

The Impact of Reference-sheets on Undergraduate Students' Learning in Electrical and Computer Engineering

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Abstract

Assessment practices in engineering influence both students' learning experiences and their motivation. Reference-sheets are a common type of exam format used in engineering courses which have been known to reduce exam-related anxiety. Despite this, little is known about how students understand and experience reference-sheets in relation to learning outcomes such as expectation for success, study methods and time management during their exam through Expectancy Value Theory (EVT). In addition, limited research has explored these experiences using motivational lenses.

The purpose of this qualitative study was to explore how undergraduate electrical and computer engineering students described their experiences with reference-sheets in regard to exam-related anxiety, time management, expectation for success and study methods, and to interpret these experiences using EVT. Semi-structured interviews were conducted with undergraduate engineering students at the United States based R1 institution. We analyzed transcripts with both deductive coding aligned with EVT constructs (expectancy for success, attainment value, intrinsic value, and utility value) and inductive thematic analysis.

Findings show that the use of reference-sheets supported the students' confidence and their preparation for their exams while reducing pressure during examinations. Participants described using reference-sheets as a tool for organizing and reviewing materials which helped their studying be more effective. In addition, when reference-sheets or open book format was allowed, students reported continued studying showing attainment value and being motivated rather than relying on their score alone.

This study extend prior research on the use of reference-sheets by revealing how motivational value is being perceived by students beyond reduction in exam-anxiety and exam performance. The findings show that assessment design can reduce exam-related anxiety while still supporting student motivation to learn.

Keywords: Reference sheets, Exam formats, Undergraduate, Interviews, Student experience

Introduction

Reference-sheets are tools students can use during exams. Generally, they are pieces of paper that contain formula(s), key concepts, or other relevant exam-specific information [1]. The use of reference-sheets is an emerging instructional method, especially in disciplines that involve problem-solving or calculations [2]. The goal of using a reference-sheet is to support students in preparing for and taking their exams by providing them access to formula(s) or concepts during the exams [1, 3]. However, the impact of reference-sheets on engineering students' learning is not fully understood. Because they are not seen as a tool that is helpful for improving students learning and facilitate better understanding but as a tool only to aid memory, i.e. only to recall concepts or useful information [1].

The use of reference-sheets during exams can help students stay motivated and reduce anxiety [3, 4]. Reference-sheets can also help facilitate students' conceptual understanding, rather than solely memorization [3, 5]. However, even though reference-sheets may help reduce anxiety and improve confidence for some, others may over rely on it, leading to hindrance in deeper learning [3]. Therefore, more research is necessary in order to understand the perception of students on the impact of reference-sheets on their anxiety, academic performance, and learning in engineering.

This study will focus on the impact reference-sheets could have on students' experiences in undergraduate electrical and computer engineering courses. Guided by EVT, this study theory explores how students' motivation is driven by beliefs about their success and the perceived value of their task. Specifically, this study answers the following research questions:

1. How do exams with reference-sheets impact students' expectancy for success within their courses?
2. How would undergraduate students describe the usefulness of reference-sheets with respect to exam-related anxiety, and time management before and during their examinations?
3. How do exams with reference-sheets influence students' study methods?

Literature Review and Theoretical Background

2.1 Exam Formats in Engineering

Traditional undergraduate engineering courses use examinations as major summative assessments. Exams are usually provided at the end of a unit of material, whereas final exams being a cumulative exam covering all material covered in a given course. Within engineering, exams are often a significant portion of one's final grade [6].

Past research has reported the importance of examinations such as identifying students strengths and weaknesses, determination of grades and evaluating teaching effectiveness [7]. The assessment could be formative or summative. Formative (assessment for learning) provides continuous feedback during learning and focuses on improvement rather than grades while summative assessment measures students' achievement at the end of the course and it contributes to the final grade [8].

Exams are usually administered in person, although some can be taken-home or done using online systems. Students are usually provided the same to double the standard lecture time for their exams, depending on instructor, institutional norms, and coverage of the assessment. The core instructors of courses set the norms for exams within their syllabus. There are several choices instructors must make: time of exam, content coverage (cumulative or restricted to new content), number of exams, and more [9].

A large factor that can impact students' anxiety around exams is whether or not the exam will follow an open or closed book format [10-12]. Open book examinations allow students access to various study materials, such as textbooks or materials provided during the course for their exams [13-15]. In contrast, a closed book examination prohibits access to such materials, requiring students to rely solely on their memory, which has its own benefits like helpful when students are required to solve problem on a spot [16]. Closed book exams cause anxiety and encourage more memorization leaving students to focus less on application [12, 17]. Open book exams are known to reduce anxiety and stress and can encourage critical thinking. However, open books can also lead to issues such as time management problems, a false sense of security, over-reliance on resources, and inequality in access [18]

Formula sheet(s) are often provided by the instructor to the students, where the instructor gives a set of equations or information that is core to the exam [19-21]. Formula sheets can also reduce anxiety [20]. However, the main disadvantage of formula sheets is that the information is generated by the instructor where students cannot personalize the content. Sometimes, the information provided doesn't contain the meaning of the concepts or formula(e) provided which might make students struggle with how to correctly use or apply the formula [21]. One way faculty have sought to address this is to provide the formula sheet earlier in the course for homework or other assessments to allow students to become familiar with it prior to a high-stakes exam environment [19].

2.2 Reference sheet as an assessment tool

Exams with reference-sheets involve students making their own set of notes while preparing for their exams. These reference-sheets are typically restricted in page length (one 8.5" x 11" sheet of paper back and front, etc.), format (handwritten, digitally printed, etc.), and allowable content (e.g., notes from class, no homework problems, etc.). Reference-sheets offer many benefits like open book examinations and can overcome some of the limitations of open book exams [4, 22].

Instructors authorizing students to use a paper or card on exams has been referred to several ways, including "cheat-sheet," "crib sheet," "summary card," or "reference-sheet" [23]. The term "cheat-sheet" has been criticized in the literature as it is an authorized aid for students to "cheat" with during their exams because of this it is better to change the word in order to promote a more educational and professional tone [24]. The term "reference-sheet" was used in this review because reference-sheets are like a type of sheet students can refer to during exams and this is also generally understood by students from the word "refer."

There are varying perspectives on the use of reference-sheets. Reference-sheets can help students focus on applications and deeply encourage problem solving [1, 3] because students are able to

shift their focus from rote memorization to more of problem solving. Past research also noted that reference-sheets can significantly increase students' confidence before and during their exams since they are able to practice better when preparing for reference-sheets [25, 26].

In addition, students are often more prepared for their exams with the use of reference-sheets leading to a significantly increased confidence to do well before and during their exams [25]. Increasing students' confidence surrounding their exams can increase their focus and study habits while also improving their overall academic performance [27, 28]. For example, by breaking large information into more manageable pieces, helping the students know what to focus on whenever they are studying.

Research reveals how anxiety could negatively impact students' problem-solving skills and memory [29-31]. In engineering, assessment is very crucial, and anxiety may negatively affect students' persistence and confidence [32]. In addition, chronic test anxiety has been connected to demotivation and decrease in knowledge retention especially in STEM majors [33, 34]. Anxiety should not be encouraged in order to help students stay motivated. Anxiety can hinder students' ability to prepare for an exam and their performance during examinations, thus affecting students' self-efficacy [35]. Using a reference-sheet for their exam can be useful in not only taking their exams, but also in preparing for their exams [36]. Instead of struggling to memorize a collection of formulas for an exam, they have the opportunity to write useful formulas on reference-sheets, which can help the students focus on the applications of the material instead of memorization [35-37].

Academic pressure could help support discipline and resilience [38, 39]. However, studies reveal that too much anxiety does more harm than good; it weakens motivation instead of boosting it [40-42]. Mild stress can help students stay focused, but too much anxiety could be detrimental, leading to cognitive overload [43]. Cognitive overload can hinder students' academic performance, not allowing them to fully showcase what they know [44].

Despite the potential advantages of the use of reference-sheets, research provides some counter arguments for example, over reliance of reference-sheets during exams may lead students to engage less in retrieval practice (the process of recalling information or concepts from memory to promote learning). Research in cognitive psychology reported that retrieval practice plays an important role in deepening conceptual understanding and long-term memory [45].

2.3 Theoretical Lens - Expectancy Value Theory (EVT)

Eccles's Expectancy Value Theory (EVT) was the guiding theoretical framework for this study displayed in Table 1. It was leveraged in the study design, data collection process (i.e., guiding interview protocol development), data analysis, and discussion of findings.

EVT was originally developed by Jacquelynne S. Eccles and colleagues [46] in the early 1980s and later refined with [47]. The theory describes how the expectation for success of perceived choices alongside subject-task values a student places on these choices and the value students put on a task could influence the way the student does the task, their persistence, and later achievement [47, 48]. The subjective task values were is described as four constructs: attainment value (the importance of doing well in a task), intrinsic value (interest or enjoyment one gains from doing a

task), utility value (usefulness of the task which involves both current and future goals) and cost (what a person has to give up in doing a task, anxiety) [49].

Past research has shown how expectation for success has been used in STEM disciplines [50]. For example, [49] used EVT to study students' motivation in engineering and conclude that the usefulness of their coursework and how preparing for their future careers had a positive impact on their engagement. In addition, [51] used EVT to understand the influence characteristics of assessment had on students and the value they had on learning. The authors found that cost can demotivate students even in situations where students see value in the task [49, 51]. These studies reveal how EVT has been able to explore how value and cost could shape students' cognitive and emotional dimensions of learning.

Utility value refers to how useful a task is for achieving future goals [47, 52]. In exam contexts, students using reference sheets may feel that it makes learning and practical closer to the real-world. For example, in real engineering work, engineers could easily look up formulas, hence, students may feel that learning how to apply the formulas is more useful [6].

Intrinsic value relates to how enjoyable or interesting the task is [52]. Students may enjoy solving problems more when they do not worry about memorizing formulas. On the other hand, if they rely too much on reference sheets, they may engage less deeply with the material.

Attainment value refers to how important it is for students to do well on a task (Expectancy–Value Theory of Achievement Motivation, [52]. In terms of reference-sheets, some students may feel the exam still reflects their competence, hence, they want to demonstrate true understanding of the materials by ensuring they study well even when allowed to use reference-sheets for their exam. On the other hand, some students may feel the exam is less about mastery if formulas are provided.

In the context of EVT, "cost" refers to the perceived negative aspects of engaging in a task [47]. Cost involves psychological and emotional stress of academic tasks like fear of not doing well or feeling disappointment over preparation [53]. During assessments, especially in testing environments, students with a high level of cost might experience anxiety, which can affect their concentration skills and their performance [54]. In a closed-book exam, cost load could increase because of the increase in anxiety students have for this type of exam format [55], since there is no back up for them during their exams. This study will explore how reference-sheets act as an instructional scaffold that can help reduce students' cost perception and strengthen students' confidence.

Table 1. The core aspects of EVT framework definition and examples in the context of reference-sheet

Theoretical Framing	Definition	Example within Reference-Sheets context
Expectancy for success	Students' belief in their ability to perform well in a task	Students being able to write those formulas they struggle with could give them an edge to success; this helps them stay focused, motivated and feel more ability in themselves to succeed.

Perceived choices	The decision students make based on expectation to success and task value	We're scoping specifically to exam formats that allow reference-sheets, with perceived choices for exams being the study aids they are allowed to use.
Utility value	The usefulness of the task	Since it involves current and future goals, this could help them in structuring how they study, taking exams, and focusing on applications rather than memorization [56]. For the long-term goal, having a good grade like A+, will positively impact their GPA and help them get internships, as internship experience could provide practical experience and also boost job prospects and resume [56].
Intrinsic Value	The enjoyment or interest students gain from the task	Students could still make reference-sheets when studying for their examination because it could assist them in structuring how they study even though they are not using it for their exams. Thus, students could prepare reference-sheets because of the enjoyment they gain or the relief it gives them when studying.
Attainment value	The importance of students doing well in the task	Students will still study regardless of any type of exam format because of how important learning the material is to them.
Cost	Perceived negative aspects on engaging in a task	Reference-sheets could help lower students' perceived anxiety, reduce the stress of memorizing formulas, and help them feel relieved in formulas they might forget during their exams.

Methodology

Positionality Statement

The research team involve three members from different experiences and background, they all contributed to the interpretation and triangulation of the data. The first author experienced had her first degree in an African Institution. During her first degree, all her exams were closed book examinations. This created anxiety, especially when trying to recall what she had studied. Another observation was that after the exam, she would likely forget some of the material she had read before the exam. This experience prompted her to explore whether reference-sheets could benefit students' academic performance, reduce anxiety, aid in time management, and improve retention. The second author was an undergraduate electrical and computer engineering student. Having taken classes with different exam modalities, they provided perspective on their experiences. The third author is a white cisgender woman faculty member whose scholarship touches on Universal Design for Learning and accessible teaching practices in undergraduate engineering. The fourth author is a white cisgender woman whose research scholarship focuses on investigating the mental health experiences of engineering students. She has experience teaching electrical and computer engineering students, with her experiences as an instructor aiding how the team conceptualizing reference-sheets as a tool to support students' learning. Overall, the research team's various positionalities were leveraged to contribute to the rigorous assessment of the data, codebook, and emergent themes.

Data Collection Procedures

A semi-structured interview protocol was developed by the research team. Semi-structured interviewing was chosen to balance consistency in interviews with flexibility in response, allowing for rich data collection while giving room for the participant to freely elaborate on important points [57]. The team interviewed one another to test and revise the protocol. Participants (detailed in Table 2) were then recruited using an online survey. After participants completed the consent form, a follow-up semi-structured interview was conducted on the impact of reference-sheets on their anxiety, academic performance, time management, and retention through EVT lens (Appendix A provides the full interview protocol). Interviews conducted lasted 45 to 60 minutes and were conducted online, via Zoom. Post-interview reflections were completed by the interviewer, including unspoken cues and analytic thoughts. These notes supported analysis later. Audio transcripts were later uploaded to MAXQDA for analysis, where we coded themes and patterns related to EVT. The next section details how the data was analyzed.

Table 2. Demographics of the Participants.

Pseudonym	Gender	Major (Intended)	Year in program	Race and Ethnicity
Sanjay	Male	Computer Science Engineering	Freshman	Asian (Indian)
Jordan	Agender, AMAB	Electrical Engineering	Sophomore	White
Logan	Male	Computer Science Engineering	Freshman	White
Cameron	Male	Intended Electrical Engineering	Sophomore	White
Morgan	Male	Electrical Engineering	Freshman	Asian (South Asian)
Riley	Male	Computer Systems Engineering	Sophomore	White
Parker	Female	Computer Systems Engineering	Sophomore	White
Jjay	Male	Computer Systems Engineering	Freshman	Asian (Indian)
Casey	Male	Electrical Engineering	Junior	White
Rowan	Male	Electrical Engineering	Junior	Pacific Islander

Data Analysis Procedures

The deductive codebook was generated, leveraging EVT and expected themes based on the interview protocol (detailed in Appendix). Authors 1 and 2 worked to code each transcript following [58] four-step iterative coding process. After completing data familiarization, Author 1 and 2 completed their initial coding independently. We allowed for open coding which resulted in inductive findings. Author one merged the resulting coded transcripts, and they then met to reconcile. Codes may have been added, removed, or adjusted in scope during this process. At the end, Author 1 led the integration of themes. This resulted in the final codebook (detailed in Table

3). The team is currently working on the synthesis of findings and groupings of themes across participant data.

Ethical Considerations

To minimize the chance of harm around negative experiences, participants were reminded that they can withdraw from the study at any time. In addition to this, safeguards to minimize these risks include storing audio recordings on a password protected and encrypted system, transcribing audio recordings and replacing the participants' names in the transcriptions with pseudonyms and then deleting the recordings. All online surveys were stored in password protected accounts and the name in data collection was replaced directly with the participants' pseudonym. All names and any identifying information (e.g., university ID numbers) were removed as soon as practical. Each participant was assigned a pseudonym and subject ID after the informed consent was completed. These IDs were assigned to each participants' respective survey and interview data. A key document that links the participants' pseudonyms to their name and subject ID was created. Only research team members had access to the key document, which was stored on a password protected system separate from any data collected.

Preliminary Findings and Discussion

This section presents the preliminary findings and discussion of the analysis. This includes a preliminary analysis on the most frequently coded theme (expectancy for success) and presentation of the final EVT codebook and frequency count of codes (Table 3).

As detailed in Table 3, Expectancy value theory has 143 number of unique codes followed by cost which have 123 unique codes, Utility value also has 113 unique codes, while Attainment value and intrinsic value both have 19 codes which shows that not all the students gain enjoyment when making the reference-sheets and also suggest that students might study differently with the use of reference-sheets.

Table 3. Codebook used to code EVT and distribution of codes among EVT themes.

Theme	Definition	Examples to Guide Coding	Example Quote from Data	Number of Unique Quotes
Expectancy for success	How a student perceives their likelihood of achieving a set goal Can also be defined as individuals' anticipations that their performance will be followed by either success or failure.	<i>"Using a reference sheet, I will be less stressed in the exam and do better as I know it's there"</i> <i>"I expected to fail this exam"</i> <i>"I was told this class would be hard"</i>	"I think I'd pass. I don't know if I'd do super well, because... "	143
Cost	Refers to what individual has to give up to do a task Perceived negative aspects of engaging in a task, including effort, anxiety, stress, time, or lost opportunities.	<i>"Using reference-sheets takes away stress"</i>	"I think using a reference-sheet is helpful because it makes you less stressed".	123
Utility Value	How a task fits into an individual's future plans. Usefulness of the task	<i>"Taking a math class to fulfill a requirement for science degree"</i> <i>"Reference sheets will be help my studying to be structured"</i>	"I'd say so because it allows us a different set of guidelines for studying as in we can view and view study while making the reference-sheet."	113
Attainment Value	Is the importance of doing well on a given task because it connects to some/multiple aspects of their PERCEIVED identity; confirms something about themselves. importance value.	<i>"I will still study even with reference-sheets"</i>	"I would study the same because this is i feel like I enjoy what I study..."	19
Intrinsic value	Is the enjoyment one gains from doing the task	<i>"Reference-sheets make my studying enjoyable"</i>	"...working out a problem and solving it is more enjoyable ...".	19

Preliminary Findings around Expectancy for Success

In this study, expectancy for success focused on the use of reference-sheets and its potential to impact students' confidence and beliefs to succeed in their engineering courses. Reference-sheets were often connected to students' emotions surrounding their exams. Cameron shared

“[Having a reference-sheet] definitely makes me more confident. I feel confident if I have a reference-sheet ... I generally feel good about exams that I have a reference sheet on.”

Cameron felt confident on exams because of the reference sheet. Logan also stated that reference-sheets help him feel more confident. Because he said that

...I definitely think that's ... the reference-sheet did help me feel more confident.

Cameron and Logan described feeling confident because they have reference-sheets. Research has revealed that when students feel confidence, this could help them stay motivated, have a positive attitude towards learning and thus improve their academic performance [28, 59]. Therefore incorporating assessment tool that can help students feel more confidence could help their overall learning and academic performance.

Jjay expanded this point, saying

I think [without a reference-sheet] ... emotionally that I'd be more anxious for the exam. And I think that when given a reference sheet, I would perform better just because I'm less anxious and I'm more confident in my answers. Versus what I don't have a reference sheet. I have... a tendency to like doubt myself and then change my answers, even though if my answer was initially right. But so just reference-sheet makes me more confident in my answers and makes it so that, you know, I'm not doubting what I have to write on the test. This study suggests having an assessment support system like reference-sheets for students can better help them understand the material, stay focused and make their studying more structured.

Conclusions and Future Work

This study explores undergraduate students in engineering experiences with reference-sheets in regard to expectancy for success, exam-related anxiety, study methods and, time management through EVT lenses. Preliminary findings suggest that reference-sheet could help students stay motivated, improve their confidence, thereby leading to better academic performance. We anticipate future findings to detail that reference-sheets improve students' confidence and preparation for their exams, reducing stress related to exams. This study may suggest that assessment practices can help reduce exam-related anxiety while strengthening students' motivation to learn. Future research may investigate additional theoretical perspectives such as cognitive load theory.

This study demonstrates how assessment support (like reference-sheets) can improve students motivational experiences without undermining academic integrity. By examining students' experience with the use of reference-sheets through expectancy value theory lens, this revealed reduced cost and increase in attainment value and utility value. These findings provide evidenced based guidance for engineering educators looking for an opportunity to design assessment that support motivation, learning, and wellbeing in high-stake assessments.

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Appendix A

Background/Warm-Up

1. What year are you in?
2. What did you think undergraduate engineering courses would be like
 - a. Why did you think that?
 - Expectancy Value Theory
 - How confidence were you in your ability to do well in your test or exams before and after you were told you could use a reference sheets

Engineering Exams/ Assessment

3. What are exams in engineering like for you?
 - a. What emotions do they invoke? How do they make you feel?
 - b. Tell me about a time when you took an exam that evoked ____ emotion” (whatever emotion they talk about in part a)
 - c. Is there any difference in the exams per level (1st year compared your second year)
4. How do you prepare for your exams?
 - a. Think about the one of the recent engineering exams you took. What class was that for? Then if answer “circuits” you would say “can you tell me about how you prepared for the circuits exam?” And then ask more follow ups
 - b. Can you explain why you choose to study this way?
5. What are your thoughts on exam formats?
 - a. Open note, closed book, cheat sheet, given formula sheet?
6. How do you think the use of cheat sheets is perceived within your engineering class?
 - Is it seen as a legitimate aid or as an unfair advantage?
 - How do your classmates feel about using cheat sheets in exams?
7. Do you believe that the option to use a cheat sheet affects the perception of academic integrity in your class?
 - Why do you think this is the case?
 - Has the use of cheat sheets influenced how you and your peers approach studying?

Cheat Sheets

8. Can you describe a recent experience with using a cheat sheet for an engineering exam?
 - How did you approach preparing the cheat sheet?
 - What was your experience during your exam?
 - How did you use it?

- Were you surprised by this?
 - How did having it make you feel?
- How are you approaching other exams in that class?
 - Do they have cheat sheets?
- How has having cheat sheets impacted how you view the class?

9. What if you were not allowed a cheat sheet, and instead were given a closed book exam?

- a. How would that have changed your experience during the exam?
 - i. How do you think you would have felt?
 - ii. Please name an emotion (s)
 - iii. Why do you think that? Is there an experience you're thinking of?
- b. Would you have prepared differently?
 - i. How so?
 - ii. Can you give me an example?
- c. What about an open book exam?
- d. What about a pre-set formula sheet?

10. Going bigger picture now, how do you think cheat sheets impacted your experience in that class?

- How did you think it would impact your performance?

11. Do you think cheat sheets impacted your understanding and retention of the material?

- a. Why/why not?

12. If I asked you to take the exam again right now with nothing else, how well do you think you would do?

- a. Why?
- b. What if I told you, you could use your cheat sheet? Why?
- c. What if open notes? Why?

13. Have using cheat sheets helped you in terms of time management for exams?

14. Going back, how do you plan to approach exams in the future?

- a. Does this depend on the course exam format?
 - i. Would you still make a cheat sheet if the exam was (1) open note or (2) closed note.

Cool Down

15. Reflecting on your experience, would you prefer to use cheat sheets in future exams?

- What are the main reasons for your preference?
- Would you like to see more exams in this format?

16. If you could suggest any changes to how cheat sheets are used in your class, what would they be?

- How do you think these changes would impact student learning, time management during exams, and anxiety?

17. Fun question: If there were no restrictions on time, resources, or ethics, how would you study?

18. Do you believe that using a cheat sheet has helped or hindered your ability to retain and apply what you've learned in future coursework or practical applications? Good

- Why do you think that is?
- Have you noticed any differences in how well you remember the material compared to traditional closed-book exams?

End

Thank you for taking the time to participate. As a reminder, I will be following up in 1-2 weeks regarding compensation for the study and the interview exit survey. Before we exit,

19. Is there anything you wish I would have asked about your experiences with the cheat sheet?

- Is there anything you would like to add?

20. Do you have any questions for me?