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Using Cornell notes to teach rational expressions

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USING CORNELL NOTES TO TEACH RATIONAL EXPRESSIONS

A Thesis

Presented to the

Faculty of

California State University,

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In Partial Fulfillment

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in

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by

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ABSTRACT

The Cornell note taking strategy was developed in 1949 and has been used in high schools across the nation to teach students how to take notes and use them as a test study guide. Despite their proven success, Cornell notes are rarely used in mathematics classrooms. This study investigates whether students' who are taught the Cornell note taking method, during a unit on rational expressions, will have better achievement on a multiple choice test and obtain a deeper conceptual understanding on fraction concepts. Students in one class were instructed on how to use the Cornell note taking strategy. Another class was able to use any note taking method during the lesson. Both classes were pre-tested and post-tested. The test scores from the two classes were compared and found to have statistically no significant difference in achievement. Five out of sixteen students that turned in all three sets of notes showed gains in Cornell note taking and also had test scores with average gains of twenty-one points. The results of a survey showed that many students agree that note taking is an important skill for learning new information and studying for a test. However, many of the students scored poorly on the higher level thinking tasks of questioning, reviewing, and summarizing, which are emphasized by the Cornell note taking method. Therefore, more time should be dedicated to helping students become proficient in these areas and more research is needed before the Cornell Note taking method is seen as unsuccessful in the mathematics classroom.

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CHAPTER ONE

USING CORNELL NOTES IN MATH

Introduction to the Study

Background

This thesis consists of a study on the use of the Cornell note taking strategy and its effect on students' conceptual understanding and achievement in mathematics. I elected to implement this strategy into one of my Algebra II classes during the unit on Rational Functions, while using another Algebra II class as my control group. I chose the topic of Rational Functions because I have noticed over the last seven years of my teaching the subjects Algebra I, Algebra II, and Pre-Calculus that many students continue to struggle with fraction concepts year after year.

Statement of the Problem

Cornell Note Taking. The purpose of my project is to determine whether or not students who learn how to take structured notes using the Cornell Notes format will develop a deeper conceptual understanding and an increased comprehension of concepts involving rational expressions as evidenced on their performance on a multiple choice and free response test. For many years, "...theory and research in cognitive psychology suggest how taking notes on a lecture might affect learning at both the listening/"encoding" and reviewing/studying stages" (Anderson & Armbruster, 1986, p.4). The listening

and encoding stage refers to students actively participating in note taking by listening to the lecture and then deciding what to write down. Furthermore, the reviewing and studying stage is done by the student at home at some later time. The Cornell note taking method consists of students using a specific structured format to record notes during the listening encoding stage and then reviewing, asking questions, and summarizing at home for the second stage. Since both stages are implemented in the Cornell Note taking method, I feel it is a worthwhile method to test student conceptual understanding, comprehension, and achievement. By implementing the Cornell note taking method while teaching a normally difficult topic in Algebra II, I hope to deepen the students' understanding of fraction concepts.

Fraction Concepts. I have noticed that many students have a fear of working with fractions in any context, as well as a lack of confidence in basic numerical skills involving fractions. Combined with the complexity and abstractness of polynomial functions, students are easily overwhelmed by rational expressions despite the similarity in concepts and procedures to operations on fractions performed at the elementary level. Many students lack conceptual understanding of rational functions in the following areas: simplifying numerical and algebraic fractions by using equivalent fractions, factoring numbers and polynomials using prime factorization, and finding least common multiples using prime factorization.

In my experience, I have noticed that many high school students are repeatedly misunderstanding the proper way to simplify algebraic fractions and are misusing the concept of equivalent fractions. Many students merely cross out any two numbers that are the same in the numerator and denominator without understanding why or when it is appropriate. For example, in the rational expression $\frac{x+5}{5}$, students erroneously cross out both of the fives and obtain *x* for their answer. This is incorrect because you can only divide common factors, not individual terms that are a sum or difference. In the book *Elementary and Middle School Mathematics, Teaching Developmentally*, by John Vanderwalle, it states a "strong conceptual foundation of equivalence is important in many other mathematics topics, one of which is computation of fractions" (p. 315). Similarly, the same misunderstanding occurs when simplifying more complicated rational expressions that require factoring polynomials to divide out the greatest common factor of the numerator and denominator, as in the polynomial rational expression $\frac{x^2+11x+24}{x^2-5x-24}$. A common misconception is students will most often "cancel" the common terms in the numerator and denominator (in this case, the x^2 and 24) instead of the common factors. Factoring, whether it relates to a whole number or a polynomial entails the same concept. The students must understand that factoring is the process of finding two numerical or polynomial factors that when multiplied together will give the original number or polynomial, for example $4 \bullet 6 = 24$. Both 4 and 6 divide evenly into 24, therefore both 4 and 6 are factors

of 24. However, if you factor the numbers 4 and 6 further, into $2 \bullet 2$ and $2 \bullet 3$, respectively, they are called prime factors because each of the factors is a prime number. When factoring polynomials students need to be able to find prime factors as well. Furthermore, many students fail to realize this is merely the equivalent of the distributive property. Since most students struggle with the multiplication of polynomials, it is reasonable that they would also struggle with factoring.

Problems with factoring polynomials also lead to problems when finding least common multiples for adding and subtracting polynomial fractions. Most students have been taught to find positive integer multiples that the numerical denominators have in common using a listing method. For example, to find the least common multiple between the numbers four and six, to find $\frac{1}{4}+\frac{1}{6}$ students in grade school are taught to list the multiples of four and the multiples of six in two columns side by side until they came across the first multiple that is common to both numbers. This is a useful method for very small positive whole numbers or for students who are proficient with their multiplication tables; however, it is not very practical for larger whole numbers. For example, it would be very cumbersome to use the listing method to find the least common multiple for the numbers 15 and 81 and they are not even very large numbers. Furthermore, it is even less useful for finding common multiples of algebraic expressions. For example, it would not be very practical when finding the least common multiple

for the polynomials $2x^2+5x-7$ and $x^2-3x-40$. For these types of problems students need to have a solid understanding of prime factorization of polynomials in order to find the lowest common denominators of rational expressions. The first step is to prime factor each polynomial over the integers. The polynomial $2x^2+5x-7$ is equivalent to $(2x+7)(x-1)$ and the polynomial $x^2-3x-40$ is equivalent to $(x+5)(x-8)$. Therefore, the least common multiple is the product of each of the linear factors from both polynomials, resulting in $(2x+7)(x-1)(x+5)(x-8)$. Once students are able to find the least common multiples of polynomials they can use their conceptual knowledge of fractions to add or subtract rational expressions, such as, $\frac{2x}{(x+5)(x-8)}+\frac{4}{(2x+7)(x-1)}$.

Research Questions. Due to the difficulty of student's conceptual understanding of both numerical and polynomial rational expressions, it is a worthwhile venture to experiment the usefulness of applying a well-known note taking method to the unit on Rational Expressions in order to determine if note taking will have a positive influence on their achievement and understanding of fraction concepts. My research will ask the question: In what areas do high school students who use Cornell note taking procedures differ from those who use other forms of note taking with regard to the following topics:

1. performance on a multiple choice Rational Expressions unit test?

2. comparison of Cornell notes scores and test performance to determine if there is a correlation between note taking and gains in achievement?
3. performance on free response questions on concepts underlying simplification of rational expressions?
4. Students' responses to a note taking survey regarding their note taking habits?

Purpose of the Study

The purpose of this study is to investigate whether there is a correlation between using Cornell notes and student's conceptual understanding on fraction concepts. I believe that the Cornell note taking strategy is a good means for the students to overcome their difficulties with rational expressions for several reasons. First, Cornell note taking provides a simple structure in which students can easily adapt their regular note taking into its body. It teaches students how to capture main ideas, key vocabulary, and the use of paraphrasing in order to keep up with encoding information while writing during lectures. In addition, it requires students to review their notes and then write questions about anything in their notes that they still do not understand. Furthermore, students reread their notes and write a daily summary for homework, which helps students develop good study habits and metacognitive skills. "Brazeau (2006) argued that active learning, a key aspect of student engagement, is reduced when students are not directly involved in the process of collecting and sorting information for note taking" (Maydosz, 2010, p. 179). Moreover, "Issacs (1994) indicates there is

general agreement that note taking and note reviews enhance short-term and longer term recall of lectures and that students' note taking and test scores are correlated" (Eades & Moore, 2007, p. 18). My thesis supports the current research that active note taking and reviewing leads to better understanding.

Since rational expressions seem to be a difficult topic for most of my students, I introduced the note-taking and summarizing procedures of the Cornell note taking strategy into one Algebra II class in order to determine whether improving students' note-taking abilities is correlated to student comprehension and test scores on the topic of rational functions. I have not heard or read of any research that has investigated the topic of rational expressions by using note taking as an approach to better understanding or increasing test scores. Most of the current research on note taking does not take place in the field of mathematics. However, there has been an increase in focus on implementing more writing in math classrooms recently due to the upcoming transition to the Common Core Standards.

Current Research on Writing. Writing across the curriculum has become a nationwide topic in education. With the implementation of the Common Core State Standards (CCSS) approaching, focus has shifted to a more rigorous curriculum which emphasizes critical thinking as described in Bloom's Taxonomy. Students will be expected to make connections between major concepts and be able to express their thoughts at a deeper level of understanding. The new standards eliminate rote memorization of procedural steps and embraces self-

discovery. Students will need to be able to clearly explain how concepts are related, describe similarities and differences, and justify their thought processes in writing. "Some researchers suggest that the act of taking notes engages students in learning tasks and deepens their understanding and ability to apply new material (Katayama & Crooks, 2003)" (Maydosz & Raver, 2010, p. 179). According to an article on the California Department of Education (CDE) website, *Highlights of the Common Core State Standards for Mathematics*, "Students who master the CCSS for mathematics will be prepared for college-level courses and possess the skills necessary for success in today's workforce" (California Department of Education [CDE], 2010). While most social science and language arts classes are adept in incorporating writing into the curriculum, mathematics teachers have always been more focused on numerical concepts and procedures. In a Power point presentation by Tom Adams, Director Standards, Curriculum Frameworks & Instructional Resources Division, in October 2011, it is further stated that "the Common Core Standards for English-language arts also set requirements for reading and writing in the social and natural sciences" (CDE, 2011).

One aspect of writing that takes place in every classroom around the world, from middle school to college, is taking notes. Good note taking skills are important in all subjects in order for students to be able to receive new information on a topic, process the relevant details, and be able to make connections and eventually store everything in long term memory. "Note-taking

requires students to listen to incoming verbal information, select important points from extraneous lecture content, relate important lecture content to prior knowledge, abbreviate or rephrase information in to a succinct form, and then record the relevant information into organized and legible notes" (Boyle, 2011, p. 52). Furthermore, "most people who do not take notes will forget 80 percent of what they hear in class within a two-week period and 95 percent within a four-week period, it is hard to question the importance of note taking in the classroom (Hatcher and Pond 1988)" (Walmsley & Hickman, 2006, p. 615).

Limitations of the Study

This study is limited to one unit in Algebra II and specifically scaled down to only include the concepts of simplifying, multiplying/dividing, and adding/subtracting rational expressions. This study took place over six two-hour block periods. This allowed one day for discussing the Cornell note taking strategy and its purpose along with a sample lesson on using the note taking template while learning fraction pre-requisites. There was one day for each of the above topics, one day for review, and then one day for the test. Since the study was approved in the middle of May 2012, there was no additional time available for improvisation due to the end of the regular school year on June 1st. There was no time for any quizzes throughout the unit and therefore I relied upon daily checking for understanding through practice problems. Furthermore, several students neglected to turn in all required materials within the grading period.

CHAPTER TWO

RESEARCHING CORNELL NOTES

Literature Review

History

According to the University of Houston-Victoria Academic Center, Cornell notes were developed in 1949 at Cornell University by Walter Pauk (www.uhv.edu/ac). Due to frustration over student test scores, Pauk developed the note taking system to be used as a test study guide. His method was later adopted by most major law schools as the preferred note taking method. A article from the University of Houston-Victoria states "This system allows you to keep your notes organized, summarize the main points of a lecture quickly, and review for tests more efficiently" and also "you can use it for any class or subject" (Ruschhaupt, 2010, p. 1). The Cornell notes method simplifies the process of writing notes for students by organizing their paper into three sections: the note taking column, the cue column, and the summary section. First, students record their notes by focusing on main ideas and key vocabulary and not word for word copying. Second, students preview their notes within twenty-four hours and fill in any missing gaps in information. Next, students write questions in the cue column. The questions should either be answered by the information in the note taking column and/or should pose higher level thinking about the concepts covered. Lastly, students summarize their understanding of the concepts in the

summary section. It is also recommended by Pauk that students spend at least ten minutes a week reviewing all of their previous notes. Later, students can prepare themselves for quizzes and tests by covering the note taking column and answering their own questions. "Active engagement with the notes before, during, and after class is the most important element of the split-page method of note-taking" (Pardini, Domizi, Forbes, & Pettis, 2005, p. 40).

Current State of Affairs

The AVID Program. Many schools currently teach students the Cornell note taking method through the Achievement Via Individual Determination (AVID) college preparatory program (www.AVID.org). The program was introduced by Mary Catherine Swanson in 1980. AVID has been advocating its success by focusing on helping the underserved students in the academic middle that need additional support and guidance in order to meet the college entrance requirements for over the last thirty years. According to a video provided on the AVID website, the brain retains new information for a longer period of time when it is reviewed within the 10/24/7 guideline. Students review their notes for ten minutes within twenty-four hours, and again for ten minutes within seven days. AVID elective classes are offered to middle and high school students in order to teach good note taking, critical thinking, and organizational skills that will benefit them in college. "Seventy-five percent of the students in middle school programs for two or more years were on-track for meeting four-year university requirements due largely to teaching students the importance of studying and note-taking

(Guthrie & Guthrie, 2000)" (Pagano, 2009, p. 12). Unfortunately, not every student who plans to attend college can take the AVID elective course. Some students do not have room in their schedules due to extra-curricular activities, honors or advanced placement classes, or other college preparatory courses. Data collected in 2002 showed that the AVID program reaches from 5% to 20% of the high school student population on average at the top eight AVID certified schools (www.AVID.org). In the article, AVID a Bright Light in College-Readiness, Put Under Budget Knife, by Kimberly Beltran, she explains that recent budget cuts proposed by Governor Jerry Brown "would all but guarantee elimination of AVID in California's schools" affecting "roughly 1,400 middle-and high schools...some 150,000 students would lose their main support system for completing more rigorous college prep courses" (http://www.siacabinetreport.com/articles/printarticle.aspx, April 2012). Therefore, it is important that good note taking and study skills are taught by content teachers throughout middle and high school in order to ensure all students are college and career ready.

The Non-AVID Student. While every student is expected to take notes as a means to learn new subject matter, outside of the AVID program, very few students have ever been taught good note taking strategies. "Research suggests that note taking is a study habit that can improve academic achievement by encouraging deeper student engagement and reflection with the content all while connecting new knowledge with prior knowledge (Armbruster,

2000: Trabasso & Bouchard, 2005; Williams & Eggert, 2002)" (Wilkinson, 2012, p. 3). Unfortunately, the majority of high school students have had to figure out their own techniques for recording information. They are unsure of what information to write down, how to keep up with the instructor, whether to listen and then write or try to write while listening. In my experience, the students rely on the teacher to teach using a PowerPoint presentation, provide fill in the blank notes, or write the important ideas on the board and they merely copy down everything word for word. This technique may work for some students, however there is very little thought put into this process and students are merely writing what someone else has organized for them. These various note taking methods are explained in the next section.

Note Taking Strategies Overview. Many different strategies for note taking are currently used from middle school to college. A few common methods include guided notes, parallel note taking using web notes, two column notes, and Cornell notes. Guided notes are usually provided by the teacher and duplicate the format of the lecture, but allow the students to fill in missing areas of information and therefore allow for more time to listen and less time spent on writing. Parallel notes are similar to guided notes in that the teacher provides notes ahead of time and students print them out.

> On the backs of these pages the student draws a margin approximately two inches wide. On the wider side of the margin the student writes notes that "parallel" the text of the Webnotes, and in the narrower side writes

> process notes, summaries, predicted test questions, and other annotations (Pardini, Domizi, Forbes, & Pettis, 2005, p. 43).

Parallel note taking was developed due to difficulties in students understanding teacher provided notes when used as a sole source of obtaining lecture information in order to actively engage students in the learning process when web notes are provided. Many college students viewed web notes as a means for obtaining information without attending class, yet had difficulty interpreting the subject matter from the format provided or complexity of the information. Others saw teacher provided web notes as a substitute for student responsibility of note taking. Two column notes are mostly utilized when reading text, however they can be incorporated into the classroom lecture as well. Two columns are created vertically on a sheet of paper with the right column larger than the left. The left column is for main ideas and the right side is for supporting details. The notes are recorded one paragraph at a time by stating the main idea and then listing important details and then leaving a space between main ideas when starting a new paragraph. A sample of two column notes and explanation can be found on the Landmark School Outreach Program website (www.landmark.outreach.org). The Cornell note taking method has been previously described and is most closely related to the two-column note taking method because they both extend beyond just recording notes and emphasizes the need to use notes as a study skill.

> The split-page method and textbook annotation are effective strategies for student learning because they require students to actively engage with new information. These strategies involve processing information in ways that make it meaningful to the individual student, and self-testing techniques that insure the student properly understands the information and can successfully analyze and apply it (Pardini, Domizi, Forbes, & Pettis, 2005, p. 40).

All of the note taking methods emphasize the need for student participation in the writing and organizing of information in order to foster the thinking, understanding, and remembering processes.

Current Research

One study of three note taking methods (including column notes, mini books, and traditional) in a geometry class found that "a positive relationship can be found between changing the traditional style of note taking and student perception of their own increased use of note taking and understanding of material" (Walmsley & Hickman, 2006, p. 619). This shows that students become more active learners when they are provided with good note taking skills and taught how to use their notes as an effective study tool. According to current research by Marzano, Pickering, and Pollock (2001), summarizing and note taking are strategies with "a high probability of enhancing student achievement for all students in all subject areas at all grade levels (p. 7)" (Donohoo, 2010, p. 224).

The closest study to my own that I was able to find consisted of using Cornell Notes in a middle school mathematics program. This study was conducted on lower achieving students in numerous 7th and 8th grade math classes over a three month period. First each class was pre-tested on the upcoming unit. Each of the teachers in the note taking group taught the students the Cornell Note taking method over a period of two to three weeks. By the end of the third week, the students were proficient enough with all stages of the system and were able to complete the reviewing, questioning, and summarizing steps at home. At the end of the unit the students were given the post-test for the unit. The pre-tests and post-tests for both groups were compared to determine if the Cornell Note group had higher achievement. There was no significant difference found in the achievement of the two groups based on two t-tests for the pre-test and post-tests. However, in a survey given to the students regarding how much time they spent reviewing their notes, there was higher achievement for those students who spent the most time reviewing.

Several studies have been found in which the use of the Cornell note taking method has been successful in other content areas. A study was conducted using Cornell note taking in an 8th grade Language Arts and 8th grade U.S. History class. The same eight students were selected in both classes and pre-tested. They were taught the Cornell note taking method and later post tested. Results showed "student test scores improved an average of 24.5% in

U.S. History and 20.4% in Language Arts when students used the CNTS" (Zorn, 2007, p. 20).

A study comparing guided notes and Cornell note taking in two sophomore English classes found interesting results. While the students who were taught the guided notes showed a higher increase in test scores from the pre-test to the post-test, the researcher found that the students who were taught Cornell note taking were better able to synthesize information and respond to higher level questions.

> Based on my research, both of these note taking methods have the potential to be effective teaching and learning tools. The guided notes method should be more effective when information requires knowledge, recall, or basic comprehension, while the Cornell method (once students are able to use it properly), seems to be more effective when the synthesis, application, or evaluation is required of students (Jacobs, 2008, p. 2).

A study of 9th grade world culture students found that while the students may not be completely capable of using notes for encoding at this age, there are still other benefits to using the Cornell note taking method.

> At some point between the seventh and twelfth grades, note taking shifts from the external storage function to an encoding function, and the beginning of this transition is marked by an increased ability to identify the

main and subordinate ideas of a passage (Faber, Morris, & Lieberman, 2000, p. 3).

This can easily be applied to mathematics by organizing notes into main ideas and supporting details using the Cornell method. In addition, the study found that "ninth-grade students can master the note-taking technique well enough to improve comprehension" (Faber, Morris, & Lieberman, 2000, p. 12). Even more importantly, the following passage from the study further exemplifies the importance of using Cornell notes:

> Note taking did enhance the encoding process for ninth grade students. Knowing that note taking, when taught as part of a content-area course, facilitated comprehension may encourage teachers to integrate note taking into their courses and to encourage their students to actively take notes. Another conclusion that can be drawn from these findings is that little distinction needs to be made between ability level of students when providing note-taking instruction, because both high- and low-ability students showed higher comprehension after instruction and practice in taking notes, and no interaction between training and ability level was found. This has implications for the classroom teacher, in that instruction can be given to a heterogeneous group with confidence that both extreme ability groups will benefit. (Faber, Morris, & Lieberman, 2000, p. 12).

Therefore, teaching students how to organize ideas while learning new information helps all students process the information by encoding, which leads to better comprehension.

There was one last study I found in which Cornell Notes was implemented and achievement was measured between the Cornell Notes group and another group of students who were allowed to use any method of note taking that they wanted. The study took place in the spring semester of 2011, in two Child Development classes. There were 23 students in one class and 17 in the other, however the inclusion in the research was voluntary and only 16 students from each section were utilized in the data collection. The majority of the students were female and sophomores; however there were a mix of juniors and male students as well. The baseline scores used to determine abilities prior to implementing the Cornell Note taking was the district administered ACT PLAN, a nationally-normed test which consists of questions in English, Math, Reading, and Science and measures academic progress in high school. A t-test was performed on the PLAN scores and "the results showed no significance difference in the PLAN scores for the two sections which indicate that both sections were at a similar academic level prior to the research beginning" (Quintus, Borr, Duffield, Napoleon, & Welch, 2012, p. 33). Three unit tests were given over a fifteen week period of taking notes. In all three tests an independent samples t-test was conducted and showed no significant difference in scores. The notes were not scored in this study and there is no indication of whether the

students put forth effort in reviewing or summarizing. As stated before, just doing the notes is not enough to guarantee learning is taking place. Students need to be active participants and be taught how to use their notes to study.

According to the U. S. Department of Education, only twenty percent of students entering community college graduate with an associate's degree in three years, and only forty percent earn a bachelor's degree within six years of entering a four-year institution. Furthermore, "Mortimore and Crozier (2006) found that approximately 20% of students reported note-taking as an area of difficulty and note-taking was also reported as one of the top three areas (i.e., note-taking, general organization, and time-keeping) of difficulty for students as they transitioned from high school to college" (Boyle, 2011, p. 52). High schools must do more to increase the rigor in order to close the gap between the level of difficulty in college courses and the high school curriculum. In my opinion, high schools should accept the responsibility of providing non-content related skills, such as note taking and studying, that will make the transition to college more efficient for students. Furthermore, "Note-taking is an important skill for college-bound students to learn in middle and high school because it is used by almost all students in college" (Boyle, 2011, 53).

Over the last few years, the high school where I work has provided teacher in-services on the latest and greatest educational research prior to the start of the school year. These have included Kagan strategies for student collaboration, Marzano's strategies for student achievement, and John

Antonetti's engagement cube. One thing that all presenters have struggled with is applying their ideas and providing examples of their use in the mathematics classroom. Mathematics teaching also seems to be the exception when it comes to incorporating note taking strategies. In one study of postsecondary developmental math students, it was observed that "it appears some students readily take notes in other disciplines, though not in mathematics" (Eades, & Moore, 2007, p. 19). This is a prime example of how the mathematics classroom differs from other content areas. Furthermore, most research on note taking is mainly focused on the language arts and social science curriculums or is specialized toward English Language Learners and students with learning disabilities. In the article, *Real Time Teaching*, by Jenni Donohoo, several teachers from the science department of a high school in Canada incorporated the use of the Cornell note taking system and had great success on student achievement on their midterm exams. They reported that "students of teachers who had implemented the Cornell note-taking method had higher class average scores than those of teachers who had not" (Donohoo, 2010, p. 227). So while other content areas are incorporating note taking skills and reporting success, very little evidence of structured note taking in the mathematics classrooms has been found.

My project has filled the void of the current research by incorporating a well known note taking strategy into the high school mathematics classroom. This study required students to not only take structured notes, but also to review

and edit their notes, write questions, and summarize the main ideas, as an effective way to establish good study habits. Furthermore, this study introduced students to the Cornell note taking technique, which temporarily replaced their traditional practice and exposed students to an alternative method of note taking that may be useful to them in college.

CHAPTER THREE

IMPLEMENTING CORNELL NOTES

Methodology

Instructional Design

My project consisted of teaching one class of Algebra II students the Cornell note-taking strategy and I required them to implement this strategy while learning the unit on rational functions. I taught the same lesson to a second Algebra II class using the same instructional strategy and these students used their regular note-taking method. I used the district adopted textbook, Prentice Hall Mathematics, Algebra II for instruction and homework assignments. The rational functions unit focused specifically on the following concepts: simplify, add, subtract, multiply, and divide rational expressions.

Population

I was currently teaching two Algebra II classes during this school year. I selected one class to be the control group and one to be the treatment group. I chose the class with the lower overall class grade average to be the treatment group with the assumption that they needed the most intervention and the Cornell Note strategy would benefit them the most. Also, I felt that if improvement was made with this group, it would be proof that the Cornell Note strategy was the reason.

The class which was chosen as my treatment group and used the Cornell note taking strategy, consisted of thirty-eight total students. There were sixteen male and twenty-two female students. Furthermore, there were three ninth graders, twelve tenth graders, fifteen eleventh graders, and eight twelfth graders. Of the total students, there were two resource students, one English learner, and one GATE student. There was one student listed as "designated instructional service." Overall, eight of the students were re-designated fluent and four were initially fluent upon enrolling at our school. The class average as of April 16, 2012 was 70.8%.

The comparison group, which did not use the Cornell note taking strategy, consisted of forty students. There were twenty male and twenty female students. Furthermore, there were two ninth graders, seventeen tenth graders, fourteen eleventh graders, and seven twelfth graders. There was one resource student. There were no English learners or GATE students in this class. Overall, five of the students were re-designated fluent and five were initially fluent upon enrolling at our school. The class average as of April 16, 2012 was 74.9%.

Treatment

First, I pre-assessed both classes on simplifying, adding, subtracting, multiplying, and dividing fractions, as well as, factoring polynomials. The daily lessons were taught using the same power point presentations for instruction in both classes in order to maintain consistency in all areas apart from note taking. In both classes, I thoroughly explained the concept of prime factorization as a

tool to finding the lowest common multiple of the denominator in order to add or subtract rational expressions. In addition, each class completed the same daily homework problems assigned from the textbook. At the end of the unit the students from both classes took the exact same chapter test. Students demonstrated their understanding of the procedures for each operation by solving numerous multiple-choice questions and they demonstrated conceptual understanding by answering several free response questions. The multiple choice questions were graded by scanning them into Data Director and the free response questions were graded using the Classic Exemplars Rubric from the website http://www.exemplars.com. The rubric consists of three categories: understanding; strategies, reasoning, procedures; and communication. Furthermore, there are four different levels on the rubric and they were assigned points accordingly: novice-0, apprentice-1, practitioner-2, and expert-3. The students were given an overall score, from zero to three, for each free-response question based on the depth of the understanding, efficient strategy and complex reasoning, and clear explanation of their solution. Both the multiple choice and free response scores were compared to the Algebra II class which did not use the Cornell note method.

For the Algebra II class in which I conducted my project, I introduced, explained, and modeled the Cornell note taking strategy for my students by teaching a mini lesson on fraction concepts covered in the pretest. I hoped to accomplish two things by doing this. First, I wanted to review basic rules of

operations on fractions and provide scaffolding for the upcoming unit. Secondly, I wanted to provide a note taking template for the students to follow for subsequent lessons and an opportunity to practice the format with a topic that is familiar to most students. I modeled how I expected the students to highlight main ideas and vocabulary and summarize the notes for homework. Lastly, I provided them with a copy of the rubric which I would be using to grade their notes. This rubric is broken into five categories: page set-up, legibility, notes, questions, and summary. The scores for each section are ranked from one to five, with five being the best. For the purpose of this study, I only considered the last three sections in order to verify the quality of work students put forth with regards to the structure of Cornell Note taking.

At the end of each of the daily lessons the Cornell student group was asked to write two or three questions in the left column of their notes. The questions should reflect the main ideas in the body of their notes, inspire further investigation, or ask for clarification. For homework they were expected to reread their notes, highlight important concepts, and then write a summary on what they had learned. The summary should include main ideas about the lesson, additional questions they still have, and address the essential question for the lesson. The student's notes and homework were collected the following day after going over the homework questions. The Cornell notes, including summaries, were graded using a rubric provided by AVID. In addition, I created

a spreadsheet with the score for each student in order to monitor changes among individual students.

Upon completion of the unit the Algebra II students in both classes provided me with feedback on their note taking experience by completing a short survey. The survey questions indicate if the Cornell group of students followed the entire Cornell note taking process throughout the entire unit. Also, it determines if the control group that did not take Cornell notes employs any of the same strategies of reviewing, questioning, or summarizing in their traditional note taking method and if any of the students used their notes to study for the test. Lastly, the survey is an opportunity to get the student's opinions on how beneficial they felt note taking was to their learning and whether they felt comfortable with their note taking abilities. The survey was completed on a voluntary basis in order to measures students' opinions of note taking. The options of always, sometimes, and never were provided for answer choices and assigned a value of two, one, or zero, respectively.

Instruments. The fraction pre-test consists of seven multiple-choice and four free response questions. The post-test consists of twelve multiple-choice and four free response questions. All of the multiple-choice questions were selected from Examview, a test generating software provided by the textbook publisher with question banks correlating to California state standards and the corresponding chapter on rational functions from the textbook. The original rational functions unit test was created by a group of Algebra two teachers at

Eleanor Roosevelt High School and chosen as a common assessment for this school year. All math teachers at Eleanor Roosevelt High School create and utilize common assessments at the end of each unit. I replaced the regular common assessment with a test that I have created by combining eleven carefully selected multiple-choice questions from the original common assessment with four free response questions. Five of the multiple-choice and three of the free response questions were included on both the pre-test and post-test and used as the covariant.

The quantitative data was collected from multiple choice scores on a pre-test and a post-test, from both the experimental and the control groups, as well as, three sets of notes from each student in the experimental group. The qualitative data was collected from the free response questions on both the pre-test and the post-test, the Cornell notes, and a survey completed by all students. The pre-test was implemented for several reasons. First it was used to determine what knowledge on rational expressions students already had and what misconceptions existed. In addition, it was necessary to provide a foundation for the level of knowledge in each group to determine their growth after the lesson was taught and to rule out any advantages between the groups. The post-test was administered after the lesson and compared with the pre-test in order to measure the conceptual understanding of the fraction concepts addressed in the study. Furthermore, the measures of the gains from pre-test to post-test where compared between the experimental group and the control group

to determine if there is any connection between Cornell Note taking and test performance. The qualitative data was collected from the free response questions on the pre-test and the post-test. The data was compared to determine if the conceptual understanding of fraction concepts had been mastered. In addition, data from a survey was utilized to determine students' perceptions on the purpose and usefulness of note taking as a means of learning new information and preparing for tests.

Data Analysis Procedures

The purpose of this study was to determine if the Cornell note taking strategy had a positive effect on student comprehension on rational expressions, which resulted in improvements on the chapter assessment and an overall deeper conceptual understanding of the concepts. Once all of the data had been collected, I performed a Rasch analysis in order to transform the raw scores into linear interval measures (transformed logits). This transformation places the logit measures on a range of zero to one hundred and makes them more useful for statistical analysis. I compared the mean measures of students from both the pre-test and the post-test in both Algebra II classes. The reliability of person measures has also been recorded. Furthermore, a multiple regression analysis was performed to examine the relationship between group membership (i.e., treatment group (Cornell note students) and the control group) and student measures on the rational expressions post-test. Next, the pre-test scores were

analyzed using a *t* test for two samples with equal variances to determine if the two groups were statistically equal at the start of the study.

In order to answer the research question #1, regarding test performance, the average gain between the pre-test score and post-test score from each group was calculated and compared. In addition, a *t* test was calculated between the pre-test and post-test for each group to determine if there was any significance in the individual gains for each group. In addition, an ANCOVA between the pre-test and post-test was conducted to control for any differences in the groups as reflected in their pre-test measures.

For question #2 with regard to the Cornell Notes scores, the average scores from each set of notes was compared to evaluate an increase or decrease in scores over the course of the unit. Following the averages, the gains between each of the notes was calculated, and an average gain for each student was obtained. Finally, an ANCOVA test was performed on all three sets of notes for each student in the experimental group in order to further investigate the mean gain differences. The pre-test to post-test gains were then compared with the Cornell Notes gains.

To evaluate the free response questions on the pre and post-tests, and answer question #3, each question was scored using the Classic Exemplars Rubric from the website http://www.exemplars.com. The scores for like questions were then compared side by side to determine if there was any improvement in conceptual understanding on fraction concepts. Next, I aligned

the gains from the Cornell notes with the gains from the free response questions to determine if there is a relationship with note taking scores and free-response scores. The qualitative findings from the free-response and Cornell notes' scores will provide additional information to support any findings from the quantitative analyses.

The fourth question refers to the students' responses on the survey. This question is also analyzed qualitatively to determine the amount of effort and participation in note-taking, the students' perception of their own note-taking abilities, and whether the notes were review, summarized, and/or used to study for the unit test. The possible answers for each of the survey questions were Always, Sometimes, or Never. They were given points 2, 1 and 0 respectively. For negatively asked questions the reverse points were given. It was determined by the point system assigned that a score of 4 or less would mean no effort was given to using notes as a tool for learning. A score between 5 and 11 would imply some effort was made to use notes to study, however student may not be confident or may have low abilities in taking notes. A score of 12 to 20 suggests confidence in note taking and uses the components of the Cornell note taking method for the most part. The findings from the scores on the survey will provide additional information to support the quantitative results.

CHAPTER FOUR

RESULTS OF USING CORNELL NOTES IN MATH

Results and Discussion

Presentation of the Findings

This section is dedicated to presenting the findings of the study on using Cornell Note taking in a secondary mathematics class. Question #1 of the study focuses on determining whether teaching students the Cornell Note taking method in a high school mathematics Algebra II class would improve the mathematics achievement of students on a multiple choice rational expressions unit test. This part of the study uses a quantitative analysis to measure the mean gain difference in math test scores between a pre-test and post-test given to two different Algebra II classes, referred to as the experimental group and the control group. An independent samples t-test on the pre-test was performed to rule out any differences in the initial achievement levels between the experimental and control group.

The second research question also consists of a quantitative study. Question #2 of the study deals with the comparison of the students' Cornell Notes scores with the measured achievement on the multiple choice portion of the post-test. Three sets of notes were collected and scored according to a Cornell Notes rubric found on the AVID website (http://avid.org). I specifically used three essential elements of Cornell notes to score the students: reviewing,

questioning, and summarizing. The rubric measures the amount of effort placed on reviewing their notes as evidenced by highlighting, underlining, and revising of the notes. Next, the rubric measures the level of questions asked by students according to Blooms taxonomy. Lastly the rubric signifies the quality of the summary the students wrote at the end of each section. These scores were totaled and entered into an excel spreadsheet. The gains for each student were measured between each of the three sets of scores and an average gain was obtained for each student. These were then compared to the gains calculated between the pre-test and post-test scores in order to determine if there were any similarities in achievement on note taking versus test achievement.

The third research question is also a quantitative design. Both the control group and the experimental group completed a pre-test and post-test on concepts from the unit on rational expressions. Each test consisted of both multiple choice and free response questions. There were four free response questions on each test. The first and fourth questions are identical, and relate to the concept of finding the lowest common denominators of rational expressions in comparison to common denominators of numerical expressions. The second question on the pre-test examines the concept of equivalent numerical fractions. On the post-test, however, the second question asks students to simplify a rational expression by using factoring in order to find an equivalent fraction. The third questions are both error analysis type questions related to common errors made when simplifying fractions, however on the pre-test it is completely

numerical while on the post-test it is algebraic. The purpose of designing the pre-test and post-test in this manner was to determine if students had progressed in their conceptual understanding of fraction concepts with regards to common misconceptions on equivalent fractions, simplifying rational expressions, and prime factorization. The free response questions were scored using the Classic Exemplars Rubric from the website http://www.exemplars.com. The scores for both the multiple choice and the free response questions on both the pre-test and the post-test were both included in the Rasch Analysis, which I converted to linear interval measures. Furthermore, I evaluated the questions individually and compared like questions from both tests to each other to determine if progress had been made in the conceptual understanding of the topics.

Research question #4 is a qualitative analysis, which was included to determine the students' perception of the purpose and importance of note taking with regards to learning new information and studying for a test. All students in both the experimental and control groups were given the survey. Each survey question could be answered by one of the following three choices: always, sometimes, or never. Several questions on the survey were asked to determine the level to which the students used each of the key elements of a structured note taking method. In addition, students were asked about their confidence level on their ability to take good notes. Furthermore, the survey inquired about their use of notes to study for the unit test. This will help to qualitatively determine if there is a relationship between those students who stated they used

the Cornell note taking method completely as instructed, from taking notes, to reviewing, questioning, summarizing, and up to studying for the test. This information could then be compared with their achievement on the post-test.

Data Analysis

In order to establish a beginning measure for the two groups a pre-test was given. After implementing the Cornell Notes taking method to the experimental group a post-test was given to all students in both groups. The descriptive statistics for the pre-tests and the post-tests for each group were calculated and the results are shown in Table 1. All scores are represented as transformed logits.

Table 1
Group Statistics: Pre-Test and Post-Test Scores

	N	Mean	Std. Deviation	Std. Error
Pre-Test				
Experimental Group	36	33.05	8.96	.16
Control Group	39	34.64	10.74	.26
Post-Test				
Experimental Group	29	46.08	5.65	1.05
Control Group	33	47.77	5.11	.89

The statistical analysis shows that there was no significant differences in the mean math scores between the experimental group (M = 33.05, SD = 8.96)

and the control group (M = 34.64, SD = 10.74) on the rational expressions pre-tests. In addition, there was no significant difference in the mean math scores between the experimental group (M = 46.08, SD = 5.65) and the control group (M = 47.77, SD = 5.11) on the rational expressions post-test. The data is represented in the following graph, figure 1.

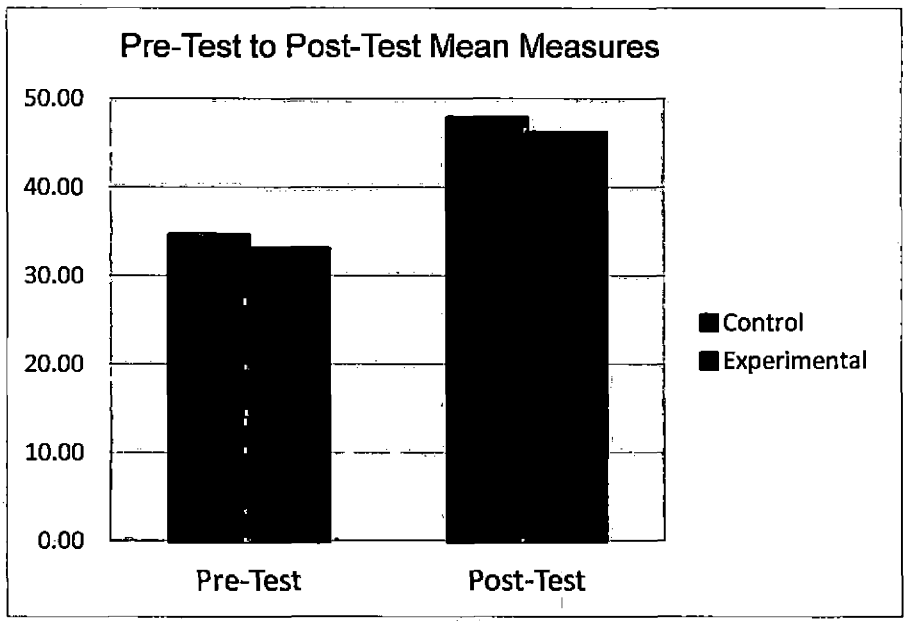

Figure 1. Pre-Test to Post-Test Mean Measures

Next, an independent sample *t*-test was performed to compare the two groups prior to teaching the lesson on rational expressions to determine if there was a significant difference in abilities between groups prior to administering the treatment to the experimental group. Along with the *t*-test, an F ratio was obtained to determine if there were any differences in the variances of the two groups. Table 2 shows the results from comparing the variances on the pre-test.

Table 2
t-Test Independent Samples: Pre-Test Scores

	Df	Mean	F	P
Experimental Group	36	33.05	1.44	0.14
Control Group	39	34.64		

The F ratio was calculated to be F = 1.44, and p = 0.14. Since p = 0.14 is greater than 0.05, it was determined that the F ratio is not significant, therefore the variances for the experimental and control group can be considered equal. Since the variances were found to be equal, I was able to utilize the summary data from the *t*-test for independent samples with equal variances, which are compiled in Table 3.

Table 3
t-Test Independent Two-Sample, Equal Variance: Pre-Test Scores

	t	Df	Sig. (2-tailed)	Mean	95% Confidence	
			p	Difference	Lower	Upper
Both Groups:	-0.7	75	0.49	-1.58	-6.09	2.92

The *t*-test was used to determine if the two groups are similar in mean values and to establish the equality of the two groups with respect to the pre-test. There was no significant difference in results of the math pre-tests; *t*(75) = -0.7,

p = 0.486, since p = 0.486 is greater than 0.05, therefore it has been established that the two groups are considered similar in abilities prior to administering the treatment.

After implementing the treatment of using Cornell Notes to the experimental group, each group was given a post-test. I performed a *t*-test for independent samples between the pre-test and the post-test for each individual group. This would allow me to see if there was any difference noticed in the mean gains between the two groups and allow me to measure the amount of achievement of each group individually and then compare the results. Table 4 displays the results of the two separate *t*-tests for the gains between the pre-test and the post-test scores.

Table 4

t-Test Independent Two-Sample: Pre-Post Test Gain Scores

	T	*Df*	Sig. (2-tailed)	Mean Difference	95% Confidence Lower	Upper
Experimental Group	-0.87	36	0.39	-3.0592	-10.19	4.08
Control Group	-1.23	39	0.22	-4.7672	-12.59	3.06

Table 4 shows the results of the *t*-test between the math pre-tests and post-tests. The results of the experimental group show $t(36) = -0.87$, $p = 0.39$, and the control group show $t(39) = -1.23$, $p = 0.226$. Since p = 0.39 and p =

0.226 are both greater than 0.05, there was no significant difference in results of the *t*-test between the math pre-tests and post-tests. Therefore, it was found that there was no significant difference in gains between the experimental group and the control group on the post-test.

Although I chose to do a *t*-test between the pre-test and post-test to measure the significance in gains, I also elected to perform an ANCOVA and I adjusted for any initial difference in groups by using the pre-test as the covariate. Table 5 shows the results of the ANCOVA.

Table 5
ANCOVA: One-way, Independent Samples, Pre-Test Covariate

Source	SS	Df	MS	F	P
adjusted means	4.37	1	4.37	0.05	0.82
adjusted error	4981.24	57	87.4		
adjusted total	4985.61	58			

Table 5 shows F = 0.05 and p = 0.82. Since p = 0.82 is greater than 0 .05, there is no statistical difference between the two groups. The ANCOVA implies both groups are equivalent in gains between the pre-test and post-test.

Out of the thirty-six students in the experimental group, only sixteen of them turned in all three sets of Cornell Notes to be graded. An ANOVA test for independent samples was conducted comparing each set of notes. Each of the three categories for note taking were given a score between 0 and 5 for a total of

15 possible points. Table 6 shows the mean and standard deviation for each set of the graded notes.

Table 6
ANOVA: Independent Samples, Cornell Notes Scores, Students With 3 Notes

	N	Mean	Std Dev.	Std error
Cornell Notes #1	16	9.63	3.05	0.76
Cornell Notes #2	16	9.25	2.14	0.54
Cornell Notes #3	16	8.75	2.86	0.72

According to the ANOVA data, the mean values for Cornell Notes #1, Cornell Notes #2, and Cornell Notes #3 are 9.63, 9.25, and 8.75 respectively. While there is very little change in the mean values over the course of the rational expressions unit, it does show a slight decrease in values from the first note taking lesson to the last. This is visually depicted in the following graph, figure 2.

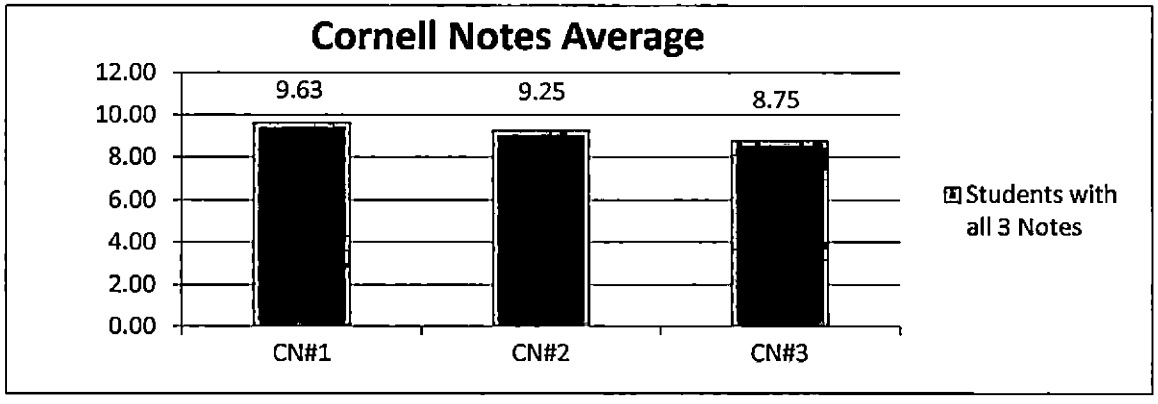

Figure 2. Cornell Notes Average

Table 7 shows additional data taken from the ANOVA test of independent samples.

Table 7
ANOVA: Independent Samples, Cornell Notes Summary

Source	SS	df	MS	F	P
Between Groups	6.17	2	3.08	0.6	0.55
Within Groups	331.75	45	7.37		
Total	337.92	47			

Table 7 shows F = 0.06 and p = 0.55. Since p = 0.55 is greater than 0.05, there is no statistical difference between the scores of the three graded Cornell Notes. Therefore, the students were consistent in their abilities on Cornell note taking throughout the unit on Rational Expressions.

Next, I quantitatively compared the mean gain scores from the students who turned in all three sets of notes to the gain scores from their pre-test to post-test for the of the experimental group. The results are displayed in the following bar graph, figure 3.

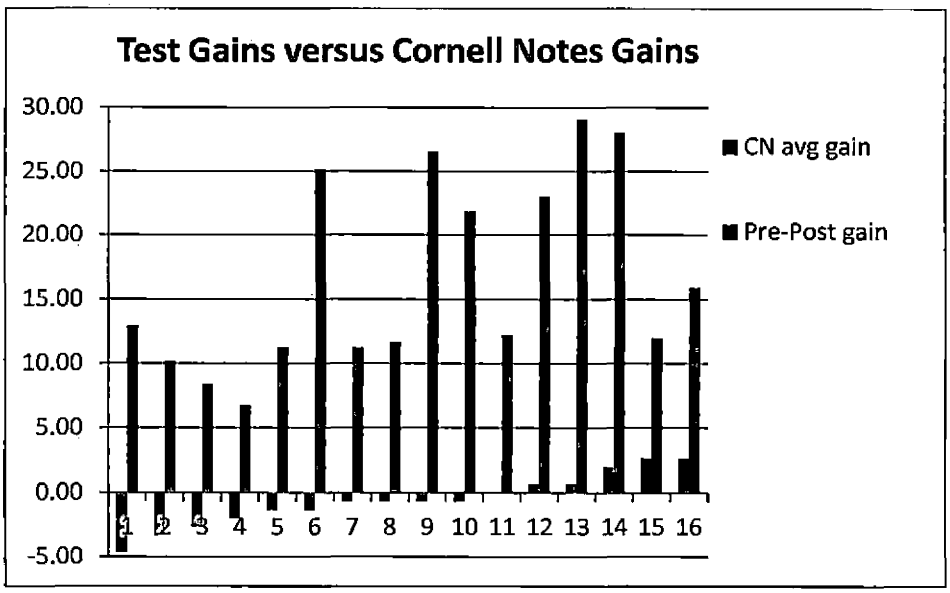

Figure 3. Test Gains versus Cornell Notes

According to the chart, students who experienced a loss in Cornell notes still showed some achievement in test scores. Three of the students with the highest gains in test scores showed some improvement in Cornell notes and three showed no gain or a loss. There were five total student gains in Cornell notes, one with no gain or loss, and ten students with losses. The average gain for the Cornell notes was actually a loss of -0.58. The average increase in tests scores for the same students was 16.65 points. Three out of the eleven students with losses had test gains over fifteen points, about 27% of the students. One significant finding is that of the five students that did show a gain in Cornell Notes, four of them had test gains over fifteen points, which is 80% of the students in this group.

In order to answer question #3, I compared the scores from the free response questions on the pre-test to the corresponding questions on the post-test to determine if there was any improvement in the students' understanding of fraction concepts. Each question was given a score ranging from 0 to 3 points. Table 8 shows the results of the difference in average gains for each free response question.

Table 8

Free Response Comparison

	Q #1	Q #2	Q #3	Q #4	Total
Control Group average gain	0.82	0.27	0.88	0.73	2.70
Experimental Group average gain	0.52	0.24	0.79	0.76	2.31
Difference in gain	0.30	0.03	0.09	-0.03	0.39

Table 8 shows that on question #1 there was the largest difference of 0.30. This question related to finding the lowest common denominator in order to add algebraic fractions. This question was identical on both the pre-test and post-test. On questions #2, #3, and #4, there is very little difference in the gain values between the pre-test and the post-test free response questions. On question #4, the experimental group slightly exceeded the control group in gain measures. This question asked students to determine the lowest common multiple between two given terms, both numerical and algebraic, and describe

the similarities or differences. In addition, the post-test gave an example of polynomial terms. In order to research the data further, table 9 was created to compare the free response scores of the students who turned in all three sets of Cornell Notes to the control group.

Table 9
Free Response Comparison (All 3 Notes)

	Q #1	Q #2	Q #3	Q #4	Total
Experimental (3 notes) average gain	0.50	0.63	1.13	1.25	3.51
Control Group average gain	0.82	0.27	0.88	0.73	2.70
Difference in gain	-0.32	0.36	0.25	0.52	0.81

Table 9 shows that the students who took all three sets of notes had higher scores on three out of the four free response questions. Question #1 was the only exception as noticed in table 8. Not only did this subgroup score higher, their total average gain exceeded the control group by 0.81.

The survey which was used in the study is included in the appendix. There are twelve questions total. Four of the questions addressed the student's self perceived ability to take notes, five questions determined whether they implemented the review, questioning, and summarizing procedures of Cornell notes, and three questions about their opinion on the purpose of note taking. Each question was given a score ranging from 0 to 2 points. The average scores

for each question for both the experimental group and the control group are included in Table 10 along with the difference of each.

Table 10
Survey Results

Question #	1	2	3	4	5	6	7	8	9	10	11	12
Experimental Group	1.48	0.52	1.21	0.69	0.72	0.52	1.03	1.07	1.00	1.31	1.83	1.72
Control Group	1.71	0.65	1.26	0.52	0.48	0.48	0.77	0.26	0.97	1.39	1.74	1.68
Difference	-0.23	-0.13	-0.05	0.17	0.24	0.03	0.26	0.81	0.03	-0.08	0.09	0.05

The survey results show that on the first three questions the control group scored higher than the experimental group. Question #1 asks the students if they feel they are good note takers. More students in the control group felt they are good note takers. The control group also scored slightly higher on questions #2 and #3. This means that the control group felt slightly more confident in the note taking abilities with regard to what to write down and using abbreviations, however the difference is very small. Question #4 is about being able to keep up with the lecturer while taking notes. The experimental group, who used Cornell Notes, felt more able to keep up with taking notes during the lecture. Questions #5 through #8 are related to the Cornell Note taking processes of reviewing notes within twenty-four hours after writing them, highlighting main ideas, summarizing, and reviewing prior to the test, respectively. While the two groups were pretty even on question #6, in all four of the questions the experimental group scored

higher than the control group. Question #8, regarding summarizing, had the most noticeable difference. The experimental group scored higher by a difference of 0.81. The scores for questions #9 through #12 were very close. Question #9 asked about reviewing their notes before the test and there was only a slight difference of 0.03. The control group scored higher by a difference of 0.08 on question #10, which asked the students if they feel notes are helpful in preparing for the test. Question #11 asked both groups if they have used Cornell notes in other content areas and the two groups scored similarly with a slight difference of 0.09 led by the experimental group. Question #12 asked if the students felt note taking is important for learning new information. Both groups answered similarly again, with a difference of only 0.05. Overall, the experimental group, which was taught the Cornell Note taking method, scored higher on eight of the twelve questions.

Discussion of the Findings

The results of the pre-test and post-test descriptive statistics revealed that the control group slightly outscored the experimental group in both cases. According to the *t* test, there was no significant difference in the scores because they were so close. In analyzing the scores for each individual group, it was found that the percentage increase from the pre-test to the post-test for the experimental group slightly exceeded the control group by 1.5%. Therefore, the Cornell Note taking group showed more improvement on the scores for the multiple choice questions from the pre-test to the post-test. With regard to

research question #1, students who took Cornell notes out-performed those who did not on the multiple choice rational expressions unit test.

In order to answer the second research question I compared the Cornell Notes scores to the test scores. Even though there was a slight decrease in the scores from the first set of notes to the last, the ANOVA test showed that there was no significant difference in gains from the three sets of Cornell Notes. This implies that the students maintained the same ability in Cornell Note taking skills throughout the lesson. The Cornell Note scores may have slightly decreased because the material became more difficult over the course of the unit. When comparing all students in the experimental group, there was no correlation found between gains in note taking and gains in test scores. However, out of the sixteen students who turned in all three sets of Cornell notes, five of the students showed a gain in note taking scores and had an average test gain of approximately twenty-one points. Therefore, eighty percent of this subgroup achieved gains of more than fifteen points. In comparison, the other eleven students had a loss in note taking scores and an average test gain of fourteen points. Only twenty-seven percent of this subgroup had test gains over fifteen points. Therefore, the students who achieved gains in the Cornell note taking method had higher average test scores. In conclusion, a positive correlation was found between Cornell Note taking and test achievement.

With respect to the performance on the free response questions on fraction concepts, the control group scored higher on the question related to

finding the lowest common denominator in order to add two rational expressions when compared to all students in the experimental group. On all three of the other free response questions the control group also scored higher, however the amounts were found to be insignificant. However, when the scores from the control group were compared to the scores from the sixteen students who turned in all three sets of Cornell notes, the results were drastically different. On three out of four of the free response questions, the average gain in scores from the experimental subgroup exceeded the control group. On question #2, related to simplifying rational expressions, the experimental subgroup scored higher by a difference of 0.36. On question #3, related to error analysis for "canceling," the same subgroup was higher by 0.25. Lastly, on question #4, students were asked to describe similarities and differences between three given problems about finding the LCM, the experimental group scored higher by 0.52. The only question in which the control group scored higher than the experimental group was regarding finding the lowest common denominator in order to add two rational expressions. The control group scored higher by a difference of 0.32 in both comparisons. This shows that the control group scored higher on the procedural question, yet the experimental subgroup of students who were proficient in Cornell Note taking, scored better on questions requiring higher level thinking skills and explanations.

The survey results confirmed that most students feel that they are good note takers, have little difficulty deciding what to write, and are able to keep up

with the lecture while writing notes. Therefore, the in-class portion of the note taking process seems to be working for most students. However, most of the students admitted that they did not spend at least five minutes to review their notes within twenty-four hours after writing them nor prior to the next lesson. Furthermore, less than half of the students in the control group did any kind of highlighting or editing and approximately one-eighth of the students in the control group did any summarizing. This proves that reviewing and summarizing are not common practices for the majority of the students. Just slightly over one-half of the students in the experimental group did the required reviewing and summarizing, however not within the first twenty-four hours. Over one-half the students in each group agreed that they used their notes to study for the test and felt this was helpful to them. Surprisingly, a majority of the students from both groups reported using the Cornell note taking method in other classes and agreed that note taking is an important process for learning new information. Overall, the experimental group which was taught the Cornell Note taking method scored higher than the control group on nine out of the twelve questions. This shows that the experimental group did follow the note taking process to some extent and students who are not asked to follow a particular note taking structure do not normally do the reviewing, editing, and summarizing tasks. One study of three note taking methods (including column notes, mini books, and traditional) in a geometry class found that "a positive relationship can be found between changing the traditional style of note taking and student perception of their own

increased use of note taking and understanding of material" (Walmsley, A., & Hickman, A., 2006). There is significant value found in teaching students how to take notes that is worthy of further research.

CHAPTER FIVE

USING CORNELL NOTES IN MATH SUMMARY

Summary, Conclusions, and Recommendations

Summary

After seven years of teaching high school mathematics, I was shocked to discover that many students at all levels of mathematics, from Algebra to Pre-Calculus, continue to struggle with fraction concepts. While teaching the unit on rational expressions each year, I noticed that many of my students had difficulty with simplifying rational expressions using prime factorization, finding lowest common multiples, and knowing when it is appropriate to "cancel" or divide common factors in the numerator and denominator. Fraction equivalence and prime factorization are key concepts for understanding the unit on rational expressions.

I chose to use the Cornell Note taking method as my treatment because it has been a well known note taking strategy for increasing test achievement amongst law students at Cornell University since 1949. The Cornell Note taking method encompasses three stages: the in-class note taking, the reviewing and questioning, and the summarizing. All stages should be done within twenty-four hours of taking the notes in order to increase the ability to retain the new information over a longer period of time. Many other note taking structures have been invented; however the Cornell method is the only one that includes both the

note taking phase, which focuses on listening and encoding information, and the studying phase which include the reviewing, questioning, and summarizing. According to research over many decades, the latter process is the key to moving information from the short term memory to the longer term memory for learning and retaining new information. The Cornell note taking method stimulates critical thinking skills and help students better prepare for tests.

The purpose of my project was to determine whether students who learn how to use the Cornell Note Taking method would develop a deeper conceptual understanding of concepts involving rational expressions, such as simplifying, multiplying, dividing, adding, and subtracting. My research determined in what areas high school mathematics students who use the Cornell Note taking method differ from those who use other forms of note taking with regard to the following four topics:

1) performance on a multiple choice rational expressions unit test?

2) comparison of Cornell notes scores and test performance to determine if there is a correlation between note taking and gains in achievement?

3) performance on free response questions on concepts underlying simplification of rational expressions?

4) Students' responses to a note taking survey regarding their note taking habits?

Method. I chose one Algebra II class as the control group and one as my experimental group. Both classes were given a pre-test. I taught the

experimental group the purpose and format for taking Cornell notes, including how to write questions and summaries, and then I gave them a rubric. The control group was taught the same pre-requisite lesson without the Cornell strategy. Next, I taught both classes the entire unit on rational expressions using the same PowerPoint presentations, same direct teaching style, and the same assignments. Finally, both classes were given the same post-test for the unit and asked to complete a survey immediately afterward. The entire unit took six block days to complete.

Instructional Tools. The Cornell Note taking method was the treatment used in the experiment and consisted of three sets of notes collected and graded using the rubric from the AVID website. Both a pre-test and post-test were given to both classes and included multiple choice and free response questions. The survey asked the students to respond by answering always, sometimes, or never to twelve questions pertaining to their perception of their note taking abilities, whether they did any reviewing and summarizing, and if they used their notes to study for the test.

Instructional Design. The study consists of both a quantitative and a qualitative design. The pre-test and post-test scores, the Cornell note scores, and the free response scores are all compared quantitatively to determine any numerical gains in achievement. The free response questions and survey were analyzed qualitatively and the results were used to support any quantitative findings.

Results. Research questions #1 asks to investigate the results on the rational expressions unit test. The results from the pre-test to post-test gains measured showed the control group had higher overall scores. The *t* test reported no significant difference in gains. This is most likely due to the fact that the pre-test and post-test scores were so close together. However, the experimental group showed a slightly higher percentage increase in values (39.4%) from the pre-test to the post-test than the control group (37.9%), a difference of 1.5%.

Research questions #2 asks to compare the results of the Cornell note taking scores to the test scores. First, the results from the three sets of Cornell notes scores were analyzed individually and they showed that the students had a slight decrease in average values from the first set of notes taken to the last. The ANOVA test on the three sets of notes showed no significant difference in scores, most likely because they were so close in value. Next, the gain scores from the notes were compared to the gains from the pre-test to post-test scores. At first the results didn't seem to correlate. Some students did poorly on notes, but did great on the test and then others did great on notes, yet poorly on the test. However, with further review it was discovered that only sixteen of the students turned in all three sets of notes. The test scores were compared for these students and the results showed that five of the students had gains in Cornell notes and also had test gains. The other eleven students in the group had a loss in scores on notes, but still showed gains in test scores. The eleven

students had an average gain of fourteen points and three of them had a gain over fifteen points (27%). The five students with gains in notes had an average gain of twenty-one points and four of the five scored over fifteen points (80%). Therefore, the students that turned in all three sets of notes and showed gains in their scores also had the highest gains in test scores.

Research questions #3 asks to investigate the results on the free response questions on the rational expressions unit test and compare with the pre-test free response questions to determine if students showed better understanding of fraction concepts. When comparing the results of the free response questions for both groups, the control group showed slightly higher scores than the experimental group on three out of the four questions. Questions number one on the free response showed the largest difference, with the control group 0.30 points higher than the experimental group. The other three questions had differences of less than 0.10. However, once I compared the free response scores from the control group to the sixteen students in the experimental group that turned in all three sets of notes, the results changed dramatically on three of the four questions. The experimental subgroup scored higher on questions two, three and four by 0.36, 0.25, and 0.52 respectively. The control group still out-scored the subgroup on question number one by 0.32 points. The experimental group scored higher by 0.81 points overall. Furthermore, the first question is more procedural, whereas, the other three questions required higher level

thinking. Therefore, those who turned in all three sets of notes were better able to find similarities and differences and summarize their results.

Research questions #4 explores the minds of the students with regard to note taking procedures and regular habits. The qualitative results of the survey showed that overall, both groups used notes to study for the test and agree that note-taking is an important tool for learning new information. As expected, the experimental group which learned how to review, write questions, and summarize, scored higher on eight of the twelve questions. The most significant difference of 0.81 points was seen on question number eight regarding summarizing. Surprisingly, neither group read and reviewed their notes every day within twenty-four hours. Also, it was interesting to find that an equal number of students in the control group have been exposed to the Cornell note taking method in other classes, although they did not follow the procedures during this unit as evidenced by the survey.

Conclusion

The results of this study indicate that for those students that turned in all three sets of notes, there was a correlation between note taking and test achievement on both multiple choice and free response questions. The survey indicates that most students understand the importance of note taking and the benefit of using their notes to study for a test. However, unless students are required to review, write questions, and summarize their notes and held accountable for these responsibilities they would elect not to do them at all.

These steps are the key elements to helping students achieve higher order thinking skills and retain information for longer periods of time. Even just exposing students to a new method for taking notes and helping them to feel more confident in the process will help prepare students to conceptualize more rigorous information in the future. One study of three note taking methods (including column notes, mini books, and traditional) in a geometry class found that "a positive relationship can be found between changing the traditional style of note taking and student perception of their own increased use of note taking and understanding of material" (Walmsley, A., & Hickman, A., 2006). Even though this was a very small unit of study conducted over a short period of time, positive results can be found which warrant further research in the area of Cornell note taking in mathematics and test achievement.

Significance. My project has had an immediate and significant impact on the students in my Cornell note taking group. The Algebra II students in my study group were exposed to a different note taking style, which is rarely seen in a mathematics classroom. The Cornell note strategy focused on teaching students how to identify main ideas, understand key vocabulary, promotes higher level thinking and questioning, as well as, how to summarize their thoughts. Furthermore, when students performed the above activities, they were also developing meta-cognitive skills for learning, understanding, and remembering new material. In 1885, Hermann Ebbinghaus researched how much the brain remembers over time, called the curve of learning. Today the AVID program

advocates the same concept called the curve of forgetting borrowed from research from the University of Waterloo. "The essence of this research demonstrates the need for students to revisit information, in order to kick the information out of the short-term memory and store it in the much more reliable long-term memory" (www.AVIDcollegeready.org). Therefore, research over the last one hundred years undeniably proves that when notes are used properly as a study guide and reviewed frequently students retain the important concepts much longer. By changing one simple note taking procedure in the mathematics classroom, students were provided with a beneficial way to organize new information and obtained study skills that enabled them to better prepare for taking their assessments if done properly.

The students in my study benefited from learning how to take organized notes, learning how to apply higher level thinking to math concepts, and by obtaining study skills which will make them more college and career ready. Furthermore, Cornell Notes are one of the components of the AVID curriculum used successfully in other subjects in high schools throughout the nation to help prepare students for college. According to statistics provided on the AVID website, 89% of all AVID students in California applied to a four year college in the 2010-2011 school year and 74% of those students were accepted (http://www.avid.org/abo_dataandresults.html).

Implications. Results of this study will be shared with fellow teachers in the math department and should have a scientific base for or against the use of

Cornell notes in our math classrooms. The math department is especially lacking in strategies and techniques relating to writing in the curriculum. Many mathematics teachers at my school continue to teach their students the same way they were taught, using direct instruction. Students are rarely asked to engage in discussions or produce any written assignments. Furthermore, there is no common note taking method used throughout the math department. Students must rely on their own note taking skills either learned in other content areas or not at all. This is a critical missing component in helping students prepare for college. This study provides teachers with the option of implementing Cornell notes in their classrooms in order to improve test achievement and study skills necessary for college.

One small adjustment in the way that academic information is recorded and utilized by students, in effect, could change how the curriculum is taught in mathematics classrooms in the future. Our students must be prepared for the increase in rigor in college by implementing more writing and critical thinking into the high school math classroom. Students must know how to problem solve, explain their ideas, and justify their thinking in order to survive in today's ever changing technologically advanced world. By teaching students a note taking method that incorporates these skills, teachers will be making students more college or career ready. "Note-taking is a valuable skill for students in middle and high school and will become an essential skill as students take on greater

responsibility for their own learning in college and in their careers as professionals" (Boyle, 2011, 61).

Limitations. This study was conducted during one unit on rational expressions which took place over six block periods in two separate Algebra II classes. Due to this unit taking place at the end of the regular school year, there was little time for repetition of concepts. The method of the study was established and each lesson was taught once, practice problems were completed in class, and then students worked independently on homework after school. The students were also expected to perform the review, questioning, and summarizing at home on their own following the rubric. This may or may not have had an impact on the conceptual understanding of the unit, depending on the individual student. Some students may have needed more time for practice or repetition. Another limitation from the time constraint was related to providing feedback to students on their notes. The students received feedback on the first two sets of notes prior to the test. I did not collect their last set of notes prior to the test because this would prohibit them from being able to use them to study. I collected the last set of notes on the day of the test. Many of the students did not turn in one or more sets of their notes when due. Since this was a new requirement for the class they had a tendency to forget to bring them the next day. Holding the students accountable for the data necessary to the study was difficult. It may have been beneficial for the students to complete the reviewing, questioning, and summarizing in class; however either way the notes could not

be collected because the students would not be able to review them within the recommended twenty-four hours.

Recommendations. The Cornell note taking strategy in itself is a more complex process than I originally expected. I found that the students had a difficult time creating higher level questions in mathematics. In addition, the summaries turned in where very repetitive of the words in the notes. The students struggled to put their thoughts into their own words and make connections on their own. Therefore, I recommend spending more time helping the students to become proficient in these areas prior to implementing any material related to the study. In addition, it may have been more beneficial for the students to read their questions and summaries to the other students in class in order for them to help each other improve their skills by hearing multiple examples from their peers. This would have also provided a good review prior to beginning the next lesson. Furthermore, since the students had never answered free response type questions on tests that asked for similarities and differences or explanations, there should have been questions given in class that gave opportunities for them to expand their thinking skills in this area. Lastly, it may have been beneficial to the study to have the students complete a survey on their perspectives on note taking prior to the study, in addition to the one afterward. This would measure if there were any changes in their opinions over the course of the unit. I definitely believe that more research is needed in this area. Students had a lot of difficulty working cognitively at higher levels, completing

their writing in a coherent manner, and putting their thoughts onto paper in their own words. Cornell notes are a great vehicle to enhancing the necessary skills that will better prepare students for college and career choices and enable them opportunities otherwise unavailable. Further research on Cornell notes should include a longer time period to establish the note taking strategies and also to measure growth over multiple concepts.

APPENDIX A

RUBRICS

Name: _____ Quarter: _____ Begin Date: _____ Period: _____

Student Handout 3.5

Cornell Notes Rubric

	5	4	3	2	1
Page set-up	• All parts (name, date, class, and topic) are clearly labeled in the correct place.	• All parts but one (name, date, class, and topic) are clearly labeled in the correct place.	• Some parts (name, date, class, and topic) are labeled in the correct place.	• Missing 2 parts (name, date, class, and topic) but are correctly labeled.	• Missing 3 or more parts (name, date, class, and topic) and may not be in the proper location.
Legibility	• Neat and completely legible	• Completely legible	• Mostly legible	• Mostly non-legible	• Not legible
Notes	• Notes are selectively and accurately paraphrased. • Use of logical abbreviations. • Notes have been edited. • Key word have been highlighted and/or underlined. • Revisions/additions are made in a different color.	• Notes are selectively and accurately paraphrased. • Use of logical abbreviations. • Some key words have been highlighted or underlined. • Partial revisions/additions are made in a different color.	• Notes may/may not be accurate, information not always paraphrased. • Some use of abbreviations. • No highlighting or underlining evident. • No revisions made.	• Notes are incomplete. • No use of abbreviations.	• Notes do not reflect Cornell Note format
Questions	• Questions check for understanding, and directly reflect notes (see Bloom's level 1 & 2 or Costa's level 1). • Questions also include Bloom's level 3–6 or Costa's level 2 & 3 as appropriate.	• Questions check for understanding, and directly reflect notes (see Bloom's level 1 & 2 or Costa's level 1). • Most questions are lower level in Bloom's or Costa's.	• Questions are basic and may reflect notes (see Bloom's level 1 & 2 or Costa's level 1). • Most questions are lower level in Bloom's or Costa's.	• Questions are limited and do not accurately reflect notes.	• Questions are missing.
Summary	• Shows learning by effectively identifying all main ideas.	• Shows learning by effectively identifying some main ideas.	• Summary is re-stating of notes but is connected to some learning.	• Summary is a re-stating of the notes and is not connected to learning.	• No summary

Achievement Via Individual Determination (AVID), http://www.avid.org

Classic Exemplars Rubric

Level	Understanding	Strategies, Reasoning, Procedures	Communication
Novice 0	• There is no solution, or the solution has no relationship to the task. • Inappropriate concepts are applied and/or procedures are used. • The solution addresses none of the mathematical components presented in the task.	•No evidence of a strategy or procedure, or uses a strategy that does not help solve the problem. • No evidence of mathematical reasoning. • There were so many errors in mathematical procedures that the problem could not be solved.	• There is no explanation of the solution, the explanation cannot be understood or it is unrelated to the problem. • There is no use or inappropriate use of mathematical representations (e.g. figures diagrams, graphs, tables, etc.). • There is no use, or mostly inappropriate use, of mathematical terminology and notation.
Apprentice 1	• The solution is not complete indicating that parts of the problem are not understood. • The solution addresses some, but not all of the mathematical components presented in the task.	• Uses a strategy that is partially useful, leading some way toward a solution, but not to a full solution of the problem. • Some evidence of mathematical reasoning. • Could not completely carry out mathematical procedures. • Some parts may be correct, but a correct answer is not achieved.	• There is an incomplete explanation; it may not be clearly presented. • There is some use of appropriate mathematical representation. • There is some use of mathematical terminology and notation appropriate of the problem.
Practitioner 2	• The solution shows that the student has a broad understanding of the problem and the major concepts necessary for its solution. • The solution addresses all of the mathematical components presented in the task.	• Uses a strategy that leads to a solution of the problem. • Uses effective mathematical reasoning. • Mathematical procedures used. • All parts are correct and a correct answer is achieved.	• There is a clear explanation. • There is appropriate use of accurate mathematical representation. • There is effective use of mathematical terminology and notation.
Expert 3	• The solution shows a deep understanding of the problem including the ability to identify the appropriate mathematical concepts and the information necessary for its solution. • The solution completely addresses all mathematical components presented in the task. • The solution puts to use the underlying mathematical concepts upon which the task is designed.	• Uses a very efficient and sophisticated strategy leading directly to a solution. • Employs refined and complex reasoning. • Applies procedures accurately to correctly solve the problem and verify the results. • Verifies solution and/or evaluates the reasonableness of the solution. • Makes mathematically relevant observations and/or connections.	• There is a clear, effective explanation detailing how the problem is solved. All of the steps are included so that the reader does not need to infer how and why decisions were made. • Mathematical representation is actively used as a means of communicating ideas related to the solution of the problem. • There is precise and appropriate use of mathematical terminology and notation

Exemplars® K-12 We Set the Standards!

Classic Exemplars Rubric (2006). Retrieved from http://www.exemplars.com/assets/files/math_rubric.pdf.

APPENDIX B

CONSENT FORMS

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO

College of Natural Sciences
Department of Mathematics

LETTER OF CONSENT OF PARENT/GUARDIAN

Mrs. Tammy Young is conducting a master's thesis project through the Master's in Teaching Mathematics (MAT) program at California State University, San Bernardino (CSUSB) under the direction of Dr. Laura Wallace, Professor of Mathematics. The Institutional Review Board at CSUSB has reviewed and approved this project. Your child is being asked to participate in certain classroom activities to help determine the success of this project, and the data from your child's participation will be of great value.

PURPOSE/DESCRIPTION: The primary goal of this project is to conduct a study on the effect of using the Cornell note taking strategy on students' conceptual understanding of algebraic expressions. Students will implement the Cornell note taking strategy for one chapter in the unit on Rational Functions and complete corresponding chapter assessments. In order to collect measurable data throughout the project, classroom discussions will be digitally audio recorded and students' notes will be collected daily. At the end of the project students will be asked to complete a voluntary survey regarding their note taking experience.

DURATION: The entire unit consists of four sections from the chapter on Rational Functions and will require six class periods to complete between the dates May 14 and May 23, 2012.

PARTICIPATION/ANONYMITY: Your child's participation in data collection is voluntary and not participating in the process will not have any effect on your child's grade. Every effort will be made to preserve the confidentiality of the students. Digital audio recordings will be reviewed daily and then deleted. No personal student information will be obtained from these recordings. Note taking, assessment, and survey data will be entered into a spreadsheet using your child's school identification number. The spreadsheet and analyses data will be kept on my private, password protected computer for three years and then deleted.

RISKS/BENEFITS: There are no foreseeable risks to participating in this study. The potential benefits of participation in the project will include increased note taking ability and study skills, as well as a deeper understanding of rational expressions. There is currently little information available to the education community about the benefits of using Cornell notes in a mathematics classroom. Therefore, the results from this project will be published in a master's thesis and kept on file at California State University, San Bernardino.

CONTACT: If you have questions about this project please send an email to tyoung@csusb.edu or call Dr. Laura Wallace, Professor, California State University, San Bernardino at (909) 537-7113.

If you agree to allow Mrs. Tammy Young to use your child's math work and survey data to be collected and analyzed as part of this research project, please sign and return this form as soon as possible. Thank you for your support on this most important project.

Mrs. Tammy Young

I have read the "Parent Consent Letter" for the Cornell note taking project and I consent to the use of my child's data from the following activities below - please check all that apply:

☐ Audio recordings ☐ Survey

Your Name (please print clearly): _____ Parent ☐ Guardian ☐

Your child's name (please print clearly): _____

Your Signature: _____ Date: _____

909.537.5301
5500 UNIVERSITY PARKWAY, SAN BERNARDINO, CA 92407-2393

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO

College of Natural Sciences
Department of Mathematics

CARTA DE CONSENTIMIENTO PARA PADRES

La Sra. Tammy Young está llevando a cabo un proyecto para el programa de tesis de maestría en enseñanza de las matemáticas (MAT) en La Universidad Estatal de California, San Bernardino (CSUSB) dirigido por la Dra. Laura Wallace, profesora de Matemática. La junta de revisión institucional de CSUSB ha revisado y aprobado este proyecto. Se le pide la participación de su hijo/hija en ciertas actividades en su clase para ayudar determinar el éxito de este proyecto y la participación de su hijo/hija será de gran valor.

PROPÓSITO/ DESCRIPCIÓN: El objetivo principal de este proyecto es llevar a cabo un estudio en los efectos de la utilización de la estrategia de Notas de Cornell (Cornell notes) y el entendimiento conceptual de los estudiantes de expresiones algebraicas. Se les pedirá a los estudiantes poner en práctica la estrategia de Notas de Cornell en un capítulo de una unidad de Funciones Racionales y tomar exámenes sobre los conceptos en el capítulo. Para poder medir el éxito del proyecto, se les pedirá a los estudiantes participar en grabaciones de audio de las discusiones durante las clases y apuntes de los estudiantes serán colecados diariamente. Al final del proyecto, los estudiantes tomaran una encuesta voluntaria en cuanto a su experiencia sobre tomando apuntes.

DURACIÓN: La unidad entera consiste en cuatro secciones desde el capítulo de Funciones Racionales y requiere seis períodos de clase para completar entre el 14 de Mayo y el 23 de Mayo del 2012.

PARTICIPACIÓN/ANONIMATO: La participación de su hijo/hija es voluntaria y el no participar en el proceso no tendrá ningún efecto sobre la calificación de su hijo en la clase. Se hará todo lo posible para preservar la confidencialidad de los estudiantes. Las grabaciones de audio digital serán revisadas diariamente y luego eliminadas. Ninguna información personal de los estudiantes será obtenida de estas grabaciones. Los apuntes, la resultados de exámenes, y datos de la encuesta serán introducidos en una hoja de calculo usando el numero de identificación escolar de su hijo/hija. La hoja de calculo y los datos de análisis serán guardados en mi computadora privada, protegida con contraseña durante tres años y luego serán eliminados.

RIESGOS/BENEFICIOS: No hay ningunos riesgos previsibles de participar en este estudio. Los potenciales beneficios de la participación en el proyecto incluye un aumento en la capacidad de tomar apuntes así como un entendimiento conceptual más profundo de expresiones racionales. Actualmente, existe poca información disponible a la comunidad educativa acerca de los beneficios de utilizar la estrategia de tomar apuntes de Cornell (Cornell Notes) en una clase de matemáticas. Por lo tanto, los resultados de este proyecto serán publicados en una tesis de maestría y serán mantenidos en archivo el La Universidad Estatal de California, San Bernardino.

CONTACTO: Si tiene preguntas acerca de este proyecto por favor envíe un correo electrónico a tyoung@csusb.edu o llame a la Dra. Laura Wallace, Profesora, La Universidad Estatal de California, San Bernardino al (909) 537-7113.

Si esta de acuerdo que la Sra. Tammy Young utilice el trabajo de matemáticas de su hijo/hija y que los datos de la encuesta sean coleccionados y analizados como parte de este proyecto de investigación, por favor firme y devuelva esta forma lo mas pronto posible.

Sra. Tammy Young

He leído la "Carta de Consentimiento Para Padres" para el proyecto de Notas de Cornell (Cornell Notes) y consiento en la participación de mi hijo/hija en las actividades a continuación – por favor comprueba todas las que apliquen:

☐ **Grabación de audio** ☐ **Encuesta**

Su nombre (por favor escribir claramente): _____ ☐**Padre/Madre** ☐**Guardián**

Nombre de su hijo/hija (por favor escribir claramente): _____

Su firma: _____ **Fecha:** _____

5500 UNIVERSITY PARKWAY, SAN BERNARDINO, CA 92407-2393

APPENDIX C

DATA COLLECTION DOCUMENTS

Cornell Notes Template (AVID)

Topic: Essential Question:	Name:
	Teacher:
	Class:
	Date
Questions/Main Ideas:	Notes
Summary:	

Achievement Via Individual Determination (AVID), Retrieved from http://www.avid.org

Algebra 2 Chapter 9 Pre-Test

Multiple Choice

Identify the choice that best completes the statement or answers the question.

Simplify the rational expression.

1. $\dfrac{p^2+4p}{4p}$

   a. p^2+1

   b. $\dfrac{p+4}{4}$

   c. $\dfrac{5p}{4}$

   d. p^2

2. $\dfrac{2(x-1)+4}{(x-1)(x+1)}$

   a. $\dfrac{2x+6}{(x-1)(x+1)}$

   b. $\dfrac{2x-6}{(x-1)(x+1)}$

   c. $\dfrac{6}{x+1}$

   d. $\dfrac{2}{x-1}$

Multiply or divide.

3. $\dfrac{4a^5}{7b^4}\cdot\dfrac{2b^2}{2a^4}$

   a. $\dfrac{4a}{7b^2}$

   b. $\dfrac{4a^9}{7b^6}$

   c. $\dfrac{4}{7}a^9b^6$

   d. $\dfrac{7b^2}{4a}$

4. $\dfrac{3a}{a+2}\div\dfrac{2}{3a+6}$

   a. $\dfrac{3}{a+2}$

   b. $\dfrac{9a^2+3}{2}$

   c. $\dfrac{9a}{2}$

   d. $\dfrac{6}{a}$

Add or subtract. Simplify if possible.

5. $\dfrac{7}{a+8} + \dfrac{7}{a^2-64}$

a. $\dfrac{7a-49}{(a-8)(a+8)}$

b. $\dfrac{14}{(a-8)(a+8)}$

c. $\dfrac{14}{a^2+a-56}$

d. $\dfrac{7a+63}{(a-8)(a+8)}$

6. $\dfrac{3}{5ab} - \dfrac{2}{3ab}$

a. $-ab$

b. $\dfrac{-1}{15ab}$

c. $\dfrac{1}{15ab}$

d. $\dfrac{1}{2ab}$

Solve the equation. Check the solution.

7. $\dfrac{5}{6w} + \dfrac{1}{w} = -4$

a. $\dfrac{11}{6}$

b. $-\dfrac{3}{14}$

c. $-\dfrac{31}{24}$

d. $-\dfrac{11}{24}$

Short Answer

8. Find the sum of the fractions below.

   a. $\frac{1}{3}+\frac{3}{4}=$

   b. $\frac{1}{3a}+\frac{3}{4a}=$

   c. Explain how the procedures for each of the problems above are similar and/or different.

9. Give an example of a fraction equivalent to $\frac{3}{5}$. Explain the steps that led to your answer.

10. When simplifying a fraction, a student wrote the following: $\frac{2+1}{2+7}=\frac{1}{7}$

    Is this student correct? Explain.

11. Find the Lowest Common Multiple (LCM) for each pair below.

    a. $12 \ and \ 30$

    b. $12a^2b \ and \ 30ab^3$

    c. Explain how the procedures for each of the problems above are similar or different.

Developed by Tammy Young

Chapter 9 Test: Rational Expressions

Multiple Choice

Identify the choice that best completes the statement or answers the question.

Simplify the rational expression.

1. $\dfrac{q^2 + 11q + 24}{q^2 - 5q - 24}$

a. $\dfrac{-(q+8)}{q-8}$

b. $\dfrac{q+3}{q-3}$

c. $\dfrac{-11}{5}$

d. $\dfrac{q+8}{q-8}$

2. $\dfrac{p^2+4p}{4p}$

a. $\dfrac{p+4}{4}$

b. $\dfrac{5p}{4}$

c. p^2

d. p^2+1

Solve the equation. Check the solution.

3. $\dfrac{5}{6w} + \dfrac{1}{w} = -4$

a. $-\dfrac{3}{14}$

b. $-\dfrac{11}{24}$

c. $\dfrac{11}{6}$

d. $-\dfrac{31}{24}$

4. $\dfrac{-2}{x+4} = \dfrac{4}{x+3}$

a. $-\dfrac{11}{3}$

b. $-\dfrac{8}{3}$

c. -11

d. $-\dfrac{13}{6}$

5. Find the least common multiple of $x^2 + x - 12$ and $x^2 + 2x - 15$.

a. $(x + 4)(x - 3)(x + 5)$
b. $(x - 4)(x - 3)(x - 5)$
c. $(x - 3)(x + 5)(x - 4)$
d. $(x + 4)(x - 5)(x - 3)$

Multiply or divide.

6. $\dfrac{4a^5}{7b^4} \cdot \dfrac{2b^2}{2a^4}$

a. $\dfrac{4}{7}a^9b^6$
b. $\dfrac{4a^9}{7b^6}$
c. $\dfrac{4a}{7b^2}$
d. $\dfrac{7b^2}{4a}$

7. $\dfrac{z^2}{z+1} \cdot \dfrac{z^2 + 3z + 2}{z^2 + 3z}$

a. $\dfrac{z+2}{z+3}$
b. $\dfrac{2z^2}{z+1}$
c. $\dfrac{2z^2}{z+1}$
d. $\dfrac{z^2+2z}{z+3}$

8. $\dfrac{x^2 - 16}{x^2 + 5x + 6} \div \dfrac{x^2 + 5x + 4}{x^2 - 2x - 8}$

a. $\dfrac{(x-4)^2}{(x+3)(x+1)}$
b. $\dfrac{1}{(x+3)(x+1)}$
c. $\dfrac{(x+4)^2(x+1)}{(x+2)^2(x+3)}$
d. $\dfrac{(x-4)^2}{(x+3)(x+1)}$

Add or subtract. Simplify if possible.

9. $\dfrac{7}{a+8} + \dfrac{7}{a^2-64}$

a. $\dfrac{7a-49}{(a-8)(a+8)}$

b. $\dfrac{7a+63}{(a-8)(a+8)}$

c. $\dfrac{14}{(a-8)(a+8)}$

d. $\dfrac{14}{a^2+a-56}$

10. $\dfrac{3}{5ab} - \dfrac{2}{3ab}$

a. $\dfrac{1}{2ab}$

b. $\dfrac{-1}{15ab}$

c. $-ab$

d. $\dfrac{1}{15ab}$

11. $\dfrac{d^2-9d+20}{d^2-3d-10} + \dfrac{d^2-2d-8}{d^2+4d-32}$

a. $\dfrac{2d^2-11d+12}{(d+2)(d+8)}$

b. $\dfrac{2d^2-11d+12}{2d^2+d-42}$

c. $\dfrac{2d^2+8d-28}{(d+2)(d+8)}$

d. $\dfrac{d^2+8d-28}{(d+2)(d+8)}$

12. $\dfrac{b^2-2b-8}{b^2+b-2} - \dfrac{6}{b-1}$

a. $\dfrac{b^2-2b-14}{b^2+b-2}$

b. $b-10$

c. $\dfrac{b-4}{b-1}$

d. $\dfrac{b-10}{b-1}$

Short answer

13. Find the sum of the fractions below.

    d. $\frac{1}{3}+\frac{3}{4}=$

    e. $\frac{1}{3a}+\frac{3}{4a}=$

    f. Explain how the procedures for each of the problems above are similar or different.

14. $\frac{x^2+5x+6}{x^2+6x+8}$

    a. Is it possible to simplify the expression above without using factoring? Explain your answer.

    b. Simplify showing all work completely.

15. When simplifying a fraction, a student wrote the following: $\frac{\not{a}+5}{\not{a}+7}=\frac{5}{7}$

    Is this student correct? Explain.

16. Find the Lowest Common Multiple (LCM) for each pair below.

    a. 12 *and* 30

    b. $12a^2b$ *and* $30ab^3$

    c. $x^2 + x - 12$ and $x^2 + 2x - 15$.

    Explain how the procedures for each of the problems above are similar or different.

Survey on Note Taking
Algebra II
Chapter 9: Rational Functions

Answer the following questions based on your experience in math class during the most recent chapter on Rational Functions.	Always 2	Sometimes 1	Never 0
1. I feel I am a good note taker.	☐	☐	☐
2. I have a difficult time deciding what information to include in my notes during the lecture?	☐	☐	☐
3. I use short sentences or abbreviations in my notes?	☐	☐	☐
4. I feel I have a hard time keeping up with writing notes during the lesson?	☐	☐	☐
5. I spent at least 5 minutes to review my notes prior to the next lesson?	☐	☐	☐
6. I spent at least 5 minutes to review my notes within 24 hours after writing them?	☐	☐	☐
7. I highlight main ideas and key words in my notes for each lesson?	☐	☐	☐
8. I summarized my notes after each lesson?	☐	☐	☐
9. I read my notes within the last 24 hours to help prepare for the test?	☐	☐	☐
10. I feel that my notes are helpful for studying for the test?	☐	☐	☐
11. I have used the Cornell note taking method in other classes?	☐	☐	☐
12. Overall, I feel that note taking is an important tool for learning new information.	☐	☐	☐

Developed by Tammy Young

APPENDIX D

INSTITUTIONAL REVIEW BOARD APPROVAL

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO

Academic Affairs
Office of Academic Research • Institutional Review Board

May 18, 2012

CSUSB INSTITUTIONAL REVIEW BOARD
Full Board Review
IRB# 11096
Status
APPROVED

Ms. Tammy Young
c/o: Professor Laura Wallace
Department of Mathematics
California State University
5500 University Parkway
San Bernardino, California 92407

Dear Ms. Young:

Your application to use human subjects, titled "A Study on Using Cornell Notes to Teach Rational Functions in the Secondary Math Classroom" has been reviewed and approved by the Institutional Review Board (IRB). The attached informed consent document has been stamped and signed by the IRB chairperson. All subsequent copies used must be this officially approved version. A change in your informed consent (no matter how minor the change) requires resubmission of your protocol as amended. **Your application is approved for one year from May 18, 2012 through May 17, 2013. One month prior to the approval end date you need to file for a renewal if you have not completed your research. See additional requirements (Items 1 – 4) of your approval below.**

Your responsibilities as the researcher/investigator reporting to the IRB Committee include the following 4 requirements as mandated by the Code of Federal Regulations 45 CFR 46 listed below. Please note that the protocol change form and renewal form are located on the IRB website under the forms menu. Failure to notify the IRB of the above may result in disciplinary action. You are required to keep copies of the informed consent forms and data for at least three years.

1) **Submit a protocol change form if any changes (no matter how minor) are made in your research prospectus/protocol for review and approval of the IRB before implemented in your research.**
2) **If any unanticipated/adverse events are experienced by subjects during your research,**
3) **Too renew your protocol one month prior to the protocols end date,**
4) **When your project has ended by emailing the IRB Coordinator/Compliance Analyst.**

The CSUSB IRB has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval notice does not replace any departmental or additional approvals which may be required.

If you have any questions regarding the IRB decision, please contact Michael Gillespie, IRB Compliance Coordinator. Mr. Michael Gillespie can be reached by phone at (909) 537-7588, by fax at (909) 537-7028, or by email at mgillesp@csusb.edu. Please include your application approval identification number (listed at the top) in all correspondence.

Best of luck with your research.

Sincerely,
Sharon A Ward, Ph.D.
Sharon Ward, Ph.D., Chair
Institutional Review Board

SW/mg

cc: Professor Laura Wallace, Department of Mathematics

909.537.7588 • fax: 909.537.7028 • http://irb.csusb.edu/
5500 UNIVERSITY PARKWAY, SAN BERNARDINO, CA 92407-2393

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