materials at their disposal, including textbooks, lecture notes and dictionaries, but does not obtain answers directly or indirectly from other students". Moreover, Tussing[15] showed that the advantages for students with open book examinations include reduced anxiety, a shift in emphasis from memorization to reasoning, and a reduction of cheating. A more contemporary suggestion was to allow student created cheat sheets, or support sheets. For example, Erbe[7] found that support sheets can reduce examination anxiety while increasing learning, particularly in courses that measure on the first three levels of Bloom's taxonomy[1]. Furthermore, Erbe suggested that open book examinations can cause students to be complacent in their exam preparations, luring them into a false sense of security if they had not prepared adequately. Moreover, Erbe found that preparing support sheets were enough for preparing for the exam, that is, students tailored the information to their own needs, which allowed them to determine which topics they needed to prepare for, and which they already understood.

The purpose of this study is to determine if there are benefits of allowing students to use support sheets and moreover, if there exists a relationship between what is recorded on the support sheet and the students' performance on the exam. The context of this study is an undergraduate mechanics of materials course. We wish to find any commonalities on support sheet materials across all student created support sheets. With this aim, we structured this paper into five sections. First, we include a literature review of the research done on student created support sheets. Next, we describe our research methods, and then describe and present our findings as they relate to prior work and conclude with our planned future work.

1.1 Literature Review

The earliest article found by the authors investigating students using support sheets during examinations was by Dorsel and Cundiff[5]. These researchers concluded that the making of a support sheet is beneficial if the student does not become dependent on it, that is, if the student knows they will not use it during the exam, they perform just as well, if not better than if the support sheet was not made. This suggests that the act of making a support sheet is beneficial to exam performance. During that time, another study done by Hindman[8], found that support sheets aid in reducing students need for rote memorization, but support sheets are less helpful in concept learning. They concluded that "concepts and their relationships must be understood before they can be summarized on a crib sheet and the value of writing them down may be primarily in the organizing and clarifying what has been learned." A similar conclusion was drawn by Trigwell[14], whereby students' anxiety about examinations had been reduced, and time was not wasted during the exam, yet the use of the support sheet may encourage surface learning rather than deep approaches to learning. In addition, Drake et al.[6] also showed that students' anxiety during examinations was reduced using support sheets. Moreover, they also observed that students created sheets were diverse, detailed and intricate. When the authors viewed the sheet, they were not able to determine if the content held any meaning for the user. Yet, when students were inquired about the usefulness of the sheets, they replied positively, proceeding to the demonstrate the organization and understanding of their sheet.

Contrary to the above studies, Dickson and Miller[3] found that the use support sheets did not improve exam performance and did not reduce student anxiety. In the Dickson and Miller study, support sheets were not student created and instead provided by the instructor. Dickson and Miller[4] later studied student created support sheets, showing that student created support sheets increased examination performance, but did not encourage greater learning.

As for what students record on their support sheet, Visco et al.[16] found that there can be variety in the quality and composition of a student created support sheet, similar to the results of Drake et al.[6] In particular, they found a large variety among student support sheets and suggested that the goodness of the support sheet does not necessarily correlate to examination performance. Also, Raadt[12] showed that students who create support sheets perform better on examinations as opposed to students who did not use a support sheet. Moreover, the study revealed that certain features of support sheets were found to be related to improved performance, for example, students who recorded abstract representations in their support sheets had superior performance as opposed to students who mainly included worked out sample problems. A similar, but significantly more detailed analysis was done by Song and Thuente[13]. They developed a rating system, not unlike the one presented in this paper, which attempted to quantify the effect of the quality of the support sheet to the exam performance. Song and Thuente showed that a strong positive correlation exists between high-quality support sheets and superior course performance. With regards to the amount of information allowed on the support sheet, the two studies by Boniface[2] and Ludorf[11] showed that average exam performance significantly increased when less information was accessible. In the latter case, students could select any amount of information they could access on each of the five examinations.

By examining support sheet research, there are two contrary notions[11]. Namely, either support sheets are beneficial to students and increase performance, or have negligible effect, possibly producing negative performance. For example, for courses like abnormal psychology[8], developmental psychology[3,4], or social psychology[17] where there is significant content knowledge, support sheets have shown little to no benefit. In fact, in some studies it was observed to lead to a decrease in student performance[3]. However, when a course includes more process than content knowledge, as in the course examined for this paper (mechanics of materials), or others including statistics[11], engineering[16] or computer science[12,13], students' performance seems to be related to support sheet content. In the latter cases, we see that there is a need for instructors to become more involved in how students create support sheets, and to give guidance on how and what content they record.

1.2 Research Questions

In the engineering workplace, engineers rely on resources for specific information, such as code specifications and examples of solutions to problems. From anecdotal experience, accomplished engineers possess a wealth of knowledge, yet they are typically not required to memorize specific information, and so it can be viewed as unrealistic to expect students to do so for examinations. Student created support sheets may be used to overcome the need for rote memorization and bring other benefits, yet this topic needs to be studied and analyzed. To this aim, the following research questions are posed:

1. What features and their prevalence are found in student created support sheets?

2. How do common support sheet features relate to examination performance?

2 Methodology

In order to answer the above questions, an analysis was performed on support sheets created by students and used during a final exam. The first author of the paper was the teaching assistant for the course, and the second author was the instructor of the course. All data was analyzed after the course was completed and in line with IRB protocol HS# 2018-4211at the University of California, Irvine.

2.1 Setting

The examination was conducted at the end of an undergraduate mechanics of materials course at the University of California, Irvine, a large southwestern US R1 institution. The exam was cumulative over the entire course. There were 227 who attended the examination and submitted an electronic scan of their support sheet. Students were informed about the topics which would be covered on the exam, and the exam included a mix of multiple-choice questions, testing of a specific concept or topic, long questions, which required a greater depth of understanding, and one question which attempted to synergize the course topics into one "super" problem. All questions could not be answered by simply copying from the support sheet.

Students were free to record any information they deemed relevant on their support sheets. The size of the sheet was restricted to a double sided 8.5"x11" sheet of paper and were to be handwritten. The restrictions were intended to force students to become familiar with the course material and separate essential from non-essential material. Because of these restrictions, students would be required to read through the appropriate subjects, actively process the information, and organize it in such a way to be comprehensive. The support sheets were also required to be submitted with their exam, in addition to being submitted electronically.

The grading for the final exam was based on a 100% scale. The course performance was determined by the following percentages:

100%-105% - A+	83%-86.9% - B	70%-72.9% - C-
93%-99.9% - A	80%-82.9% - B-	67%-69.9% - D+
90%-92.9% - A-	77%-79.9% - C+	63%-66.9% - D
87%-89.9% - B+	73%-76.9% - C	0% -62.9% - F

2.2 Method of Analysis

The content analysis of the support sheets was conducted in three steps. First, each sheet was deidentified and given a student number, next, the sheets were separated from their accompanying examination answers, and then content features and organizational features (see Coding Framework below) were recorded against the student number.

2.3 Coding Framework

Before attempting to identify features in all support sheets, a subset of five support sheets were examined. A pre-existing coding framework found in Raadt's work[12], and similar to the coding

Layout Features	Density (D)	A measure of the amount of information on the support sheet. A rating system was used to measure the density. Rating: R1. 0%<D1<33% (sparse) R2. 33%<D2<66% (mildly dense) R3. 66%<D3<90% (moderately dense) R4. 90%<D4<100% (extremely dense)
	Organizational Rating (OR)	A measure of how organized the support sheet was to make better use of the space allotted. A rating system was used to measure the organizational rating. Rating: OR1. Messy writing, no coherent organization structure, poor use of space. OR2. Neat writing, concepts and examples separated, yet scattered throughout the sheet, decent use of space. OR3. Neat writing, concepts and examples separated by boarder and titles, good use of space. OR4. Neat writing, concepts and examples separated with boarders, titles, and/or colors organized chronologically with the course, excellent use of space.
	Annotations	Comments or explanations of the content in the support sheet.
Content Features	Problem examples	Worked out examples of specific problems.
	Abstract Representations	Concepts, diagrams or drawings which represent general topics as opposed to specific examples.
	Rules, Conventions, and Procedures	Included definitions/rules of concepts, conventions used in the course, and step-by-step procedures to solve certain types of problems.
	Equations	Equations which may be used to solve problems.
	Miscellaneous Content	Any feature not falling into the above, e.g., unit conversions or reminders.

Table 1: Coding framework used for content analysis of student support sheets.

scheme in Song and Thuente's work[13] was used and then modified as more features were identified. These features are shown in Table 1. There were two categories of features, namely, those that related to the layout (how information was organized) and content (what information was found).

The layout features include density, which is measured by rating the percentage of sheet used, and organizational rating, also measured by a rating system. The content features were identified by a percentage of the overall number of codes identified. Moreover, annotations on the support sheets were identified in a binary fashion.

Next, both researchers rated the layout features and coded the content features in each sheet (see Coding Framework in the section below). Any disagreements between coding the 30 support sheets were discussed until a consensus was reached. Note that all content analysis was conducted before comparing against student performance. Future work will include identifying features over the entire collection of support sheets.

3 Results

In the preliminary analysis, 30 support sheets were analyzed and a total of eight features were identified in students' support sheets. The list of features is given in Table 1 in the Coding Framework section above, with a description of each feature. The occurrence of each feature identified is given in Table 2 below, together with the measured impact of each feature. Figures 1 (a) and (b) below show the distribution of the layout features versus the final exam performance and course performance, respectively.

3.1 Identified Features (RQ 1: What features and their prevalence are found in student support sheets?)

By considering the Layout Features of the support sheets, we see from Table 1 that most students fall between a density rating of either 2 or 3. With only 1 occurrence of a density rating of 4. From Figure 1(a), there is a decrease in final exam performance as density increases, yet we see that course performance increases as the density of the support sheet increases. Similarly, we see that most students support sheets have an organizational rating of 2. Moreover, as the organizational rating increases, final exam performance also increases. From Figure 1(b) we see that organizational rating has little effect with course performance, yet we do see a slight positive effect on organizational rating and course performance. Furthermore, we see that students have a very slight increase in final exam performance and course performance for annotating their support sheets, yet students who provided no annotations performed significantly worse on both the final exam and course performance.

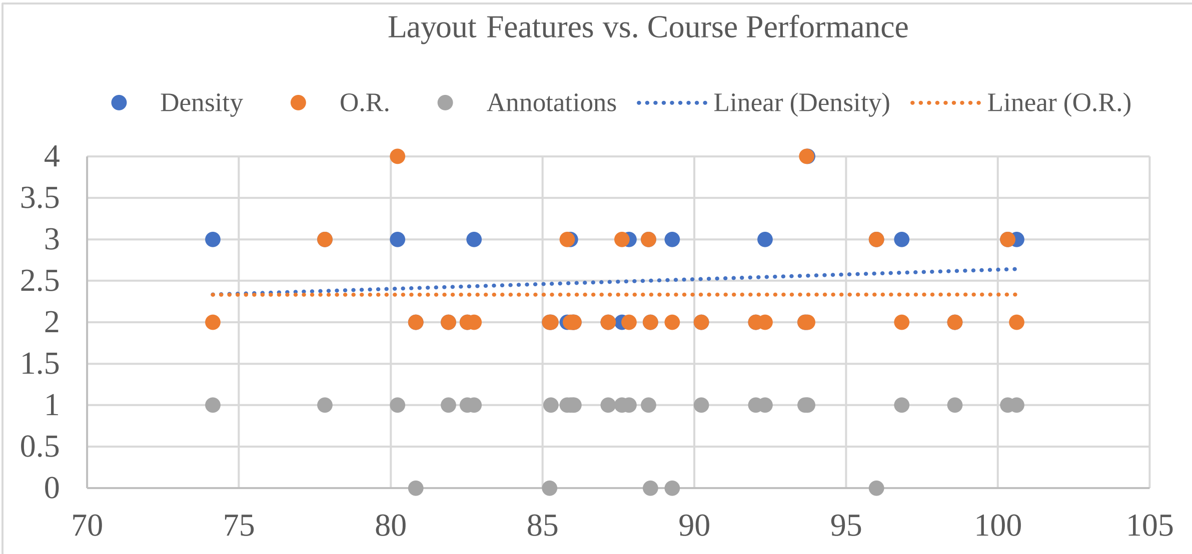

Figure 1: (a) Distribution of Layout Features vs. Final Exam performance.

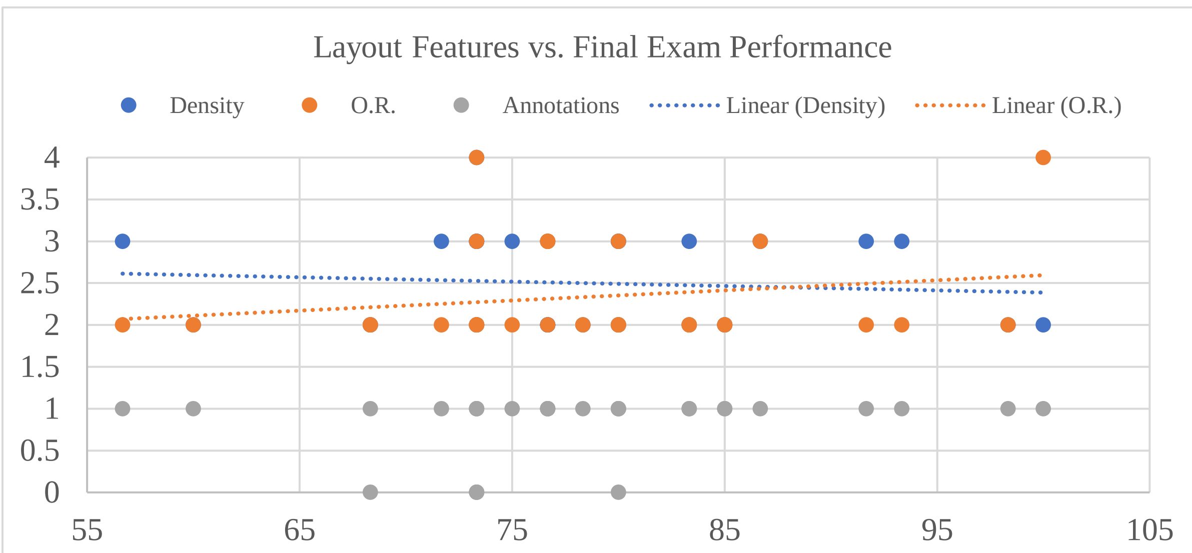

Figure 1: (b) Distribution of Layout Features vs. Final Exam Performance and Course Performance.

Density				Organizational Rating				Annotations	
D1	D2	D3	D4	OR1	OR2	OR3	OR4	Yes	No
0	16	13	1	0	22	6	2	25	5
Difference from final exam mean									
0%	0.57%	-0.31%	-5.06%	0%	-0.74%	-0.05%	8.28%	0.95%	-4.72%
Difference from course performance mean									
0%	-0.56%	0.27%	5.35%	0%	-0.13%	0.96%	-1.42%	0.08%	-0.40%

Table 2: Occurrences of each Layout Feature and the impact with respect to the mean performance.

3.2 Relationships between features and exam performance (RQ2: How do common support sheet features relate to examination performance?)

The Content Features of the support sheets with respect to the final exam performance and course performance is shown in Figures 2 and 3, respectively. From Figure 2 we see that nearly every student, regardless of final exam performance, included a high percentage of equations as compared with the other content features, with some being over well over 90%. A similar conclusion can also be drawn about course performance by considering Figure 3. In addition, we also see that most support sheets have a moderate number of abstract concepts present, yet most fall below 30% of the overall support sheet content. Furthermore, the next highest percentage of content on a support sheet was Rules, Conventions, and Procedures, on average being between 20-40% of the support sheet.

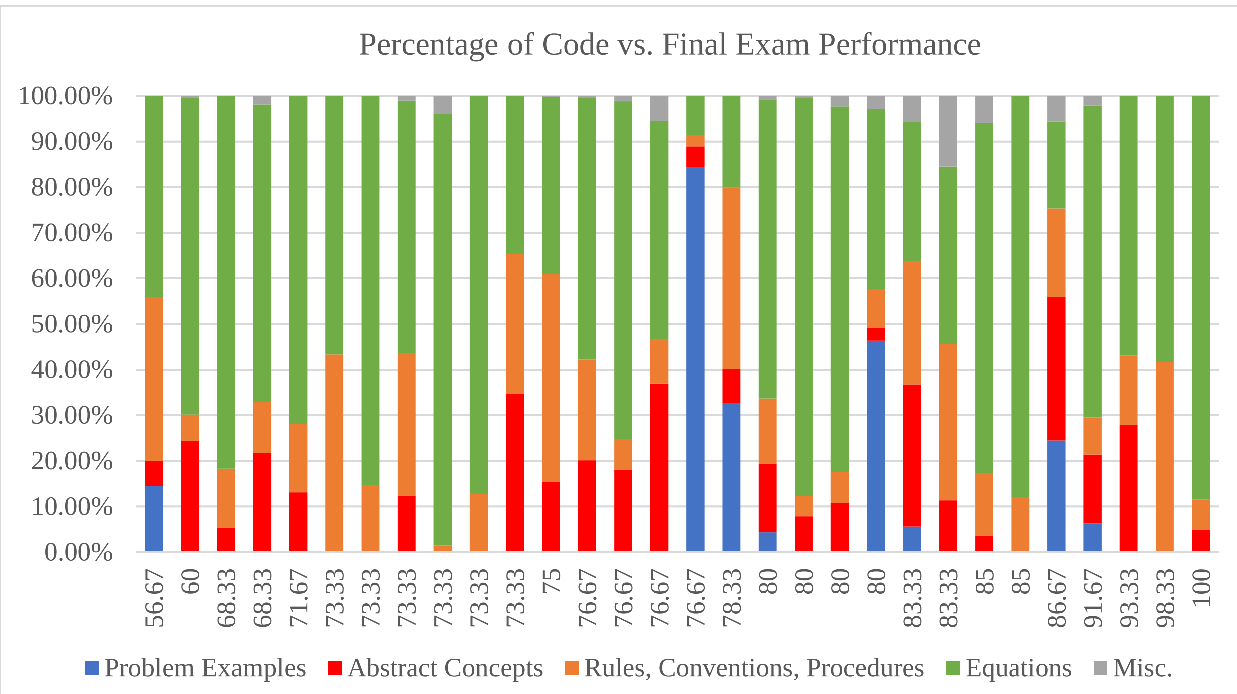

Figure 2: Percentage of Content Features vs. Final Exam Performance.

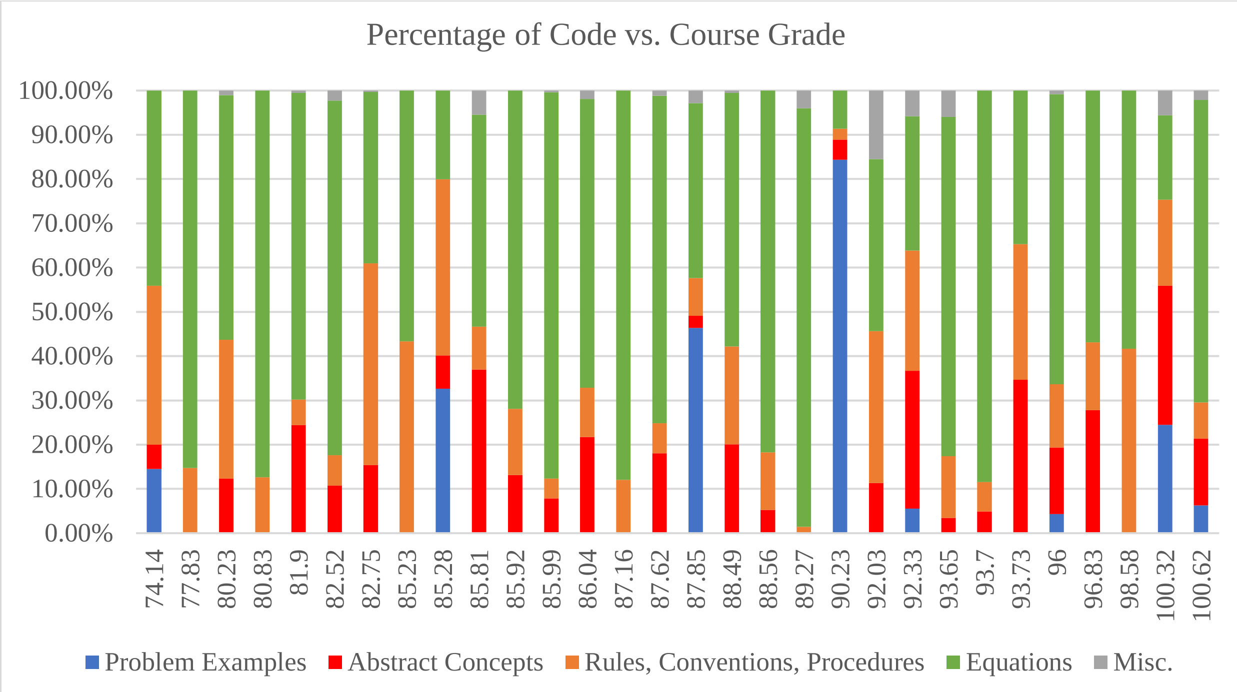

Figure 3: Percentage of Content Features vs. Course Performance.

4 Discussion

The findings of this study found a variety of features which were present in student created support sheets. Among them, the most reflective of higher performance was the use of annotations on a support sheet. Although, performance was not increased by using annotations, in the absence of annotations, it was found that performance was significantly reduced, which had not been particularly observed in prior research. Most support sheets had a density rating of D2 or D3, indicating that most students use much of the space allotted. Moreover, density ratings of D4 showed diminishing returns in terms of exam or course performance.

These two observations in this research align with the findings of Raadt[12], and Song and Thuente[13]. In addition, this further reinforces the notions found in Boniface[2] and Ludorf[11] having more information accessible can lead to lower performance. The organizational rating for most support sheets was OR2, and so a higher organizational rating did not directly relate to superior performance, contrary to what was found in Song and Thuente's work[13]. Yet, this does relate with the observations of Drake et al.[6] in which the user of the support sheet understands the content and use of the support sheet, even if a third-party cannot interpret the content or organization of the support sheet.

From the 30 sheets analyzed, it was shown that most support sheets contained a high percentage of equations, regardless of how it related to final exam or course performance. There was an intuitive hypothesis that a support sheet having a higher percentage of abstract concepts would yield superior performance, yet the opposite seems to be the case. This may have occurred due to the nature of the course, whereby, much of the necessary information required to solve problems require equations. Furthermore, we feel as though students who performed well in both the final exam and course which had a high percentage of equations present have internalized the abstract concepts necessary and simply used the support sheet as a way of avoiding rote memorization. A similar sentiment is also found in the work done by Song and Thuente[13]. Furthermore, the next highest percentage of content on a support sheet was rules, conventions, and procedures. This result would be expected if the assumption that students who have internalized abstract concepts only need to use the support sheet as a reference was true. That is, this code encompasses features of the course content which would be necessary for computations using the equations. A similar reasoning also follows for having procedures to certain types of problems accessible.

5 Conclusion

This study initially posed the following research questions:

1. What features and their prevalence are found in student created support sheets?
2. How do common support sheet features relate to examination performance?

From the data collected we used content analysis to show that for an undergraduate engineering course, mechanics of materials, which allowed handwritten support sheets, the most prevalent feature was equations on the support sheet. Abstract concepts were the next prevalent feature, with rules, conventions, and procedures following. There was also sporadic presence of miscellaneous content not falling into the above three codes. The fact that equations were recorded most by students, regardless of exam or course performance, may be a consequence of the course itself. That is, to solve most of the problems presented, one would need to have a list of equations accessible to avoid rote memorization. Moreover, we saw that both low performing and high performing students annotate their equations, yet students which had no annotations present had lower performance. Furthermore, we saw that each support sheet containing equations also had the rules, conventions, and procedure code present as well. Such a result can be expected since certain content falling under the latter code would be required to use equations. In addition to what codes were present, density ratings were recorded, and were found to have a diminishing effect on exam performance as it was increased, but a positive effect on course performance. Also, most students organizational rating was average, yet there was a positive relationship between organizational rating and exam performance. As for course performance, the organizational rating did not have a significant effect on performance.

5.1 Future Work

The results of this study will be improved by analyzing the remaining support sheets. Through that analysis, we will determine if our conclusions from this preliminary study are still held true. We may also consider examining how various groups of students, parsed by various demographics or incoming GPA, benefited from the use of support sheets. Finally, as this work only considered the support sheets and performance on the final exam and in the course, we will expand this work to consider the student's perceptions of support sheets as well. Using survey data from the class which asked students to comment on their approaches to creating and using their support sheets, we will gain even more insight into the perceptions of student support sheets for examinations.

5 References

1. Bloom, B. S. (1956): *Taxonomy of Educational Objectives*, Edwards Bros., Ann Arbor, Michigan.
2. Boniface, D. (1985). Candidates' use of notes and textbooks during an open-book examination. *Educational Research, 27*(3), 201-209.
3. Dickson, K. L., & Miller, M. D. (2005). Authorized crib cards do not improve exam performance. *Teaching of Psychology*, **32**(4):230–232.
4. Dickson, K. L., & Miller, M. D. (2008): Do Students Learn Course Material During Crib Sheet Construction? *Teaching of Psychology,* **35**(2):117-120.
5. Dorsel, T. N., & Cundiff, G. W. (1979). The cheat-sheet: Efficient coding device or indispensable crutch? *Journal of Experimental Education, 48*, 39–42.
6. Drake, V. K., Freed, P., & Hunter, J. M. (1998). Crib sheets or security blankets? *Issues in Mental Health Nursing, 19*, 291–300.
7. Erbe, B. (2007): Reducing Text Anxiety while Increasing Learning - The Cheat Sheet. *College Teaching,* **55**(3):96 - 98.
8. Hindman, C. D. (1980). Crib notes in the classroom: Cheaters never win. *Teaching of Psychology, 7*, 166–168.
9. Kalish, R. A. (1958): An Experimental Evaluation of the Open Book Examination. *Journal of Educational Psychology*, **49**(4):200 – 204
10. Ludorf, M. R. (1994). *Student selected testing: A more sensitive evaluation of learning.* Paper presented to the American Psychological Society Institute on The Teaching of Psychology, Washington, DC.
11. Ludorf, M. R., Clark, S.O., (2014). *Help Sheet Content Predicts Test Performance.* In W. Altman, L. Stein, & J. R. Stowell (Eds.), Essays from E-xcellence in Teaching (Vol. 13, pp. 3-5). Retrieved from the Society for the Teaching of Psychology Web site: http://teachpsych.org/ebooks/eit2013/index.php
12. Raadt, M. de (2012): Student Created Cheat-Sheets in Examinations: Impact on Student Outcomes, *Proceedings of the Fourteenth Australasian Computing Education Conference*, p. 71-76, January 31-February 03, 2012, Melbourne, Australia.
13. Song, Y. and Thuente, D. (2015), "A quantitative case study in engineering of the efficacy of quality cheat-sheets," in IEEE Frontiers in Education Conference (FIE), 2015, pp. 1-7.
14. Trigwell, K. (1987). The crib card examination system. *Assessment and Evaluation in Higher Education, 12*, 56–65.
15. Tussing, L. (1951): A Consideration of the Open Book Examination. *Educational and Psychological Measurement*, **11**(4):597 - 602.
16. Visco, D., Swaminathan, S., Zagumny, L., & Anthony, H. (2007): Interpreting Student-Constructed Study Guides. *Proceedings of the 114th Annual ASEE Conference & Exposition*, Honolulu, Hawaii, USA, June 24 - 27, 2007. 1 - 9.
17. Whitley, B. E., Jr. (1996). Does "cheating" help? The effect of using authorized crib notes during examinations. *College Student Journal, 30*, 489–493.