

The Use of Formula Sheets in Engineering Exams: An Analysis of Impact on Student Performance and Learning Strategies

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Abstract—This full paper presents a comprehensive investigation into the use of formula sheets in engineering examinations, aiming to assess their impact on student performance and the development of effective learning strategies. With a focus on nurturing critical thinking and problem-solving skills, the traditional allowance of formula sheets in exams has sparked debate. Engineering students are observed across semesters, comparing exams with and without formula sheets to gauge correlations with academic performance. Initial findings suggest a positive impact on exam scores, especially in math-intensive courses, but the effect on problem-solving and deep understanding is uncertain. Qualitative data from surveys explore students' perceptions of formula sheets' role in learning. This research contributes to assessment discourse in engineering education, highlighting the balance between support tools and skill development. Its insights can inform pedagogical practices and assessment strategies, aiding educators in fostering comprehensive learning experiences.

Keywords— Formula Sheets, Exams, Support tools in education

I. INTRODUCTION

In the realm of engineering education, assessments play a pivotal role in evaluating students' understanding of key concepts, problem-solving abilities, and overall academic performance. Among the various assessment methods employed, the use of formula sheets during examinations has been a subject of significant interest and debate. Formula sheets, often provided to students as a reference aid during exams, contain essential equations, formulas, and key information relevant to the course material. Novak [1] identified a significant educational challenge: “achieving the constructive integration of thinking, feeling, and applying knowledge across diverse contexts, without the burden of memorization.” Formula sheets serve to facilitate the organization of conceptual understanding among students, allowing them to focus on comprehension rather than memorization. This paper undertakes a comprehensive investigation into the utilization of formula sheets in engineering examinations, with a specific focus on assessing their impact on student performance and learning strategies. As engineering education increasingly emphasizes the development of critical thinking skills, problem-solving abilities, and deep conceptual understanding, the role of formula sheets in facilitating or hindering these educational objectives warrants careful examination.

The use of formula sheets in engineering examinations has been a topic of considerable interest and debate in the realm of engineering education. These sheets, often provided as reference aids during exams, contain essential equations, formulas, and key information pertinent to the course material. Research indicates that employing formula sheets can significantly impact student performance and learning outcomes. For instance, Sanborn et al. [2] discovered that the use of formula sheets enables students to shift their focus from

memorization to problem-solving, resulting in improved performance. Similarly, Chang's study [3] on the impact of formula sheets in physics examinations revealed that they aid students in organizing their physics concepts and reducing exam-related stress. Additionally, Laughton et. al. [4] offers valuable insights since They analyzed factors such as frequency of use, navigation, and annotation content within the FERH that students owned and understanding these patterns helps students design effective resources and strategies with and perception of formula sheet usage in engineering exams. However, the transition from traditional lecture-based teaching methods to more learner-centered approaches, such as problem-based learning and active learning, has also demonstrated significant improvements in student performance across science, engineering, and mathematics disciplines. Freeman et al. [5] conducted a study indicating that active learning strategies contribute to enhanced student performance as seen in active learning activities involved in-class problem solving within a traditional lecture-based course in these fields.

Considering the recent pandemic, there has been a growing emphasis on the development of interactive electronic student worksheets, focusing on discovery learning and critical thinking skills, to facilitate online learning. Subekti et. al. [6] found that these worksheets serve as practical and effective tools for enhancing student learning during the pandemic. Furthermore, evaluating students' conceptual understanding following a course is paramount in engineering education. Delmas et al. [7] underscored the significance of assessing students' conceptual grasp, particularly after completing a first course in statistics putting into question whether formula sheets help the students in learning this information or simply helping thin in the short term. Pepin et al. [8] examined if providing formula sheets hampers student learning and innovation in engineering. While useful, diverse teaching methods like problem-based learning, active learning, and assessment are crucial for enhancing student performance and understanding. Steinmetz [9] emphasizes the importance of a range of topics in engineering from calculus to differential equations to linear algebra to probability theory to statistics, leading to a demanding focus and understanding from students. This exemplifies the benefits of formula sheets as helpful aids for students as to not have them feel overworked or fatigued.

By employing a mixed-methods research approach, combining quantitative analysis of exam scores with qualitative exploration of students' experiences and perceptions, this study seeks to provide a nuanced understanding of the relationship between the use of formula sheets and academic outcomes in engineering education. Through the observation of engineering students across multiple semesters, both with and without access to formula sheets during exams, this research aims to identify potential correlations between the presence of formula sheets and student performance. While initial findings may suggest a positive impact of formula sheets on exam scores, particularly in courses with significant mathematical content, the broader implications for students' problem-solving skills and deeper

conceptual understanding remain less clear. Therefore, this study also delves into qualitative data obtained from student interviews and surveys to uncover their perspectives on the role of formula sheets in their learning process and performance. Ultimately, this research contributes to the ongoing discourse on assessment methods in engineering education, shedding light on the delicate balance between providing support tools and ensuring the development of essential skills demanded by the engineering profession. By offering insights into the impact of formula sheets on student performance and learning strategies, this paper aims to inform pedagogical practices and assessment strategies in engineering education, ultimately enhancing the quality of learning experiences for engineering students.

II. BASIC SPECIFICATIONS OF A FORMULA SHEET

A formula sheet serves as a valuable tool for students during examinations, providing them with quick access to essential formulas, equations, and concepts relevant to the subject matter being assessed. Study sheets should be concise, typically limited to one or two pages, to ensure they are manageable and focused, encouraging summarization and extraction of key points. Whether the study sheets are handwritten or typed is flexible, but handwritten sheets are often encouraged to reinforce learning through writing. While the specific requirements for a formula sheet may vary depending on the course or institution, there are several fundamental specifications that apply universally.

First and foremost, a formula sheet should include only the most essential formulas and equations necessary for solving problems or completing tasks within the scope of the examination. Inclusion of extraneous or irrelevant information not only clutters the sheet but also detracts from its effectiveness as a study aid. Therefore, students must carefully select and prioritize the formulas they include, focusing on those that are most likely to be used during the examination. Clarity and legibility are paramount when preparing a formula sheet. Formulas should be presented in a clear, organized manner, with attention to spacing, formatting, and font size to enhance readability. Additionally, students should avoid any attempt to obscure or manipulate formulas, ensuring that they are accurately represented without alterations or omissions. Furthermore, any additional information or notes included on the formula sheet should be directly relevant to the examination content. This may include explanations of key concepts, definitions of terms, or guidelines for problem-solving techniques. However, students should exercise caution to avoid including excessive or unnecessary information that could overwhelm or confuse them during the examination. Individual preparation of formula sheets is essential to uphold academic integrity and prevent misconduct.

Each student should create their formula sheet independently, without collaboration or sharing of materials with others. This not only ensures fairness and equality among students but also promotes personal accountability and responsibility in the learning process. Students who create their own study sheets perform better than those using pre-made ones because the process of creating the sheets involves active engagement with the material, fostering deeper understanding and retention. When students summarize information and decide what to include on their sheets, they must comprehend the material deeply, organize their thoughts, and identify key concepts and relationships. Research indicates that generating content helps with memory, and the act of writing by hand enhances learning outcomes. Moreover, the act of writing by hand has been found to improve learning outcomes. A study by Mueller et al [10] found that students who took handwritten notes performed better on conceptual questions than those who took notes on a laptop. This suggests that the manual process of writing aids in the encoding of information into long-term memory. Therefore, the

creation of study sheets is not merely a passive activity but an active learning process that reinforces comprehension and retention, ultimately leading to better academic performance compared to using pre-made sheets.

This active learning process is where real studying occurs, making it more effective. Ethical use of formula sheets is of utmost importance, aligning with the principles of academic integrity outlined in institutional codes of conduct. Students must use formula sheets responsibly, refraining from any form of cheating, dishonesty, or unethical behavior. Any suspected violations or misconduct related to the use of formula sheets should be reported and addressed according to the procedures outlined in institutional codes of honor or academic integrity policies.

Table 1 highlights the basic specifications of a formula sheet with examples, which can allow the students to maximize the effectiveness of their formula sheets as study aids and ensure fair and ethical conduct during examinations.

TABLE 1: Basic Specification of Formula Sheets

Specification	Description
Essential Formulas	Inclusion of only the most essential formulas and equations necessary for completing tasks within the scope of the examination.
Clarity & Legibility	Formula presentation must be done in a clear, organized manner, with attention to spacing, formatting, and font size to enhance readability.
Relevant Information	Any additional information added must be directly relevant to the examination content
Individual Preparation	Independent creation of formula sheet without collaboration or sharing of materials with others.
Ethical use	Refrainment from any form of cheating, dishonesty, or unethical behavior in alignment with institutional codes of conduct.

Careers [11], the Formula Sheets of Mechanical Engineering course, accessible on EduRev, functions as an exhaustive reference designed explicitly for mechanical engineering students. Its principal aim is to consolidate all crucial formulas pertinent to mechanical engineering. By facilitating swift access to essential equations, this course equips students to tackle intricate problems, refine designs, and develop a comprehensive understanding of pivotal concepts.

III. METHODOLOGY-SURVEY

The methodology of conducting a survey is a critical aspect of any research. This is why we are including a survey about the use of formula sheets in engineering exams, drawing from various sources to properly capture the needs for this subject. Table 2 outlines the essential factors for assessing the impact of employing formula sheets in engineering exams.

The first step in any survey research is defining the objective as stated by Babbie [12]. In this case, the objective could be to understand the impact of using formula sheets on student performance and learning in engineering exams. This objective guides the entire research process, ensuring that all steps contribute to answering the research question. The next step is designing the survey as mentioned in Starlight Analytics [13]. The survey should include questions that will help meet the objective. For instance, it could ask about the frequency of formula sheet usage, the types of formulas students tend to look up, and their perceptions of how formula sheets affect their performance. Sampling is another crucial step that Babbie [12] has mentioned. The researcher must identify the target population (e.g., engineering students at a specific university or in a specific course) and determine a sampling method (e.g., random sampling, stratified sampling). Once the survey is designed and the sample identified, the researcher can begin data collection as McCombes [14] states. This could involve distributing the survey online, in person, or through other methods, depending on what is most effective for reaching the target population. After data collection, the researcher can analyze the survey responses to draw conclusions about the use of formula sheets in engineering exams Starlight Analytics [13]. This could involve statistical analysis to identify trends or correlations. Finally, the researcher should report the findings in a clear and concise manner. This could involve creating visual representations of the data (like graphs or charts) and writing a report discussing the findings and their implications. Conducting a survey involves several steps, each of which contributes to the overall quality and validity of the research. By following these steps, researchers can ensure that their survey about the use of formula sheets in engineering exams is methodologically sound and yields meaningful results.

TABLE 2: Key factors necessary for impact evaluation of using formula sheets for engineering examinations.

Key Factor	Examples of Considerations
Frequency of Use	How often do students use formula sheets during exams?
Perceived Impact on Performance	Do students believe formula sheets significantly improve their exam performance?
Confidence Levels	How confident do students feel when using formula sheets during exams?
Aid in Understanding	Do formula sheets help students understand course materials effectively?
Fairness	Do students perceive the use of formula sheets in exams as fair or unfair?
Overall Preparation	Do students find that formula sheets enhance their problem-solving abilities during exams?
Problem-Solving Abilities	Do students find that formula sheets enhance their problem-solving abilities during exams?

Influence on Understanding	Do formula sheets contribute to students' overall understanding of course materials?
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The survey for this study addressed the following vital aspects:

- The survey was developed with quantitative and qualitative questions to assess how formula sheets affect student performance and learning strategies. Structured questions collected data on exam scores and preparation strategies, while open-ended questions captured personal experiences and insights.
- Targeted a diverse group of engineering students across different disciplines and academic levels, from freshmen to seniors, to ensure a representative sample and gather a wide range of perspectives on use of formula sheets.
- Distributed the survey via the online platform "Qualtrics" to ensure accessibility and anonymity, collecting data on exam scores, preparation strategies, and qualitative feedback about formula sheet usage.
- Analyzed quantitative data with statistical methods and qualitative data through thematic analysis, highlighting key insights on the impact of formula sheets on student performance and learning strategies, and presented recommendations.

IV. RESULTS

The survey delves into the influence of formula sheets on engineering exams, gathering responses from students across Freshman, Sophomore, Junior, and Senior levels. A notable majority (67%) either strongly agree or somewhat agree on their frequent use during exams, highlighting a significant reliance. Remarkably, 57% strongly agree and 29% somewhat agree that formula sheets notably improve exam performance. They are regarded as pivotal in aiding understanding, with 29% strongly agreeing and 38% somewhat agreeing. Moreover, 43% strongly agree and 29% somewhat agree that formula sheets foster conceptual understanding over memorization, while also bolstering confidence, with 43% strongly agreeing and 38% somewhat agreeing. However, opinions diverge on limitations, with 38% strongly agreeing and 33% somewhat agreeing on imposing restrictions. Nonetheless, 48% believe formula sheets positively impact overall exam preparation. When queried about potential elimination, 77% express concerns about hindering the demonstration of problem-solving skills, underscoring the significance of formula sheets. Participants provided varied one-word descriptions, including "unnecessary," "amazing," "helpful," and "vital." Overall, the survey underscores the widespread use and perceived benefits of formula sheets in improving exam performance, understanding, and problem-solving skills, thus fostering fair exam conditions and encouraging conceptual understanding. Figure 1 and Figure 2 vividly illustrate the student responses to the 10 pertinent survey questions posed to them.

1. Frequency of usage: *[Question 1: I frequently use formula sheets during engineering exams.]* 72% of students agree that formula sheets encourage a focus on conceptual understanding rather than memorization. This suggests that formula sheets may help students understand the underlying principles and theories, rather than just memorizing formulas. This is crucial because it promotes a deeper understanding of the subject matter, which is more beneficial in the long run than rote memorization.

2. Improved Exam Performance: *[Question 2: The use of formula sheets has significantly improved my exam performance.]* 86% of

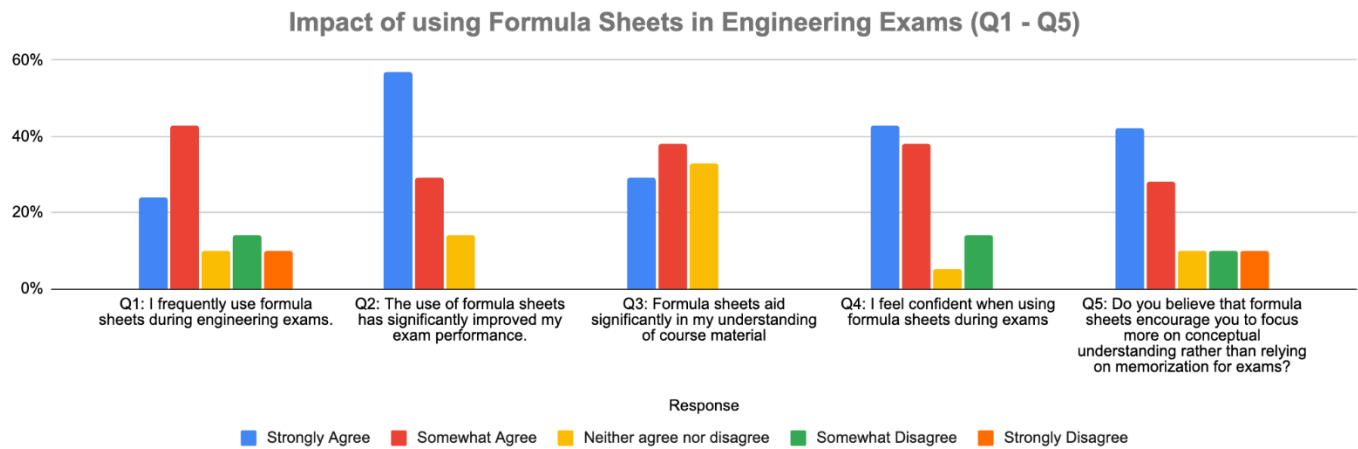


Figure 1 Results from Survey Question 1 to 5

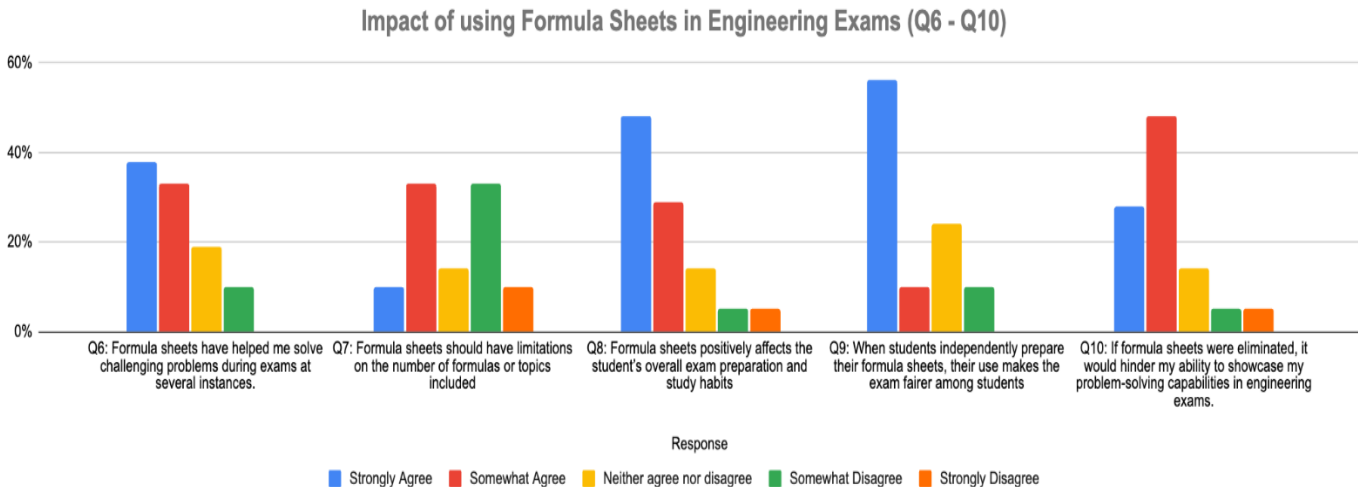


Figure 2 Results from Survey Question 6 to 10

students agree that the use of formula sheets has significantly improved their exam performance. This indicates that formula sheets could be a critical tool for success in exams. It suggests that having the formulas readily available during the exam allows students to focus more on problem-solving rather than trying to recall formulas.

3. Aid in Understanding Course Material: *[Question 3: Formula sheets aid significantly in my understanding of course material.]* 67% of students agree that formula sheets significantly aid in their understanding of course material. This suggests that these sheets can be an effective study aid. It could be that having all the formulas in one place helps students see the connections between different concepts, enhancing their overall understanding.

4. Confidence During Exams: *[Question 4: I feel confident when using formula sheets during exams.]* 77% of students feel confident when using formula sheets during exams. Confidence can lead to better performance due to reduced exam stress. This suggests that formula sheets not only serve as a practical tool but also have a positive psychological impact.

5. Solving Challenging Problems: *[Question 5: Do you believe that formula sheets encourage you to focus more on conceptual understanding rather than relying on memorization for exams?]* 86% of students agree that formula sheets have helped them solve challenging problems during exams. This indicates that these sheets can be a practical tool for problem-solving. It suggests that formula sheets can provide quick references to complex formulas that are needed to solve more difficult problems.

6. Fairness of Exams: *[Question 6: Formula sheets have helped me solve challenging problems during exams at several instances.]* 67% of students agree that when they prepare their formula sheets, it makes the exam fairer among students. This suggests that this practice could promote equity in exam conditions. It could be that when students prepare their own formula sheets, it levels the playing field as each student has the same opportunity to include the information that they find most useful.

7. Limitations on Formula Sheets: *[Question 7: Formula sheets should have limitations on the number of formulas or topics included.]* 71% of students agree that there should be limitations on the number of formulas or topics included on the formula sheets. This could ensure that the sheets are used as a guide rather than a crutch. It suggests that while formula sheets are useful, they should not replace the need for understanding the material.

8. Positive Effect on Study Habits: *[Question 8: Formula sheets positively affects the student's overall exam preparation and study habits. And Question 9 When students independently prepare their formula sheets, their use makes the exam fairer among students.]* 77% of students agree that formula sheets positively affect their overall exam preparation and study habits. This indicates that these sheets could promote effective study strategies. It suggests that the process of creating formula sheets could help students review and consolidate their knowledge, which is beneficial for their study habits. In addition 67 % of students believe making their own independent study sheet will help them better perform in their exam.

9. Showcasing Problem-Solving Capabilities: *[Question 10: When students independently prepare their formula sheets, their use makes the exam fairer among students.]* 77% of students agree that if formula sheets were eliminated, it would hinder their ability to showcase their problem-solving capabilities in engineering exams. This suggests that formula sheets allow students to demonstrate their understanding and application of concepts, rather than just their memory recall. It indicates that without formula sheets, students might spend more time trying to remember formulas instead of applying them to solve problems.



Figure 3 Words Cloud on Formula Sheets by Engineering Students

In conclusion, the data suggests that formula sheets are generally perceived as a helpful tool that promotes understanding, improves performance, and aids in problem-solving during exams. However, students also believe that there should be some limitations on their content to ensure they are used effectively. Formula sheets can play a crucial role in fostering deeper understanding and critical thinking skills among students by serving as a tool for quick reference and

reducing cognitive load. When students are not preoccupied with memorizing every detail, they can focus more on understanding the concepts and principles underlying the formulas. This can lead to a more profound comprehension and the ability to apply knowledge to complex problems. However, there are potential adverse effects to consider. Over-reliance on formula sheets might encourage memorization at the expense of true understanding, thereby hindering the development of essential problem-solving skills. Additionally, students may engage in surface-level learning, focusing on the immediate recall of formulas rather than grasping the broader concepts. To maximize the benefits and minimize the drawbacks, educators should ensure that formula sheets are used as a supplementary tool rather than a crutch, integrating them into a broader pedagogical approach that emphasizes critical thinking and deep learning. This detailed analysis provides a more comprehensive understanding of the students' perceptions of the usefulness of formula sheets.

V. CASE STUDY

The case study was developed through a detailed examination of Saul's experiences as a sophomore in Multidisciplinary Engineering. Saul's preparation for his respective Calculus II exams involved two distinct strategies: one where he extensively used a formula sheet and another where he relied solely on his memory and understanding of the subject matter. By documenting these contrasting approaches, the case study aims to shed light on the practical impacts of using formula sheets.

Interviews and extensive discussions were used to gather qualitative data on Saul's study habits, thought processes, and exam performance in each scenario. Quantitative data, such as exam scores and time spent on each type of preparation, were also collected to provide a comprehensive view of the outcomes. Saul's firsthand insights, derived from his personal experiences, provide a nuanced perspective on how formula sheets can influence learning and assessment in engineering education. These insights are critical for understanding both the advantages and potential drawbacks of using formula sheets, including their effect on students' problem-solving skills, conceptual understanding, and overall exam performance.

Table 3 in Appendix outlines the preparation steps with the use of a formula sheet, whereas Table 4 in the Appendix, delineates the preparation steps without relying on a formula sheet.

Exam Experience with Formula Sheet: On exam day, Saul rose early, brimming with anticipation and confidence. After a light breakfast, he reviewed his formula sheet and made his way to the exam hall. As he commenced the exam, he found solace in the familiarity of the challenging questions. Systematically, he tackled each problem, drawing on his formula sheet for guidance. His confidence soared with each solution. Despite moments of doubt, consulting his formula sheet reaffirmed his approach. Saul's methodical problem-solving, rooted in thorough preparation, led to a sense of accomplishment upon paper submission, emphasizing understanding over memorization for academic success.

Exam Experience without Formula Sheet: In his second exam attempt, Saul approached the exam room with a shifted perspective. No longer relying on a formula sheet, he embraced his understanding and memory. Despite palpable anticipation, he was prepared, having invested countless hours internalizing concepts and practicing. Comfort enveloped him as he faced challenging yet familiar questions, solving each systematically with intuition and comprehension. Saul navigated from one puzzle to the next, confidence growing with each correct answer, a testament to his understanding, memory, and determination. His methodical problem-solving, aided by strategic

formula use, underscored his preparation's effectiveness. Submitting his paper, he felt accomplished, regardless of the outcome, knowing his thorough, understanding-focused preparation had paid off. Saul believed true subject mastery stemmed from comprehension rather than rote memorization, a philosophy that propelled him through Calculus II with determination and pride.

Outcome: When the results arrived, Saul was pleasantly surprised to find that his performance in the exam without the formula sheet was comparable to the one with it. While the formula sheet had provided reassurance, relying on his understanding allowed him to think critically and apply knowledge creatively. This revelation reinforced Saul's belief in the power of comprehension over reliance on aids. It highlighted the importance of developing a deep understanding of the subject matter, enabling him to approach problems with confidence and flexibility. Saul recognized that his success wasn't merely about memorizing formulas but about mastering concepts and their applications. This realization fueled his commitment to continue prioritizing understanding in his academic journey, knowing that it not only yields comparable results but also fosters critical thinking and creativity.

VI. CONCLUSION

In conclusion, the research on "The Use of Formula Sheets in Engineering Exams: An Analysis of Impact on Student Performance and Learning Strategies" has provided significant insights into the preferences and performance of engineering students. The results clearly indicate a strong preference among students for the use of formula sheets during their exams. This preference could be attributed to the fact that formula sheets can serve as a useful tool in reducing the cognitive load of memorizing complex equations, thereby allowing students to focus more on problem-solving strategies and understanding the underlying concepts. However, it is important to note that while formula sheets may enhance exam performance in the short term, the impact on long-term learning and comprehension of engineering concepts requires further investigation. Future research should aim to explore this aspect, considering factors such as the complexity of the subject matter, the design of the formula sheets, and the students' learning strategies. Overall, the findings of this study contribute to the ongoing discourse on effective teaching and assessment strategies in engineering education, highlighting the potential benefits and considerations of using formula sheets in exams.

REFERENCES

[1] Novak, J.D., 2010. Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations. Routledge.

[2] Sanborn, M.J., Purchase, K.T. and Barry, B.E., 2012, June. Kicking out the crutch: The impact of formula sheets on student performance and learning. In 2012 ASEE Annual Conference & Exposition (pp. 25-873).

[3] Chang, W., 2012. The impact of using formula sheets for physics examinations. In 2nd International Conference The Future of Education (pp. 4-6).

[4] Laughton, S. and Nale, D.D., 2023, March. Student Interaction and Perception of FE-Based Formula Sheet Use in Engineering Exams. In ASEE Southeast Section Conference.

[5] Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H. and Wenderoth, M.P., 2014. Active learning

increases student performance in science, engineering, and mathematics. Proceedings of the national academy of sciences, 111(23), pp.8410-8415.

[6] Subekti, M.A.S. and Prahmana, R.C.I., 2021. Developing interactive electronic student worksheets through discovery learning and critical thinking skills during pandemic era. Mathematics Teaching-Research Journal, 13(2), pp.137-176.

[7] Delmas, R., Garfield, J., Ooms, A. and Chance, B., 2007. ASSESSING STUDENTS' CONCEPTUAL UNDERSTANDING AFTER A FIRST COURSE IN STATISTICS. Statistics education research journal, 6(2), pp.28-58.

[8] Pepin, B., Biehler, R. and Gueudet, G., 2021. Mathematics in engineering education: A review of the recent literature with a view towards innovative practices. International Journal of Research in Undergraduate Mathematics Education, 7(2), pp.163-188.

[9] Steinmetz, C.P., 1917. Engineering mathematics.

[10] Mueller, P.A. and Oppenheimer, D.M., 2014. The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. Psychological science, 25(6), pp.1159-1168.

[11] Careers, C. (no date) Formula sheets of mechanical engineering - books, notes, tests 2024-2025 Syllabus, EDUREV.IN. Available at: https://edurev.in/courses/21382_Formula-Sheets-of-Mechanical-Engineering (Accessed: 26 February 2024).

[12] Babbie, E.R., 2020. The practice of social research. Cengage AU.

[13] www.starlightanalytics.com. (n.d.). A Comprehensive Guide to Survey Research Methodologies | starlight analytics blog. [online] Available at: <https://www.starlightanalytics.com/article/a-comprehensive-guide-to-survey-research-methodologies>.

[14] McCombes, S. (2019). Doing Survey Research | A Step-by-Step Guide. [online] Scribbr. Available at: <https://www.scribbr.com/methodology/survey-research/>

APPENDIX

TABLE 3: Preparation with Formula Sheet

STEPS	DESCRIPTION	WITH FORMULA SHEET
Review Course Material	Familiarize yourself with the key concepts and formulas covered in the course.	<ul style="list-style-type: none"> The student commenced the preparation by gathering essential resources, including textbooks, lecture notes, and supplementary online materials. The student strategically identified key topics expected to be covered in the exam, such as derivatives, integrals, and Taylor series expansions. The student made a careful analysis of the course syllabus, past exam papers, and instructor guidance to pinpoint areas of focus essential for exam success.
Create Formula Sheet	Compile essential formulas and equations onto a single sheet. Ensure clarity and legibility for easy reference during the exam.	<ul style="list-style-type: none"> The sophomore initiated their study process by meticulously compiling all relevant formulas pertaining to the identified topics. The student ensured inclusion of both basic and advanced formulas related to derivatives, integrals, and Taylor series expansions. The student took a proactive step to enhance their understanding by adding annotations & contextual explanations to each equation.
Practice Problems	Work through practice problems using your formula sheet. This helps reinforce understanding and identifies any gaps in knowledge.	<ul style="list-style-type: none"> The student dedicated extensive time to solving practice problems related to the identified topics in calculus II, by utilizing the meticulously prepared formula sheet as a reference. The student got immersed in the problem-solving process, gaining firsthand experience in applying the formulas to solve various mathematical challenges.
Test Yourself	Take practice exams or quizzes under timed conditions, using only your formula sheet for reference.	<ul style="list-style-type: none"> The student incorporated timed practice exams or quizzes into their study routine, simulating the exam environment and enhancing their time management skills. The deliberate limitation of using formula sheet as the only reference, encouraged the student to rely on the understanding of the formulas and concepts, reinforcing the ability to recall and apply the relevant information efficiently within a constrained timeframe.
Seek Clarification	If you encounter any difficulties or have questions about specific formulas, seek clarification from your instructor or peers.	<ul style="list-style-type: none"> Whenever encountering difficulties or having questions about specific formulas, the student promptly sought clarification from the instructor or peers. This step underscores the student's proactive approach to learning, emphasizing the willingness to seek support and clarification when faced with challenges
Organize Material	Keep your formula sheet and any other necessary materials organized and easily accessible for the exam day.	<ul style="list-style-type: none"> The student implemented a systematic approach to organize the formulas by assigning colors based on their importance and frequency of use. Essential equations were highlighted in bold, vibrant colors, while less frequently used ones were designated with lighter shades. This visual coding system enabled the student to quickly distinguish between different types of formulas and prioritize their focus during study sessions.
Review and Revise	Take time to review your formula sheet regularly leading up to the exam. Make any necessary revisions or additions based on your practice sessions.	<ul style="list-style-type: none"> The student prioritized regular review of the formula sheet in the period leading up to the exam. The iterative approach of revisions and additions ensured that the formula sheet remained comprehensive and accurate, reflecting the student's evolving understanding of the subject matter.
Stay Confident	Trust in your preparation and the effectiveness of your formula sheet. Approach the exam with confidence and a clear mindset.	<ul style="list-style-type: none"> The student exhibited confidence in the preparation process and the reliability of the formula sheet. The student maintained a positive mindset, knowing that they had diligently prepared and possessed the necessary tools to tackle the exam challenges effectively.

TABLE 4: Preparation without Formula Sheet

STEPS	DESCRIPTION	WITHOUT FORMULA SHEET
Understand the material	Thoroughly review the course material, including key concepts, theories, and problem-solving techniques.	<ul style="list-style-type: none"> The student initiated their preparation by conducting a thorough review of the entire calculus II course material. The student dedicated time and attention to understanding the intricacies of each concept, by going through respective textbook chapters & ensuring no aspect of the material was overlooked.
Create Study Guides	Summarize important information into concise study guides or notes. Focus on understanding rather than memorization.	<ul style="list-style-type: none"> The student made notes, drew diagrams, and even taught himself out loud to reinforce his understanding. The student focused on the 'why' behind each concept, believing that understanding the reason behind a formula was just as important as knowing the formula itself.
Practice Problems	Work through practice problems to apply theoretical knowledge and reinforce understanding. Practice solving problems without relying on external aids.	<ul style="list-style-type: none"> The student gathered a collection of previous exams and started practicing. The student attempted to solve each problem without any external aids, relying solely on the conceptual understanding. When faced with challenging problems, the student refrained from simply seeking the solution. Instead, the student revisited the pertinent chapter to reinforce their understanding of the subject matter.
Memorize Key Formulas	Identify and memorize essential formulas or equations that are frequently used in the course.	<ul style="list-style-type: none"> The student prioritized comprehension over rote memorization by delving into the underlying principles behind each formula. This approach allowed the student to grasp the logic and rationale behind the formulas, enabling deeper understanding and facilitating application in various problem-solving scenarios.
Review Regularly	Set aside dedicated study time to review the material regularly leading up to the exam. Use active study techniques such as self-testing and spaced repetition.	<ul style="list-style-type: none"> The student prioritized their academic commitments by allocating dedicated study periods specifically for reviewing calculus II material consistently in the days or weeks leading up to the exam. This method allowed to continuously revisit challenging topics, apply newly acquired knowledge in problem-solving scenarios, and address any gaps in understanding.
Seek Clarification	If you encounter any challenging concepts or have questions, seek clarification from your instructor, classmates, or online resources.	<ul style="list-style-type: none"> The student demonstrates self-awareness by promptly recognizing when they encounter a concept that poses a challenge or difficulty. The student engages in effective communication with their instructor, classmates, and online resources to gain a deeper understanding of the challenging concept.
Simulate Exam Conditions	Take practice exams under timed conditions to simulate the exam environment. Practice recalling information and solving problems without the aid of notes or textbooks.	<ul style="list-style-type: none"> The student replicated the exam environment by taking timed practice exams.

		<ul style="list-style-type: none"> The student regularly practiced recalling information and problem-solving without relying on notes or textbooks.
Stay Organized	Keep your study materials organized and prioritize topics based on their importance and your level of understanding.	<ul style="list-style-type: none"> The student maintained organized study materials, prioritizing topics according to their significance and the depth of comprehension.
Stay Healthy	Maintain a balanced lifestyle with adequate sleep, healthy meals, and regular exercise to optimize your cognitive function and focus during studying and the exam.	<ul style="list-style-type: none"> The student upheld a balanced lifestyle, ensuring sufficient sleep, nutritious meals, and consistent exercise to enhance cognitive function and maintain focus during both studying and the exam.
Stay Confident	Believe in your preparation and trust in your ability to recall information and solve problems effectively during the exam. Confidence can help alleviate anxiety and improve performance.	<ul style="list-style-type: none"> The student placed faith in preparation, trusting their capacity to recall information and solve problems effectively during the exam. The student cultivated confidence, which served to alleviate anxiety and enhance performance.