Exploring the Impact of Study Sheets on Students' Performance in an Engineered Systems in Society Course

Mr. ISAAC DAMILARE DUNMOYE, University of Georgia

Isaac Dunmoye PhD in Engineering (in view), University of Georgia, USA, M.Sc. in Electrical Engineering, University of Cape Town, South Africa, 2022. B.Eng. in Agricultural and Biosystems Engineering, University of Ilorin, Nigeria, 2016.

VINCENT OLUWASETO FAKIYESI, University of Georgia

Vincent Oluwaseto Fakiyesi earned a Bachelor of Technology degree in Chemical Engineering from Ladoke Akintola University of Technology in Ogbomosho, Oyo State, Nigeria. He is currently a doctoral student in Engineering Education at the Engineering Education Transformative Institute at the University of Georgia's College of Engineering.

Similoluwa Temitope Ige, University of Georgia
Dr. Wayne Johnson, University of Georgia

Wayne M. Johnson is a Senior Lecturer in the School of Environmental, Civil, Agricultural and Mechanical Engineering at the University of Georgia (UGA) in Athens, GA. Prior to joining UGA in 2022, he was a Professor of Mechanical Engineering at Georgia Southern University-Armstrong Campus, Savannah GA. He received his Ph.D. and M.S. in Mechanical Engineering from Georgia Institute of Technology and his B.S. in Mechanical Engineering (Cum Laude) from Louisiana State University. He has published 16 papers in peer-reviewed journals, 28 papers in peer-reviewed conference proceedings, and given 12 technical presentations on various topics including: additive manufacturing, mechatronics, biomechanics, and engineering education. He currently teaches the Engineered Systems In Society, Mechanical Engineering Professional Practice, and Capstone Design I and II courses.

Exploring the Impact of Study Sheets on Students' Performance in an Engineered Systems in Society Course

Abstract

The purpose of this study is to investigate the impact of study sheets on second-year engineering students' performance in an 'Engineered Systems in Society' course. Data collected from the students include study sheets and responses to open-ended survey questions. Analyses of the data reveal that while no significant difference in exam performance was observed between more competitive students and less competitive students, more competitive students tended to produce higher-quality study sheets. Qualitative insights from the students' responses highlighted the benefits of study sheets in aiding memory recall, improving time management, and fostering active engagement with course material. However, some students expressed dissatisfaction due to mismatches between study sheet content and exam questions. The study suggests instructors need to consider the use and implications of study sheets and underscores the complexity of their impact on student learning. The implications of the findings for future research are also discussed.

Introduction

The evaluation of students' understanding of engineering course concepts through closed-book, time-limited examinations has faced criticism, with concerns raised about its efficacy in promoting a deep understanding of critical concepts [1]. Critics argue that this approach often leads to memorization without fostering genuine comprehension [2]. In response, some suggest alternative examination formats, such as permitting the use of study sheets during examination. These study sheets, also known as study guides or cheat sheets, serve as concise summaries of crucial course concepts, offering valuable support for students in their learning and exam preparation [3] .

To assess the impact of study sheets on academic performance, past studies have explored the relationship between study sheet quality and students' exam performance. For instance, the study by Song and Thuente [4], found a positive correlation between the quality of study sheets and the performance of engineering undergraduates. Similarly, the study by Gharib, Phillips and Mathew [3], reported a preference for study sheet exams over closed-book exams in an introductory psychology class. The study by Chang and Shieh [5] which explored the value of formula sheets (a type of study sheet) for physics examination, reported a significant correlation between the quality of formula sheets and students' examination scores.

Beyond assessing the impact of study sheets, research has identified the creation process and features of study sheets as crucial determinants of their effectiveness. A study by Hsiao et al [6] noted that summarizing and organizing information for study sheets aided students'

comprehension of complex programming concepts. Furthermore, the study revealed that the act of creating cheat sheets actively engaged students with the course material, leading to a deeper understanding Also, the study by De Raadt [7] found that certain characteristics of study sheets, such as study sheet density, organization, and incorporation of abstract representations were associated with improved student exam performance. Dickinson [8] further emphasized the importance of organization, showing that students who spent more time organizing their study materials performed better than the students who did not.

While some studies have shown positive effects, others question the impact of study sheets on academic performance. For example, Dickson and Miller [9] found no empirical evidence that the use of crib cards (a form of study sheet) did not enhance examination performance nor reduced their anxiety during examination. Moreover, the reliance on study sheets during exams becomes apparent in Fonk and Dickson [9], which showed a significant decrease in student performance on a pretest when “crib cards” were disallowed, compared to identical questions during the exam when crib cards were allowed. This indicates that students might not have adequately grasped the information during the creation of crib cards, depending heavily on them only during the actual test. Burns’ study [10] also revealed a negative correlation between crib card usage and exam performance, with high-achieving students using them less consistently, indicating a potential security blanket effect. Furthermore, the study found that moderate- and low-achieving students increased crib card reliance throughout the semester, supporting the dependency hypothesis and suggesting that students' abilities may play a crucial role in their crib card usage patterns.

Study Scope

Considering that divergent findings have been reported in past studies regarding the impact of study sheets on student performance, our study makes a novel contribution to the literature by expanding the scope of research on study sheets to include an engineering non-technical course. In contrast to the predominant focus on using exam grades for data analysis in prior studies [7, 9, 11], our study aims to gain insights by incorporating students' responses to open-ended questions about the effectiveness of study sheets on their learning experiences. Consequently, our research questions guiding this study are:

(1) How do study-sheet scores relate to students' exam performance in the Engineered Systems in Society course?

(2) What are the insights from students' responses to open-ended questions about their perceptions of the effectiveness of study sheets?

Method

Study Participants and Context

The participants for this study are second-year mechanical engineering students enrolled in an "Engineered Systems in the Society" course during the Fall 2023 semester at the college of engineering of a southeastern university in the United States. The course employs contemporary readings, team projects, and experiential learning elements to enhance students' conceptual and practical grasp of socio-technical systems. Additionally, the course introduces students to socio-technical complexity, guiding them in the conceptual understanding, systematic analysis, and holistic engagement with engineering settings influenced by social, cultural, economic, and ecological factors.

Data Collection

Three sections of the course were taught in Fall 2023, with 94 students distributed as follows: 40, 18, and 36 students per section. The demographic distribution of the students was 21 females and 73 males. The instructor allowed students to prepare and use a hand-written 8.5’x11” double sided study sheet, incorporating notes from readings and class lectures, during the mid-semester examination. For our analysis, we collected 92 study sheets submitted by the students (2 students did not submit a study sheet) as part of their preparation for the mid-semester examination. In addition, students completed an anonymous post-midterm examination survey with open-ended questions regarding the effectiveness of the study sheet for their learning.

Data Analysis

We evaluated the study sheets using a coding scheme adapted from a related study by Song, Guo and Thuente [1], focusing on density, organization, and content of the study sheet. The coding criteria are explained below and summarized in Table 1.

Density:

- A study sheet is considered dense when both sides of the paper are covered, leaving minimal vacant space. This indicates the volume of information on the paper and the effort invested in crafting the sheet.
- Very dense sheets may suggest inadequate preparation for the exam, potentially reflecting a last-minute effort to compile material for use during the test. Dense sheets may not necessarily indicate a strong understanding of the course concepts.
- Very sparse sheets may suggest a lack of time for exam preparation or an insufficient idea of what to include.
- Students with a solid grasp of the topics often create outlines of topics and methods rather than comprehensive discourses (moderate density).

Organization:

- A study sheet is considered organized when the space on the paper is compartmentalized to maximize its use, typically with boundaries and identifiers for compartments.
- Poorly organized sheets indicate a lack of clarity on how to effectively organize information or uncertainty about the amount of content to include. Poorly organized sheets may also make material harder to access during the exam and potentially increase student anxiety.

Content:

- A study sheet is deemed to have "content" if it includes course content and at least one figure, diagram, or table for illustration.
- A study sheet receives 1 point for any figure, table, or diagram illustrating course concepts. Additionally, the study sheet earns 1 point for covering more than half of the course topics (3 out of 5) or 0 points for covering less than half.

Table 1: Study sheet coding scheme adapted from Song, Guo and Thuente [1]

Feature	Score (Points)
Density	Very dense OR Very sparse= 1
	Somewhat dense OR Somewhat sparse=2
	Moderate Density=3
Organization	Poorly organized = 1
	Moderately organized = 2
	Well organized = 3
Content	No Figures OR Diagrams OR Tables for illustration = 0 Figures OR Diagrams OR Tables for illustration =1
	Less than half of the course topics covered = 0 More than half of the course topics covered = 1

Based on Table 1, the highest achievable study sheet score (M) is 8 (Density = 3, Organization = 3, and Content = 2).

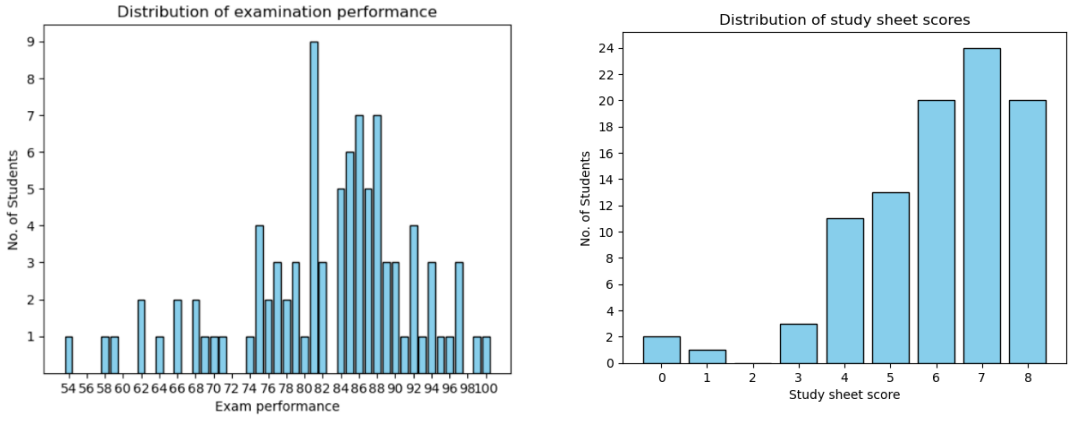
Furthermore, we adopted the methodology by Song, Guo and Thuente [1] by dividing the students into two groups: more competitive students (MCS) group if the exam grades were at the median score or above and less competitive students (LCS) group if their grades are below the median

Results and Discussion

A. How do study sheet scores relate to the students' exam performance.

To answer this research question, we represented the distribution of the students' exam performance and quality of the study sheet. In addition, we performed a t-test analysis to examine the effect of the quality of study sheet on two groups of students (MCS and LCS). While the students in the MCS group obtained a median score (85) or above, the students in the LCS group obtained a score below the median score.

Figures 1(a) and 1(b) displayed below illustrate the distribution of exam performance and study sheet scores, respectively. Although the distribution of students' exam performance is somewhat normal, the distribution of study sheet scores is not.



(a) (b)

Figure 1(a) Distribution of the students' examination performance (b) Distribution of the students' study sheet scores.

Since the study sheet scores distribution did not satisfy assumptions of normal distribution for conducting an independent t-test, we used the non- parametric t-test (Wilcoxon rank sum test) to examine if there are significant differences in the study sheet scores between the LCS and MCS groups. Table 2 below shows the results of the test. On average, the more competitive students (M = 6.26) have better study sheet quality than less competitive students (M = 5.83). The p-value obtained from the analysis is greater than 0.05, suggesting there is insufficient statistical

evidence to assert that the population of study sheet scores in the LCS group differs from that in the MCS group.

Table 2: Comparison on study sheets scores for different student groups

Group	***N***	**M**	**SD**
MCS	42	6.26	1.56
LCS	52	5.83	1.94
p-value	0.3475		

B. What are the insights from students' responses to open-ended questions about their perceptions of the effectiveness of study sheets?

To answer this research question, we collected qualitative data in the form of responses to open question on the students' perception of the study sheet effectiveness. Seventy-seven students (eighty-two percent of the total students) responded to the open questions. Consequently, we systematically categorized all students' responses into themes, encompassing aspects such as the study sheet creation process, time management and efficiency, organization, and structure, confidence and reassurance, reflective learning processes, balanced perspectives, and challenge in anticipating exam content. The coded distribution of the students' perspectives of the study sheet's effectiveness is shown in Figure 2 below.

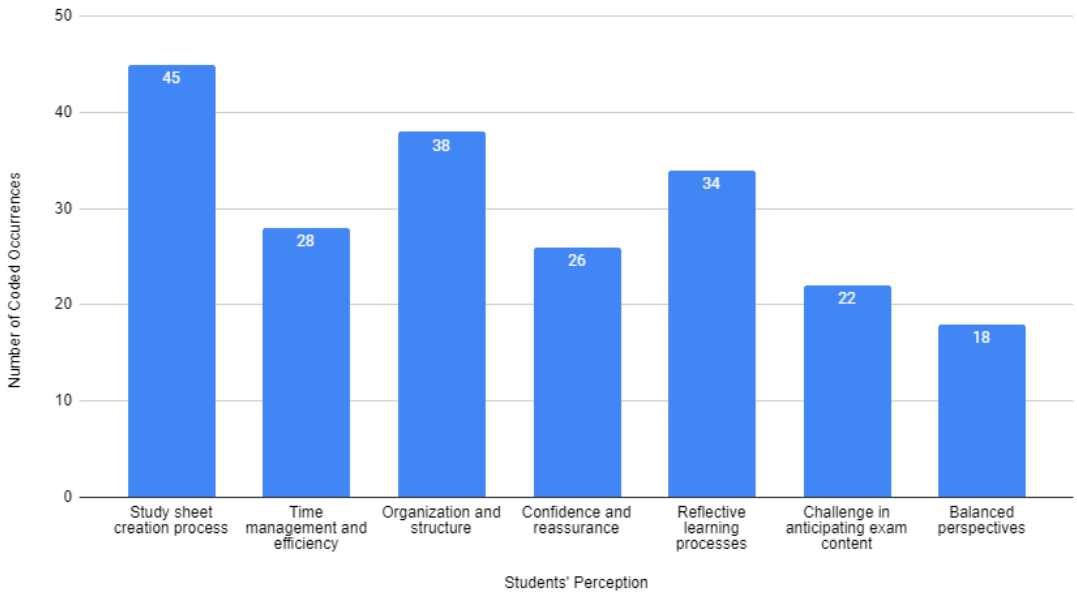


Figure 2: Distribution of student's perception of the effectiveness of study sheet

Most of the responses indicate a generally positive influence of the study sheet on students' exam preparation and performance. Numerous students emphasized its pivotal role in facilitating the review and organization of their thoughts on the course material, ultimately enhancing their preparedness. Some mentioned that it motivated them to revisit readings and class materials, resulting in improved understanding and memorization. However, a subset of students expressed mixed feelings regarding its effectiveness.

We delve into a detailed discussion of each theme, presenting excerpts from their responses for further context below:

Study sheet creation process

Some students found that making the study sheet was more helpful than using it during the exam. They reflected on how writing down information aided memory recall and understanding. The process also helped them in reviewing and clarifying concepts, especially in organizing thoughts and structuring arguments. Some of the students' responses that reflected positively on the study sheet creation process are:

"The process of making my sheet was the most impactful part. Writing out terms and definitions from the text gave me muscle memory and I didn't really need the study sheet for the exam that much."

"Making the study sheet helped me study more material than I would have without making it."

"Writing down the information helped solidify and engrain this information in my head."

Time management and efficiency

Some responses demonstrate how study sheets were perceived as tools that enhanced efficiency during exams by providing quick references, allowing for focused use of time, and aiding in making educated guesses or recalling specific details without the need for extensive memorization. Sample responses are:

"It was more time-effective when using the study sheet."

"The study sheet summarized the ideas very well, enabling well-educated guesses on specific problems and reducing study time."

"It helped when I needed a quick reference or reminder of certain terms, making it time-effective during the exam."

"It reduced my study time because I didn't have to memorize certain small details."

Organization and structure

Some of the responses reflected appreciation for the structure provided by the study sheet, helping organize key points and concepts. Example of such responses are:

“The study sheet provided me with the concepts I needed to structure my arguments, effectively and quickly.”

“It provided me information on what a system was, types of systems, and the topics of each article.”

“It identified key themes we discussed both in class and mentioned in the article.”

Confidence and reassurance

The study sheets provided a sense of confidence by serving as a reliable reference for some students during the exam, allowing them to verify answers, recall information accurately, and reduce uncertainty about their preparedness for specific topics or questions. Sample responses include:

"It was helpful because it allowed me to be sure of my answers and not second guess myself."

"Even though most of the answers I knew from memory, it was nice to be able to be sure of the answers."

"It was helpful as I just looked at the sheet to fill in definitions or cross-check options."

"The study sheet was helpful for presentations, problems, and definitions, providing reassurance."

Reflective learning process

Additionally, some of the students responded that the process of creating study sheets facilitated active engagement with the material, encouraged review and retention of concepts, and served as a valuable learning experience by reinforcing information in memory. Sample responses are:

"It made me go back and review some of the concepts I had forgotten."

"Writing down the information helped solidify and engrain this information in my head."

"Even if I didn't have the information on my study sheet, I still feel like I read over most of the information on the test while making the study sheet, so I thought it was helpful.

Challenge in anticipating exam content

However, some of the responses reflected the uncertainty the students faced in anticipating the exact content or level of specificity of the exam questions, often finding that the exam differed from what they had prepared or expected to encounter based on their study sheet. Sample of the responses are:

"The exam was not what I expected. It deviated from what I prepared on the study sheet."

"It was impossible to know exactly what to put on it. Besides the obvious notes from class, the reader examples are too numerous to include them all."

"The exam content often deviated from their expectations, leading to varying degrees of usefulness for the study sheet's contents."

Balanced perspectives

Some of the comments suggested a balanced perspective on the study sheet's effectiveness, highlighting both positive and negative aspects of its use. Examples of such responses are:

"The process of making my sheet was the most impactful part. Writing out terms and definitions from the text gave me a muscle memory and I didn't really need the study sheet for the exam that much."

"It might not have been the study sheet itself that helped me the most, but it was the process of making the study sheet."

"The study sheet helped me with specifics about certain topics that were on the exam. So, it reduced my study time because I didn't have to memorize certain small details."

Conclusion

This study's findings resonate with prior research in statistics and psychology courses [9, 11-13], revealing a nuanced impact of study sheets on the students' performance in an engineering non-technical course. The analysis, which investigates how study-sheet scores relates to exam performance reveals that more competitive students have better study sheet quality than less competitive student though it fails to yield sufficient statistical evidence supporting the notion that study sheets influence the academic outcomes of both groups. This concurs with the conclusions drawn by Dickson and Miller [14], emphasizing the need for instructors to thoughtfully assess the decision to permit study sheets on exams, as perceived advantages may not align with observed results.

Most of the qualitative insights observed from the open-ended questions shed light on study sheets benefits, suggesting that they might positively contribute to students' learning experiences. Some students derive value from the process of crafting study sheets, aiding in memory recall and fostering active engagement with course materials. Others express that study sheets enhance their time management, efficiency during examinations, study organization, and structure. Despite these advantages, some students' express dissatisfaction with the use of study sheet due to a mismatch between the content prepared on the study sheets and the actual examination questions while others provide balanced perspectives about the effectiveness of study sheets on their learning experience. These observations align with the findings of Sanborn, Purchase & Barry [15], highlighting the intricate nature of the impact of formula sheets on students' performance and retention. Furthermore, these findings also support the study by Dunmoye et al. [16], which found that study sheet seems not to hurt students learning while there could be potential benefits in its use.

While a sweeping conclusion regarding the impact of study sheets on engineering students' performance in a non-technical course remains elusive, insights from open-ended questions provide valuable perspectives on the use of study sheets. Consequently, future research endeavors may consider designing experimental studies to explore the causal relationship between the quality of study sheets and students' exam performance. One limitation of this study that future studies may consider is exploring the qualitative insights of the two groups of students (LCS and MCS) to support the quantitative findings by using a non-anonymous survey. Also, the survey questions could be restructured to facilitate quantitative coding of the students' responses to gain further insights on the effectiveness of the study sheets. Moreover, future research could utilize robust data across various semesters and classes to yield broadly applicable findings.

References

[1] Y. Song, Y. Guo, and D. Thuente, "A quantitative case study on students' strategy for using authorized cheat-sheets," in *2016 IEEE Frontiers in Education Conference (FIE)*, 2016: IEEE, pp. 1-9.

[2] L. Tussing, "A consideration of the open book examination," *Educational and Psychological Measurement,* vol. 11, no. 4-1, pp. 597-602, 1951.

[3] A. Gharib, W. Phillips, and N. Mathew, "Cheat Sheet or Open-Book? A Comparison of the Effects of Exam Types on Performance, Retention, and Anxiety," *Online Submission,* vol. 2, no. 8, pp. 469-478, 2012.

[4] Y. Song and D. Thuente, "A quantitative case study in engineering of the efficacy of quality cheat-sheets," in *2015 IEEE Frontiers in Education Conference (FIE)*, 2015: IEEE, pp. 1-7.

[5] W. Chang and R. S. Shieh, "Exploration of the value of using a formula sheet for physics examinations," *European Journal of Physics,* vol. 34, no. 6, p. 1411, 2013.

[6] I.-H. Hsiao and C. López, "Lessons learned from students' cheat sheets: Generic models for designing programming study guides," in *2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT)*, 2016: IEEE, pp. 209-211.

[7] M. De Raadt, "Student created cheat-sheets in examinations: impact on student outcomes," in *Proceedings of the Fourteenth Australasian Computing Education Conference*, 2012, vol. 123, pp. 71-76.

[8] D. J. Dickinson and D. Q. O'Connell, "Effect of Quality and Quantity of Study on Student Grades," *Journal of Educational Research,* vol. 83, pp. 227-231, 1990.

[9] S. C. Funk and K. L. Dickson, "Crib card use during tests: Helpful or a crutch?," *Teaching of Psychology,* vol. 38, no. 2, pp. 114-117, 2011.

[10] K. C. Burns, "Security blanket or crutch? Crib card usage depends on students' abilities," *Teaching of Psychology,* vol. 41, no. 1, pp. 66-68, 2014.

[11] N. Mathew, "Student preferences and performance: A comparison of open-book, closed book, and cheat sheet exam types," *2012 NCUR,* 2012.

[12] D. Butler and N. Crouch, "Student experiences of making and using cheat sheets in mathematical exams," 2011.

[13] B. Erbe, "Reducing test anxiety while increasing learning: The cheat sheet," *College teaching,* vol. 55, no. 3, pp. 96-98, 2007.

[14] K. L. Dickson and M. D. Miller, "Authorized crib cards do not improve exam performance," *Teaching of Psychology,* vol. 32, no. 4, pp. 230-233, 2005.

[15] M. J. Sanborn, K. T. Purchase, and B. E. Barry, "Kicking out the crutch: The impact of formula sheets on student performance and learning," in *2012 ASEE Annual Conference & Exposition*, 2012, pp. 25.873. 1-25.873. 19.

[16] I. D. Dunmoye, V. O. Fakiyesi, W. Johnson, and D. May, "Work-in-Progress Study on the Impact of Study Sheet Quality on Academic Performance: A Case Study in an "Engineered Systems in Society" Course Examination," in *2024 South East Section Meeting*, 2024.