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A Study of the Effects of Crib Sheets on the Math Test Preparation of College Students

By

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ABSTRACT

This study examines the effects of a well thought-out crib sheet and how it influences test grades. A “Crib Sheet,” also known as a “Cheat Sheet,” is a test-taking aid in the form of a sheet of paper or note card. The students are allowed to place any information of their choice on the crib sheet, which can then be used on an exam or quiz. Students from three different classes were told by their respective teachers that they would be allowed to use a crib sheet on their next exam. The students were also informed that they could fill out an optional questionnaire following the exam on how they felt about crib sheets. The crib sheets were scored by a set rubric and compared with the test scores. On average, crib sheet score did not have a high correlation to test score. However, for students who suffer from high anxiety, having a well thought-out crib sheet significantly contributed to a good test score.

Introduction

This research examines the role of crib sheets as a form of test preparation in a collegiate-based classroom. Every teacher knows that one must study in order to achieve good test scores. When students study, they need to decipher what is important and what is more or less a filler. The way students tend to study and/or take a test can lead to many factors that influence their score in both positive and negative ways: test anxiety, rote memorization, organizational practices, and many other factors.

This topic has always been an interest of mine ever since I had my first test involving a crib sheet (Discreet Mathematics). When I went to take this test I felt so confident of the material and the fact that I had my crib sheet that I did very well. The best part of it was that I rarely even
looked at the crib sheet. At that time, I realized why the teacher was letting us use the crib sheets, as a form of studying through coding and thorough preparation. I thought to myself, was this true for the other students too? This made me want to research further and test what relation crib sheets have to exam scores. Does a well-organized, well-thought out crib sheet lead to a good test score? What other factors does a crib sheet help a student to deal with? As a mathematics educator, cheating is something that, unfortunately, I see far too often. With recent technologies in mathematical classrooms, students seem to save answers to their calculator all too frequently or use other methods for cheating (water bottles, unauthorized crib sheets, etc.). So when we allow students to have an authorized crib sheet, we are leveling the playing field for the rest of the students. We are helping our students achieve fair and reasonable grades (Satterlee, 2002).

This study focuses on how constructing crib sheets affects students' study patterns, along with their grades.

*It is hypothesized that on a liberal arts mathematics exam college students who construct a well thought-out crib sheet will outperform college students whose crib sheets are inadequate.*

This hypothesis was tested by having the students in multiple college level mathematics classes create crib sheets for an upcoming exam. The students were told to create a crib sheet to hand in with the exam, and that the crib sheet would not be a part of their grades. This was to obtain an accurate vision of what most students figure a crib sheet should have and also to provide a variety of different examples for analysis. The students would then take the test and use the crib sheet as they normally would. Following the exam, the students then took a brief survey on various questions regarding the use of a crib sheet. The questionnaire involved questions regarding how anxious they felt with and without the crib sheets, if they thought it was
a useful form of studying, and if they would like to use a crib sheet on future tests. The questionnaire provided the opportunity to determine correlations between information on the crib sheet and students’ anxiety, among other things. This experiment should lend information to any teacher as to what benefits, and hindrances, allowing crib sheets into the classroom could have.

**Literature Review**

A “Crib Sheet,” also known as a “Cheat Sheet,” is a test taking aid in the form of a sheet of paper or note card on which the students are allowed to put any information they want to use on an exam or quiz. Upon research of the topic of Crib Sheets, it became apparent that views differ drastically on whether or not they should be used as study aids. Crib sheets have been said to reduce test anxiety, help students decipher important information, move beyond rote memorization and allow them to perform better on tests (Agarwal, Karpicke, Kang, Roediger III, & McDermott, 2008; Duncan, 2010; Eilertsen & Valdermo, 2000; Erbe, 2007; Hamed, 2008; Philips, 2006; Pittenger, 2004; Wachsman 2002). On the other hand, crib sheets have also been considered a crutch for students to rely on, gathering no intellectual stimulation (Dickson, 2007; Dickson & Bauer, 2008; Dickson & Miller, 2005, 2006; Pittenger, 2004). This literature review will examine the pros and cons of providing students a structured “cheating” environment (Pittenger, 2004).

**Types of Test Strategies**

There are many different types of tests that teachers use as forms of assessment. A test does much more than just assesses a students’ knowledge of a subject. A test’s structure contributes directly to student learning (Erbe, 2007). A student’s learning can be different pending the type of test. Tests can assess conceptual knowledge, or just rote memorization.
Recent studies have noted that if one wants a test of deeper conceptual learning, a test involving crib sheets can be a great way to induce it. Since the students have the crib sheets to look up random formulas and definitions, they do not have to waste time with the task of rote memorization (Eilertsen & Valdermo, 2000; Pittenger, 2004).

There are many differences between an open notebook test and a test using a crib sheet. Using crib sheets involves students having one sheet of information that they hand selected, as compared to their notes and a book (which could include a crib sheet). Using a crib sheet over an open notebook test tends to have its advantages. During open book tests, students tend not to use the reference materials correctly and spend a substantial amount of the class time flipping through pages in their books, just wasting time. Students who constantly refer back to their books for information seem to earn lower grades (Heijne-Penninga, Kuks, Schonrock-Adema, Snijders, & Cohen-Schotanus, 2008). By using a crib sheet, the students have all the information immediately available at their fingertips on a small page. Also, students do not waste time looking up information because if they already know it, the information is most likely not on the cheat sheet.

**Advantages of Crib Sheets**

There are many advantages to the use of crib sheets in classrooms. When students are given the option to use crib sheets and all start with one, it ensures equal testing conditions. There are multiple ways in which the crib card levels the playing field. The first way of leveling the playing field is that using a crib sheet takes away the advantage that the students who are illegally cheating have. Recent trends have shown that cheating is all too common in high school
(and even college) courses (Latova & Latov, 2008; Pullen, Ortloff, Casey, & Payne, 2000; Satterlee, 2002; Shon, 2006).

Since all students would be entitled to have a crib sheet, the ones who would have brought one in illegally anyways just lost their advantage. The second way that this option levels the playing field is that for the students who have trouble memorizing formulas (especially in mathematics oriented curriculum), they have the opportunity to review the formulas from their crib sheets (Wachman, 2002). As part of Wachman’s experiment, she collected the crib cards as a source of data. Upon an examination of the students’ crib cards, she noted that 97.3% contained formulas, 61% contained graphs, 51% contained key points and 38% contained definitions. The main purpose of the crib card, then, was just to remove the rote memorization. None of the sections listed above were of a higher level of learning/understanding. According to one of the students surveyed in a study done by Eilersteen and Valdermo (2000), the student said, “I did not have to learn by rote like I did before. That had a relaxing effect on me, and I think I felt ‘free’” (p. 96). This is an enormous benefit to those who know how to apply the concepts, only they make careless errors.

The following sections will address two important issues associated with the use of crib sheets on tests. The first category that is discussed is cheating in schools. The second sub section is devoted to ways in which crib sheets reduce test anxiety, along with the harmful effect of test anxiety on students. Having cheat sheets has also been known to reduce test anxiety in students (Agarwal, Karpicke, Kang, Roediger III, & McDermott, 2008; Duncan, 2010; Eilertsen & Valdermo, 2000; Erbe, 2007; Hamed, 2008; Philips, 2006; Pittenger, 2004; Wachsman, 2002).
Reduction of Cheating

According to recent studies, self reported admission of cheating is at an all time high of between 80-90% (Pullen, Ortloff, Casey, & Payne, 2000). When a majority of the students are cheating, it causes students to have the “if you can’t beat them, join them” state of mind. Since the students who cheat are obtaining higher scores than those who put in effort, the honest students themselves even start cheating. The reasons most students cheat, according to Anita Satterlee (2002), include the pressure to do well, low levels of self-efficacy and competition (fear of failure, desire for a better grade and external pressures).

Introduction of a crib sheet into a classroom can help to counteract cheating. A crib sheet helps purge a test of possible cheating in two main ways. First, many teachers fear calling a student out on cheating (for fear of parental involvement, disturbing the class, etc.). The crib sheets remove this hassle single handedly and provide a structured “cheating” environment (Satterlee, 2002). Also, the student cheating often has an advantage on the test since he did not have to worry about rote memorization of formulas and such. If we give all students the opportunity to use a crib sheet on their exams, we are leveling the playing field, along with rewarding the honest students.

Reducing Test Anxiety

Consider the following: Teachers often bring a sheet of paper with them to class that they refer to when they teach a lesson, a little cheat sheet, whether to remind them of what to include or help them solve a problem (Heijne-Penninga, Kuks, Schonrock-Adema, Snijders, & Cohen-Schotanus, 2008). Is there really a difference between a student bringing a crib sheet to guide them and a teacher using notes? Regardless, the fact that the teacher has this sheet reduces their
anxiety a huge amount (Pullen, Ortloff, Casey, & Payne, 2000). Letting a student have a crib sheet during an exam is not all too different from the teacher using a note sheet.

Test anxiety is the combination of fear, worry and dread about test performance, which interferes with normal learning and has the possibility to lower test performance (Huberty, 2010; Asfaw & Raju, 2009). It suffices to say that students will not perform as well on a test when they lack confidence on it. Most students are able to cope with their test anxiety, but still about 30% of them suffer from a severe case of test anxiety (Huberty, 2010). When test anxiety is high, it can hinder a student’s ability to do well. Just like getting into someone’s head often works in sports, getting into someone’s head also applies to tests.

When a student is very anxious, he or she tends to lack organization in trains of thought (Asfaw & Raju, 2009). There is an inverse correlation between study time and test anxiety. Usually, the more time spent studying tends to reduce test anxiety (Asfaw & Raju, 2009). According to a survey (Wachsman, 2002), students who created crib sheets for tests, spent significantly more time prepping and studying for the exams. According to a study by Dickson (2008), 79.6% of students felt that making a crib sheet reduced their anxiety. So many times in mathematics, the teacher who graded the tests have the problem where it seems like there is no coherent train of thought but the answer is correct. So if the students were given cheat sheets, they have time to organize their thoughts on their own time on the paper, causing them to be less anxious during the test and have more controlled answers.

**Crib Sheets in Mathematics**

In most mathematics classrooms, crib sheets are most useful for listing important formulas (Erbe, 2007; Wachsman, 2002). Most of students’ anxiety in a mathematics classroom
actually comes from remembering and memorizing formulas, rather than the application of them. The best part about having access to a crib sheet is that formulas are on the lowest level of Bloom’s taxonomy (Bloom, 1956). The crib sheet, then, just becomes a modification to promote higher learning (Erbe, 2007; Heijne-Penninga, Kuks, Schonrock-Adema, Snijders, & Cohen-Schotanus, 2008). When students spend less time on the memorization of formulas (which is irrelevant for real world use), they are able to take time to apply the formulas they are using and gain a deeper understanding of them. As educators, we know that mathematics is more than just memorization, it is application.

That is not to say that students still should not memorize formulas. We do have those crucial formulas that are used on most, if not all, exams. We need to know that the area of a square is $A = b^2$ and that the Pythagorean Theorem is $a^2 + b^2 = c^2$. On the other hand, the students do not necessarily need to know the formula for a truncated icosahedron. Emphasis first needs to be placed on when crib sheets should be used in a mathematics classroom. Not every test in a math classroom should involve a crib sheet. To enforce that students learn those crucial definitions and formulas, they should be tested in a standardized learning environment. If it seems that the students are learning by constructing the crib sheet, we could make an adaptation to allow them to create one and that it would be part of the grade, but they could not use it on the exam. They could then study the crib sheet, since they are listing all the material they need to know on it.
Crib Sheets as a Form of Studying

In an article by Bridgette Erbe (2007), she writes:

Students loved the idea of cheat sheets. They found, however, that they rarely needed them. Preparing the cheat sheets proved to be sufficient for learning what was on the test. This was the major difference between handing out information composed by me and having the students find their own. Students tailored the information to their own needs and wrote down information they still needed to learn. The act of writing and organizing the information for the cheat sheet allowed most students to fill in the holes in their knowledge. (p. 2)

What she is noting is that crib sheets tend to be a way that students study more than a crutch the students rely on to copy the information. When students create a crib sheet, they are searching for the most important information to put on it. The crib sheet works as a valuable tool for making the student recognize the important concepts (Erbe, 2007).

According to the coding hypothesis, when students select the information and write it down on their crib sheet, they are actively processing the information which enhances their learning (Dickson, 2007). While this is true, just writing down the information one time and remembering it is not relevant for all students. While writing the information and coding does help the students, they need to put in more than minimal effort. After making a crib sheet, the students should still study the material to understand it. In an experiment done by Wachsman (2002), she had students come in for an extra credit test. She told two-thirds of the students to make a crib card for the exam and the other one-third to study as they normally would. When they came into class that day, she revoked half of the crib card students' cards (so that one-third had crib cards and one-third studied as if they could have a crib card). The result of each group was truly astonishing. The students who were given a crib card had the highest scores. They were followed by the revoked crib card students in second, and the regular study students in last. This
shows that making the crib sheets (for most students) actually took the form of active studying (Wachsman, 2002).

Overall, it seems like crib sheets can produce a lot of significant benefits. However, like most things in the world, crib sheets have their disadvantages, too. Just as a lot of educators had high hopes for crib sheets, many educators hold a strong dislike for them.

**Disadvantages of the Use of Crib Sheets**

Some students, upon creating crib sheets, rely way too much on the crib sheet itself. Instead of using the crib sheet to find out and piece together the important information, some students use it as a crutch to store all of the pertinent information. K. Laurie Dickson strongly opposes the use of crib cards on tests. She believes that students rely too much on what is on the card rather than knowledge of the material (Dickson, 2007; Dickson & Bauer, 2008; Dickson & Miller, 2005, 2006). She has done extensive testing and research on this subject that is so important to her. Dickson states that “expectation of crib card use may hinder learning during crib card construction”. This means that when students expect that they can use the crib card on the test, they do not need to work on the information or to study afterwards (Keith-Spiegel & Whitley, 2002). The crib cards discourage students from studying because they just place information on the card rather than take time to understand what is on the crib sheet.

The main disadvantage of the crib card comes with how some of the students tend to use it. Crib sheet use should not involve just creating the sheet and leaving it alone until the exam. Students need to create the crib sheet and then use it as a supplement to studying. Too often the students create the crib sheet and then neglect it until the exam. By doing so the students are losing much of their valuable study time (Dickson, 2007; Dickson & Bauer, 2008; Dickson & Miller, 2005, 2006).
To avoid a drawback like this, teachers need to teach the students the proper way to use a crib sheet. The students need to know that they cannot just fill out the information on the sheet and leave the sheet alone afterwards. The students need to go back and apply the information on the sheet. The crib sheet should be a useful tool for studying along with a test taking aid.

**Overall Thoughts on Crib Sheets**

In all of K. Laurie Dickson and her colleagues’ publications on crib cards, they have a negative view of them. There is a valid reason for their negativity. This negativity stems from using crib sheets with the material that they present. K. Laurie Dickson is an Abnormal Psychology Professor at Northern Arizona University. Thus, most of her crib card research has to be taken in the context of psychology courses. In the psychology classes, crib cards proved to be ineffective. This brings up a very crucial point: crib card success is relative to the course content. From the data gathered, it is noticeable that crib sheet effectiveness is relative to course content: crib cards only serve a purpose in certain subjects and curriculum, and, in a lot of cases, they pertain only to certain students. In mathematics-based classes (Economics, Physics, etc.), crib cards are often used to place formulas, and maybe even a few definitions/concepts. Formulas and definitions are among the lowest level concepts of Bloom’s Taxonomy, which, really, is not the level of understanding we are trying to test our students on in an upper level class. By removing focus from the rote memorization, students achieve a deeper level of learning.

This is also not to say that crib sheets should be used on every test. In mathematics there are a few formulas that students should always remember regardless, due to how important and common they are. These important formulas put a classification on when crib sheets should be used, and that for certain material crib sheets should be avoided. For those formulas that are taught for one week and never used again (i.e., volume of a truncated cube), we probably should
not be worried about students memorizing them. For those life-long golden formulas (i.e., Quadratic Formula), however, students should generally know what they are.

Whether we think that crib sheets are a substantial form of studying or not, we do know that most students at least feel that crib sheets reduce test anxiety and usually result in better test scores for this reason. Since doing well on tests has been noted to improve learning, we could say that crib sheets do help students learn. In the least, crib sheets help students decipher what is truly important. This brings us to what is being tested: Does a well formatted, well thought out crib sheet correlate to a higher test score?

**Experimental Design**

This experiment was designed to test the hypothesis that a well thoughtout crib sheet would help a student perform better on his/her test. During this study, students were allowed to create and use crib sheets on their exams to test the hypothesis. I only received the raw score for the exam to compare to the crib sheet. Having no knowledge of the students enforced minimal favorability or bias to crib sheets and/ or students.

**Subjects**

The subjects who participated in this experiment at SUNY Fredonia were students enrolled in three college mathematics classrooms: two of the classes were Prize-Winning Mathematics, taught by two different instructors, and a University Survey of Calculus class. The three classes are considered introductory level mathematics courses. The total number of students for all three classes was n=70

According to information taken from SUNY Fredonia’s website, the student breakdown for undergraduates ethnically is: 84.5% Caucasian, 6% of unknown descent, 3% Hispanic, 2.6%
African American, and 3.9% are comprised of other ethnicities (Data taken from Spring 2010).

Of the students at SUNY Fredonia: 56.5% are female, while the other 43.5% are male. The classes are mainly for freshmen or sophomores, but could possibly contain juniors or seniors.

**Design**

This experiment was conducted over the span of two days, covering one test per classroom. Each class received a separate test created by their instructor and a survey created by me (Appendix C).

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<td>Prize-Winning Mathematics</td>
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Figure 1. Breakdown of the students who participated in the study

For each classroom the teacher let the students know that they could use a crib card for their upcoming exam. They were all given three days notice of the fact that they could use the crib sheet before the exam. All three of the exams given were constructed by the teacher of the class to help ensure a normal testing condition.

When the students entered the classroom on the test day, they took the test while using their crib sheets if necessary. They were also told to hand in their crib sheets along with the tests, and that the crib sheets would not carry any weight on their grades. At the end of the test, the students had an optional survey to fill out about crib sheets (Appendix C). Since this study was a volunteer study, the survey was optional. This was meant to help ensure more participants in the study, since then they would not feel they have to do extra work.
The survey asked various questions about how the students felt about this style of exam and if they felt it was useful. The questionnaire also measured anxiety at multiple times that students would perhaps feel the most anxious. It also checked whether they spent time studying on top of the crib sheet, along with what percentage the crib sheet took of their study time. The purpose of this survey was to find more distinct correlations between crib sheet scores and test scores. Most situations themselves are not as cut and dry as that, so I wanted to see what else factored in to test score. The questionnaire itself was neither graded nor reviewed by the teacher so that it would help to ensure honesty in the self reported statistics. The survey can be found in Appendix C for reference.

Data Collection

After the tests were collected, the teachers of the respective classes graded their own exams as they usually would. This was to ensure a level of fairness for the students since I had no affiliation with the classes. Upon scoring the tests, the teachers wrote the percentages of their grades on the top of each crib sheet. The names on the crib sheets were blacked out so that I had no knowledge of the students.

- Each survey was also assigned to the corresponding crib sheet of the students.
- Both the survey and the crib sheet were analyzed to see possible trends with crib sheets and students.
- Since no knowledge of students was included in this study, such as how actively they participate and how hard they work, it only measured from the test scores and questionnaires. This helped ensure the correlation between the crib sheets to test scores.
Methods of Data Analysis

This experiment contains both quantitative and qualitative data. For this reason there are several different ways to analyze the data. The data to be reviewed comes from the grades on the crib sheets, the crib sheets themselves and the survey the students completed.

Analyzing Grades on Crib Sheets

First we have to define what makes a well thought out crib sheet. A well thought out crib sheet is not as much information as we can possibly squeeze onto one sheet of paper, nor is it just a set of formulas and definitions, for which one does not know. Since everyone is different, we would assume that each person’s crib sheet should be different. The various research on crib sheets tends not to show what makes a well thought out crib sheet, but rather what most of them tend to include. The one thing that can at least be agreed upon is that a well-organized crib sheet

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<td>Organization</td>
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*If the sheet is lacking content, then no points were awarded for organization*

Figure 2. Crib Sheet Grading Rubric
is more useful. If a crib sheet is not organized, then the students waste too much time searching for information and not working on the test. To grade the crib sheets equally, I decided to create a scale including what a good crib sheet should include (Figure 2). A well thought-out crib sheet should have, if all categories are added up, a score of about 6-7. A well thought-out crib sheet should be organized and contain some non-repetitive examples, formulas, definitions, and/or graphs. Since not all students need to have all of the information at hand, organization is a key element to a well-thought out crib sheet.

Each crib sheet was scored based on the scale that is listed above. The crib sheets were then analyzed and compared to the score that the student with that crib sheet received on his/her exam. The crib sheets were analyzed using multiple different regression analysis from Minitab, to find the best regression. The R² (percentage of the data that is accounted for using this statistical model) was then analyzed to discover whether there is truly a correlation between a well-thought out crib sheet and test grade.

Crib Sheet Construction, Student Anxiety and Student Preparation

There are many other factors that lead to a good score with the use of crib sheets. The survey gathered useful data on length of study times and anxiety levels. These were tested to see the various correlations between these variables and the grades. This data was then analyzed to see what other factors the crib sheet contributed to for the students’ test preparation and performance. The variables were used as standalone and as categorical variables to obtain a better insight as to what made the students perform well on the exam.

The data was mainly analyzed graphically to see trends. Regressions of the equations were taken to see whether they seem to truly hold or if minimal data is inconclusive. Since it is
such a small sample size, the true effects of the data were taken into consideration upon evaluation.

**Taking the Students into Consideration**

Most teachers who have used crib sheets know why they continue to use them or why they do not use them anymore. That, however, does not show how students feel about crib sheets. Using comments from the survey, the impressions that 70 collegiate level students have about crib sheets can be portrayed. Through numerical and graphical analysis, the results can be shown on whether students like to use crib sheets, dislike them, or have no opinion.

The survey also left multiple areas open for comments. The most frequent comments and points that the students made are discussed in results. Since the survey left a section for open-ended comments, it brought up possible topics that one may not think of immediately. After reading the results and implications, the teacher can truly see what students think of crib sheets, and maybe influence their decision on whether or not to introduce them into their classroom.

**The Ideal Crib Sheets: Students vs. Professor**

Above, the features that seemed most important to me are listed. These, however, may not have been what were important to the students. So often taking something from an outside perspective causes misinterpretations. We cannot be truly sure that scoring high on my scale leads to high test scores. Using a regression analysis, it is noticeable what components of a student's cribs sheet tend to amount to producing a better score.

The ideal crib sheets created above (in the rubric) will be measured against the students and what they thought were the most important parts. Data will be assessed as to differences in
the crib sheets along with similarities. The results are then discussed as a combination to see what truly makes a well thought out crib sheet.

**Results**

The methods of data analysis section posed many ideas involving correlation between crib sheets and test grades, along with test anxiety and test preparation. This section will help to support these ideas with graphs and various descriptive statistics. The main results posed in this study were as follows:

- There is little to no correlation between a well thought-out crib sheet and a good test score ($R^2=9.6\%$).
- For students who suffer from high levels of test anxiety, a well thought out crib sheet had a positive effect on test score ($R^2=44.1\%$).
- The majority of students reported that crib sheets are useful as a study material and test taking aid. They favor crib sheets because they help reinforce topics through coding, help reduce test anxiety, and help students who have trouble with rote memorization.
- Organization is key to creating a successful crib sheet. Factors such as use of definitions, example problems, formulas, and graphs differ from student to students and overall do not mean a crib sheet will be well thought out by containing certain ones.

**Crib Sheet Grade vs. Test Grade**

The big question presented in this thesis was on whether a well thought out crib sheet leads to higher a test score or not. After doing multiple regressions and transformations, the best model found is shown in the graph on the following page (Figure 3). The graph was obtained through the statistical analysis program Minitab.
Observing the graph above, there is a slight trend in the regression line. The regression line appears to show that a higher crib sheet score would influence a higher test grade. While the graph does show that, we have to look at the $R^2$ value. Since we have such a low $R^2$ value of 9.6%, we see that the correlation is very weak. We can say that having a well thought out crib sheet accounts for 9.6% of the reason for the student’s grade, which is not a very significant amount statistically.

**Crib Sheets, Anxiety, and Test Grade**

In the survey after the test, the students reported the anxiety level they had while taking the test. Figure 4 on the next page is a pie chart that shows student anxiety levels. Most students face at least a low level of anxiety during a test (27:8). Also, of all the students who felt anxiety, exactly half of them felt moderate to high anxiety.
Overall, it was shown that crib sheet grade has a weak correlation to test grade. That, however, was when anxiety levels were not taken into account. Looking at the graph below (Figure 5), it is noticeable that for students with high anxiety, having a well-thought out crib sheet led to a better test score. In this case, for the students with high anxiety, we had a 44.1% $R^2$ value. This was a significant increase from the 9.6% $R^2$ value of crib sheet vs. test grade overall.

**Key**

0 - No Anxiety ($R^2$=22.9%, n=16)
1 - Little Anxiety ($R^2$=16.5%, n=25)
2 - Moderate Anxiety ($R^2$=10.7%, n=18)
3 - High Anxiety ($R^2$=44.1%, n=7)
While the graphs show the trends revealing anxiety, students’ comments help to show the true realization of test anxiety. Their comments provide a much more real sense as to how the students feel about crib sheets. In Figure 6 below, the comments students felt regarding test anxiety are shown. Notice the amount of positive comments as opposed to the negatives. Overall, out of the 14 comments obtained regarding the use of crib sheets, only 1 comment was negative, 2 were indifferent, and 11 were positive. This shows that most students show slight favor to the use of a crib sheet.

<table>
<thead>
<tr>
<th>Positive (Test Anxiety)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“With the crib sheet I was able to get through the test faster and have a lot less panic and anxiety.”</td>
</tr>
<tr>
<td>“Before taking a test I have high anxiety, but not this time because the crib sheet. But next time it needs to be organized, it was a little overwhelming on the test. Also I really didn’t use it.”</td>
</tr>
<tr>
<td>“It definitely helped my stress level stay low. I found I didn’t even look at it much while taking my test, but having it available made me feel less anxious and not blackout at all.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Negative (Test Anxiety)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Tests in general make me nervous and forgetful. Even with the formulas right there, I second guessed myself or froze.”</td>
</tr>
</tbody>
</table>

Figure 6. Students’ Opinions Taken From the Survey on the Positive and Negative Effects of Crib Sheets and Test Anxiety

**Crib Sheets as a Form of Studying**

Outside of the benefit of having a sheet with your least known materials on it, crib sheets often help as a tool for studying. It has been shown that students learn through coding, the process of actively writing the material in order to memorize it. In this study, a students’ perspective seems to agree with it. Though no questions were asked about it, many students said that writing the information helps them learn. One student said, “I feel that the crib sheet really
did help me to better remember the test material because I am a person that learns through writing, so preparing the crib sheet made me write all of the test info down.”

Not only does the process of coding help, but creating the crib sheet itself actually adds to the cumulative study time. The students usually placed the material they did not know on the sheet, which became the go to study sheet for the exam. Since the crib sheet pools the knowledge they do not know onto one sheet, they have all the information in one place to study. The survey showed that 80% of the students thought that preparing the crib sheet helped them learn the material, as shown in the pie graph below (Figure 7).

![Figure 7. Pie Chart on Whether Students Thought Creating a Crib Sheet Helped Them to Learn or not.](image)

Students comments tend to help reinforce the coding hypothesis. By observing the comments shown in Figures 6 and 8, one can gain insight into how students thought it helped. The survey itself did not even mention a word about coding, or learning by writing. So reading comments on coding was an unexpected surprise.
**Coding Hypotheses**

“I spent a few hours filling out a crib sheet. When I got to the test I didn’t even use it. Yes it was very useful.”

“I found I didn’t even look at it much while taking my test.”

“By writing it all I learned it.”

“I feel that the crib sheet really did help me to better remember the test material because I am a person that learns through writing so preparing the crib sheet made me write all of the test info down.”

---

**The Even More Perfect Crib Sheet?**

After completing the study, the rubric used seemed to hold pretty well. It seemed after observing crib sheets and their similarities, the only noticeable traits relating to score were both thoroughness and organization. The table in Appendix G shows a regression output for using the categories of definitions, example problems, and graphs to predict test grade. The data in Appendix G shows that no one category significantly led to a good test score. This would make organization the key aspect of a well-thought out crib sheet.

---

**Figure 8. Students’ Opinions Taken From the Survey on Crib Sheets and the Coding Hypothesis**

![Pie Chart of Most Useful Category](image)

---

**Figure 9. Pie Chart on the Most Useful Category According to Participants**
The pie chart on the previous page (Figure 9) shows what students reported as the most useful pieces of a crib sheet. The most prominent category chosen was formulas. The section of the pie chart entitled “none” consists of students who did not answer and/or chose more than one answer as the best. Many students reported in the comments that the main problem that they have is remembering formulas, and by having the formulas right with them, they would do much better. The comments relating to formulas are shown below in Figure 10.

**Formulas**

“(The most useful category was) formulas. I didn’t have to worry about mixing up parts, or whole equations. Plus it gave me more time to study examples.”

“(The most useful category was) formulas. The formulas are what makes math hard for me. If I could memorize all the formulas I would ace every test.”

Figure 10. Students’ Opinions on the Topic of Formulas, as Stated on the Survey.

**Implications for Teaching**

As observed in the previous section, it is noticeable that crib sheet grade does provide a weak correlation with test grade. Surprisingly, the more important pieces of information for teaching came from the survey.

*For a classroom where many students face high anxiety levels, introducing a crib sheet can help to produce higher test scores.*

Overall, it can be seen that crib sheet score versus test score provided a weak correlation; however, when I categorized it by anxiety level, I obtained a relatively strong correlation for those with high anxiety. The literature review discussed that 30% of all students suffer from
severe test anxiety, and in this study it showed about 50% suffer from moderate to high levels of test anxiety. This shows that most of the students in school currently face the disaster course of anxious test taking. Anxiety can cloud minds and cause students to become forgetful and freeze in the middle of an exam, which is usually a main part of student assessment. Since most states tend to have high stakes testing, the anxiety levels of students are through the roof.

For classes that tend to have many at risk students or students with high anxiety levels, introducing a crib sheet into the test environment could make a huge difference. Most students reported that the crib sheet helped reduce anxiety, even though the students did not always use it during the exam. One student wrote on the survey, “It definitely helped my stress level stay low. I found I didn’t even look at it much while taking my test, but having it available made me feel less anxious and not blackout at all.” Reducing the anxiety levels of students can cause significant increases in test scores.

Upon introducing crib sheets into a classroom, the teacher should help provide organizational structure on crib sheet preparation. However, the teacher should also encourage creativity.

First, crib sheets should not be set as a standard for student test taking. Crib sheets should be implemented on a test by test basis. The reason for this is that there are those extremely important facts that students should still remember. Since math is a continuation of what is learned, there is no way that it could all be stored on just one crib sheet. Crib sheets should in no way be introduced prior to high school. Students still need to develop the skills of memorization at a young age, along with remembering material for future work. Crib sheets should be used for tests where there are not so commonly used formulas, in where the application rather than the memorization is being tested.
In order to implement the crib sheets, teachers not only need to assess the curriculum, but rather the students in the classroom, too. If the classroom is full of students who struggle with high levels of anxiety, introducing the crib sheet could show the students' full potential. Still, it would have to be on a test by test basis. This could especially be used in tandem with the rules and laws that the Regents tests provide the students on its reference page. Then, it becomes one less stress the students have to worry about for the exam.

If this experiment was to be revisited in the future, it would contain a larger variety of courses, larger sample size, and more authors.

If this study was to be completed again, then certain aspects would have to be altered. The first main aspect that would be altered would be that the study would have a larger sample size. This means a larger amount of students, a larger variety of courses, and more samples of each course. Then, it may be possible to see trends revealing if crib sheets should be implemented in certain math courses but not others. With a larger sample size, maybe we would truly be able to show that crib sheet score positively influences test score.

The next change would be with timing. If a longer duration was able to be attained for the study, in which the students could be tracked, tracking would be nice to see the extent of how they do years later on the same material. That could show if crib sheets are beneficial long term and not just for an exam.

The last and final change would be to have multiple authors as a part of this study. Then, the crib sheet rubric could contain unthought-of factors not included in this study. Also, having an average of multiple graders for the crib sheet score could tend to produce overall better and more consistent scoring.
Concluding Remarks

The idea behind this study was to figure out whether or not a well-thought out crib sheet tends to lead to a better test grade. Given the results, for the mass population we do not have enough evidence to conclude that a well thought out crib sheet influences a test grade. However, we did see that for students who suffer from high anxiety, a well-thought out crib sheet can be a great instrument for test taking success. While the data from students and other tests cited in the literature review mostly tend to show positive results for crib sheet use, it should still be on a test by test basis. Not every test should welcome a crib sheet, or even need one at all.
References


Hamed, K. M. (2008). Do you prefer to have the text or a sheet with your physics exams? *Physics Teacher, 46*(5), 290-293. doi:10.1119/1.2909747


TO: Students in Pre-Calculus
FROM: Mr. Cotton
DATE:
RE: Consent Form

➢ You are being asked to participate in a research project.
➢ Participation is NOT mandatory, and will not take any extra time outside of the classroom.
➢ There will be NO penalty for not participating.
➢ To participate, simply take the class as you normally would.
➢ This project will only take one exam day, and only requires you to allow me access to your test.
➢ Your name and grades WILL NOT be given to anyone, let alone myself.
➢ Samples of work may be asked to be kept for up to 3 months in a secure, confidential location. Names will be removed prior to storage.
➢ The risks involved to this are minimal. There is most likely no risk to you at all. However if there is a problem, feel free to discuss it to either the professor or I.
➢ Please be aware that this study is an attempt to making learning easier and to improve your grades.
➢ There is no payment or rewards (other than the chance of improving your grades) for participation.

***If you have any questions at all, PLEASE ASK***

Student Consent Form
SUNY Fredonia

Thank you for choosing to be a part of this study, it is greatly appreciated! Please PRINT and SIGN your name in the spaces provided below to show that you agree to participate. Remember that signing this allows Mr. Cotton to use your data for a research project. All students must participate in class whether they sign this form or not.

Voluntary Consent: I have read the terms of this memo and am fully aware of all that this study involves. My signature below shows that I freely agree to participate in this study. I understand that there will be no penalty for not participating. I understand that I may withdraw from the study at any time, also without penalty. I understand that my name and all other personal information will be kept out of the study. I understand that if I have any questions about this study, I may contact Mr. Cotton at his email cott6397@fredonia.edu.

Student Name (Please Print): ___________________________________________________________

Student Signature: __________________________________________________________________
Post Test Questionnaire

Please fill in every question and leave additional comments! Thanks!

Check the box corresponding to how you felt at each moment of this process.

<table>
<thead>
<tr>
<th></th>
<th>No Anxiety</th>
<th>Little Anxiety</th>
<th>Moderate Anxiety</th>
<th>High Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you learned you</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>could use the crib sheet.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>While preparing the</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>crib sheet.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>During the Test.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which topics did you include on your crib sheet (Check ALL that apply):

- [ ] Definitions
- [ ] Example Problems
- [ ] Formulas
- [ ] Graphs
- [ ] If Other (Please Explain): __________

Of those topics, which did you feel was most useful? Why?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

How long did you spend preparing your crib sheet?
A) 0-1 hrs.  B) 1-2 hrs.  C) 2-4 hrs.  D) 5-6 hrs.  E) 6+ hrs.

How many additional hours did you study (Not counting time spent on crib sheet preparation)?
A) 0-1 hrs.  B) 1-2 hrs.  C) 2-4 hrs.  D) 5-6 hrs.  E) 6+ hrs.

Did you feel that preparing the crib sheet helped you learn?
A) Yes       B) No

Would you prefer to use crib sheets on your future math exams?
A) Yes       B) No

Additional Comments:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Example of a 7:

**Closed Interval**: Contains both end points \([a, b]\).

**Open Interval**: Does not contain end points \((a, b)\).

**Slope**: Ratio of the change in \(y\) to the change in \(x\). EX: Find slope + Graph points (2, 0), (3, 2), (4, 3).

**Forms of equations**:
1. **Standard Form**: \(Ax + By = C\)
2. **Slope-Intercept Form**: \(y = mx + b\)
3. **Point-Slope Form**: \(y - y_1 = m(x - x_1)\)

**Matrices on Calculators**: to do row operations: Matrix + Matrix = 3 rowswap (PA) 1, 2.

**Matrix Operations**:
1. Addition: matrices must be same size.
2. Subtraction: "-" is "-".

**Row Reduction**: 3x3. 

**Matrix Multiplication**

**Cryptography**

1. Love math quotient is 38.

2. Encode message with encoding matrix: A = \[
\begin{pmatrix}
3 & 2 \\
5 & 3
\end{pmatrix}
\]

**Matrix Multiplication**

- To decode message, we want to find \(M = A^{-1}\).
- \(A^{-1} = \frac{1}{a \cdot c - b \cdot d} \begin{pmatrix}c & -b \\ -d & a\end{pmatrix}\)

**Problem**: Fixed cost of 42,000.

**Solution**: Revenue = \(15x = 92,000 + 2.1x\).

**We know**: \(F = \text{Fixed cost} = 42,000\).

**Variable cost**: \(15x = 92,000 + 2.1x\).

**Profit**

\[
\begin{align*}
F + V &= 92,000 + 2.1x \\
C &= F + V \\
E &= \text{REVENUE} - C = 15x \\
15x &= 92,000 + 2.1x \\
12.9x &= 92,000 \\
x &= 7.13178
\end{align*}
\]
Example of a 7:

1. **Assign each letter a number**
2. **Put numbers into a 2x2 matrix**
3. **Multiply that matrix by another**

**Formulas**

- \( A^{-1} = \frac{1}{det(A)} [a, b; c, d] \)
- \( m = \frac{y_2 - y_1}{x_2 - x_1} \)
- \( y - y_1 = m(x - x_1) \)
- \( y = mx + b \)

**Row Operations**

- \( x_2, x_1, x_0 \)
- \( -2x_1 + x_2 \rightarrow x_2 \) (get 0)
- \( \frac{1}{2} x_0 \rightarrow x_0 \) (get 1)

**Example 1:**

A point on production schedule is (4, 147) for a total cost of $76,477 and 100 units/day. An additional unit of activity cost of producing x units is $16.50.

100 + 80 = 180

\( y = 75x + 1047 \)

**Example 2**

\[
\begin{bmatrix}
1 & 1 & 4 \\
2 & -3 & -2
\end{bmatrix}
\cdot
\begin{bmatrix}
4 \\
-2
\end{bmatrix} =
\begin{bmatrix}
4 - 2 \\
8 + 6
\end{bmatrix} =
\begin{bmatrix}
2 \\
14
\end{bmatrix}
\]

**Example 3**

- \( x_1 = 5 \)
- \( x_2 = 1 \)
- \( y = 2x_0 \)
- \( y = 2 + 5 \)

**Example 4**

\[
\begin{bmatrix}
1 & 1 & 5 \\
2 & -3 & 10
\end{bmatrix}
\cdot
\begin{bmatrix}
y_1 \\
x_0
\end{bmatrix} =
\begin{bmatrix} 15 \\
10
\end{bmatrix}
\]

- \( x_1 = 11 \)
- \( x_2 = 14 \)
Example of a 4:

\[
\frac{y_2 - y_1}{x_2 - x_1} \quad \text{rise}
\]
\[
\frac{1}{x_2 - x_1} \quad \text{run}
\]

\[AX = B\]
\[X = A^{-1}B\]

1. Solve by graphing
2. Solve for \(y\)
3. Enter into calc
4. 2nd, Calc, Intercept
5. Plug in, check

Matrix addition:
\[
\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} + \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} 2 & 4 \\ 6 & 8 \end{bmatrix}
\]

Matrix multiply:
\[
\begin{bmatrix} 1 & 2 \\ 3 & 6 \end{bmatrix} \begin{bmatrix} 2 & 6 \\ -1 & -3 \end{bmatrix} = \begin{bmatrix} (1 \cdot 2 + 2 \cdot -1) & (1 \cdot 6 + 2 \cdot -3) \\ (3 \cdot 2 + 6 \cdot -1) & (3 \cdot 6 + 6 \cdot -3) \end{bmatrix}
\]

\[(-2, -1) \quad (1, 6) \quad y - y_1 = m(x - x_1)\]

\[\frac{-6 + 1}{2 + 2} = \frac{-5}{4}\]

\[y + 1 = -\frac{5}{4}(x + 2)\]

A  1  E  5  19  M  13  Q  17  U  11
B  2  F  6  10  N  14  R  18  V  12
C  3  G  7  K  11  O  15  S  14  W  13
D  4  H  8  L  12  P  16  T  20  X  24
Example of a 2:

\[ y = mx + b \]

\[ \text{Compounded Interest: } A = P \left(1 + \frac{r}{m}\right)^{mt} \]

\[ \text{Continuous: } A = Pe^{rt} \]

\[ F.C. = I.V.C. = \text{Revenue} \]

Break even if \( C = R \)

\[ \ln = \text{natural log} \]

\[ \ln(ab) = b \ln a \]

\[ \ln x = y \text{ equivalent to } x = ey \]

Appendix F

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>65.67</td>
<td>11.71</td>
<td>5.61</td>
<td>0.000</td>
</tr>
<tr>
<td>Definitions</td>
<td>1.658</td>
<td>4.118</td>
<td>0.40</td>
<td>0.689</td>
</tr>
<tr>
<td>Example Problems</td>
<td>2.626</td>
<td>4.248</td>
<td>0.62</td>
<td>0.539</td>
</tr>
<tr>
<td>Formulas</td>
<td>14.87</td>
<td>11.58</td>
<td>1.28</td>
<td>0.204</td>
</tr>
<tr>
<td>Graphs</td>
<td>2.367</td>
<td>4.285</td>
<td>0.55</td>
<td>0.583</td>
</tr>
</tbody>
</table>

\[ S = 16.0412 \quad \text{R-Sq} = 4.5\% \quad \text{R-Sq(adj)} = 0.0\% \]