THE EFFECTS OF SMART PEN NARRATED SOLUTION SETS ON STUDENT STUDY ROUTINES AND THEIR PERCEPTIONS OF THE SOLUTION SETS AS A HELP RESOURCE

by

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DEDICATION

For Tisha, Wyatt, Eli, and Peyton.

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I would like to thank my parents for their unconditional support of all of my pursuits, academic or otherwise. Without their love and encouragement, this dissertation would not have been possible.

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ABSTRACT

Calculus is a roadblock mathematics course. Students who struggle in calculus are unable to pursue their chosen educational track. Research has identified student study habits as one of several key factors for student success in calculus. However, there is a paucity of research specifically on study behaviors of college students. The purpose of this mixed-methods study was to determine how students incorporate narrated solution sets created with smart-pen technology into their study routines and to ascertain their perceptions of the solution sets as a help resource. The results of the study show that students do incorporate narrated solution sets into their study routines. Frequency use data shows the majority of students procrastinate and do not access the resource until right before a test. Interview and survey data suggest that students use the resource in multiple ways. Some students use the resource as an extra lecture, some use it as a help resource when they are stuck, some students use the solutions to check their own work, and some students use the resource as a review. Many students use the resource in multiple ways. This study helps fill the gap on how college students study and how they use available help resources.

CHAPTER I

Introduction

Imagine a scenario where a student sits down to study. They open their book, flip to the page with the problems, take a look at the first one, and do not know how to solve it. What the student does next depends largely on the time and place that this scenario occurs. If the student is on campus in the middle of the day, there may be a multitude of sources of help available to the student. If the scenario occurs off campus in the middle of the night, the available help becomes much more limited. In this scenario the time allotted to studying may or may not be very productive. Having scaffolding available to students, regardless of time or place, could potentially be an effective means of helping students make the most out of the time they spend mastering information.

Calculus as a Roadblock

Calculus has been identified by researchers as being a “Roadblock Course”, a term used by Tennant (2012) to describe a course which blocks student progress in college. The terms barrier course and gatekeeper course have also been used with similar meaning (Adelman, 2006; Suresh, 2007). Student success or failure in roadblock courses directly affects their college pathway to completion (Adelman, 2006). Success in a roadblock course can determine whether a student continues on toward a desired degree or potentially changes majors to a degree that does not require that specific course or possibly leaves college altogether.

Calculus is a general term used to describe several different courses. An internet search of course offerings at major universities in Texas reveals that there are typically

two to three different calculus tracks. The pure mathematics calculus track taken by mathematics majors, and physical science majors (physics, chemistry, etc.), the calculus for life sciences, taken by biology majors, and a business calculus track for business majors (business, finance, marketing, etc.). All of these courses are considered roadblock courses. Some faculty members refer to calculus as a “weed out” course designed to weed out the poor performing students (Suresh, 2007; Tennant, 2012). This “weed out” mentality causes higher stress levels for students and can cause instructors to be unmotivated and less attentive to the needs of their students than they might be in a different course (Cipra, 1988).

Regardless of the course, student success is a dynamic attribute which is affected by many different factors. Tennant (2012) linked the following factors to success in calculus:

- Student perceptions of faculty behaviors
- High school academic experience
- Student perceptions of academic support
- Student behaviors such as
    - Study habits
    - Coping strategies
    - Interaction with faculty outside of the classroom

This is in no way an exhaustive list. See Cipra (1988) and Gerhardt, Vogel, and Wu (2006) for other specific factors that contribute to success in calculus. These other factors

identified by Cipra and Gerhardt, et al. are not directly affected by the intervention and are therefore considered outside of the scope of this research.

Help Seeking Behaviors of College Students

Help seeking is a term used in psychology research to describe a broad range of activities students engage in when they need assistance in completing an assignment. Help seeking refers to anything from re-reading the text to hiring a tutor. Nelson-Le Gall (1981) defined two specific types of help seeking; executive help seeking and instrumental help seeking. Executive help seeking is a type of avoidance strategy in which students seek out answers only. Instrumental help seeking is a mastery learning technique where students seek out only the required assistance so that they may finish the task independently.

College students have many options when seeking help. Most universities have well developed internet and computer access for students, which opens up an enormous bank of information, Google searches, Khan Academy, YouTube, and Wikipedia are all popular places where students seek help. There are also countless forums and blog sites that answer student questions. Many textbooks have online components where students can seek help. For more interpersonal assistance, many campuses have learning centers or homework labs that employ student tutors. There are also the traditional resources such as simply asking a fellow student, a parent or relative, or attending the instructors' office hours (Collins & Sims, 2006). Help seeking is a complex process involving many cognitive skills. Before a student can seek help, he or she needs to realize that they need help. They then need to make a decision on whether or not to seek help and, if so, where

are they going to go for the help. Many personal and social factors influence each of these decisions. Social influences include the instructors' expectations, the general sense of the class, behavior of peer groups, etc. Personal influences include whether or not the student is aware of potential available help, fear of being perceived as incompetent, feelings of isolation (e.g. they are the only one in the class that doesn't "get it"), or they may simply not be aware that they need any help (W. Collins & Sims, 2006). Student help seeking is generally related to task completion. Tasks are varied and subject specific so for this study typical mathematics tasks were considered. I classify the tasks into two categories, in-class tasks, and out-of-class tasks. In class tasks include quizzes and exams, as well as independent work, whether for a grade or not, that takes place during the regularly scheduled class time. Out-of-class tasks refer to not only homework assignments but also general studying behaviors, such as attending office hours, or reviewing in-class notes, which take place outside of the regularly scheduled class time. Although attending office hours may not be a task in itself, students do not usually attend office hours unless they are seeking help in completing a task or need clarification of information presented in class. The nature of these types of tasks, attending office hours, reviewing notes, working homework problems, depending on the student's perception of need, may either be executive or instrumental.

Homework

Homework has been and continues to be a topic of controversy for all involved (H. M. Cooper, 2006). Administrators, legislators, researchers, instructors, students, and parents all continue to debate the effectiveness and even the purpose of homework.

Homework for this research is defined as any course related activity the instructor expects students to complete outside of the regularly scheduled class period.

The generally accepted rule for studying in higher education is that students spend at least two hours studying outside of class for every hour spent in class. In the traditional structure of a college classroom the instructor lectures during class times while students take notes, and then there is some sort of assignment related to the lecture that the student is expected to complete outside of class (Brewer, 2009). The assignments range from readings to research to specified problem sets, such as is the usual case in mathematics.

There are instructors who are utilizing a new concept in instruction referred to as the “inverted classroom” or “flipped classroom” where students watch pre-recorded video lectures outside of class and the in-class time is spent working on problem sets or other enrichment activities. With many college students having access to the internet and computers this inverted classroom structure is gaining popularity with some instructors. However, on the campus where this research took place, the more traditional structure of lecture in class, homework outside of class is still the norm.

The university where the research is taking place requires students in the pure mathematics track to take an accompanying recitation session, commonly called “cal-labs”. Each session is taught by either a graduate assistant or possibly an undergraduate assistant who works with the instructor of the course. The activities conducted during the recitation sessions are as varied as the instructors. Some instructors have specific guidelines, problem sets, or group activities that they expect the lab instructor to complete. Other instructors leave the nature of lab time entirely up to the lab instructor.

Still others expect the lab instructors to work through any homework assignments and answer student questions about the material presented in the lecture. The recitation sessions take place every other day, alternating with the regular course (i.e. if the course meets on Monday and Wednesday, then the recitation sessions occur on Tuesday and Thursday and vice-versa). In essence, students taking the pure mathematics track calculus course have a regularly scheduled calculus class at least four days a week for at least an hour each day and each of these four meetings include some amount of practice problems or homework help.

In contrast the business calculus and calculus for life sciences courses do not have a recitation session. Many of the courses are scheduled twice a week for 80 minutes. Students attend a lecture session for 80 minutes, they have an entire day without any formal mathematics meetings, and then attend another 80 minute lecture, and then have four entire days without any formal mathematics meetings until they attend another lecture. This results in five days since they last attended calculus class over each weekend. Granted these calculus courses vary slightly in content and rigor from the pure mathematics track, however the students are still trying to learn calculus. They are still required to deal with concepts such as limits, continuity, differentiation, and integration. In order to accomplish the task of learning the material, students must spend time outside of class working on calculus.

Homework is an important part of the business calculus course. Students are expected to not only practice what was taught during lecture, but to actually learn outside of the classroom. Ideas and procedures are presented in class along with rationales and a few examples, but there is limited time available in class. The typical long semester is 14

weeks. A class that meets twice a week has a total of 28 face to face meetings in a semester. Research has shown that students who are exposed to the material more frequently learn the material better than students who are only exposed to the material sporadically. Five days between lectures is sporadic, unless students work outside of class. Although calculus courses in the pure track no doubt expect students to work outside of the class on a variety of homework activities, the business calculus course "needs" students to do so for a distinct purpose.

According to Zerr (2007), to maximize the effectiveness of homework, students need feedback on their homework and then they need to reattempt any problems that were not correct. This attempt-feedback-reattempt loop as described by Zerr, often times does not occur at the college level (Brewer, 2009; Davidson, 2004; Jacobson, 2006) and there are many reasons why the loop breaks down at this level. Instructors may not require the homework to be turned in, which makes it optional in the minds of the students, or the instructor does not have time to grade the assignment (either at all or in a timely manner to make the loop educative). Often, even when the attempt and feedback portions of the loop are met, the students do not reattempt the missed problems, possibly because doing so is considered, again, "optional". Regardless of the reason, the outcome is the same; homework at the college level often fails to reach its maximum potential effectiveness for students. Combined with the increase in expectations for and need for outside of class activities, this creates a learning problem that may be a contributing factor in business calculus' status as a "roadblock course" for student success and eventual graduation with their first-choice major.

Focus of this Study

The focus of this study is to determine how students incorporate interactive, narrated online homework solution sets created by their instructor using smart pen technology into their study routine and how the availability of the resource affects their perceptions of faculty behaviors, academic support, and interaction with faculty outside of the classroom. This study was conducted in two sections of business calculus taught at a major four year university in Texas. This course has historically high student drop rates and low passing rates. Many students self-report that they have taken the course multiple times. Business calculus at this university is a service course taught in the mathematics department as a prerequisite requirement for entry into the university's College of Business. Applicants with an overall gpa of 3.0 on a 4.0 scale are automatically admitted into the business college. Students who pass the course but who have an overall gpa of less than 3.0 are placed in a competitive selection group and may or may not be admitted. Students who do not pass the course are not eligible for admission into the business college. The requirement for success in business calculus to be considered for entry into the school of business is another reason students often consider this course to be a "weed out" course. Such a high stakes environment makes understanding student learning needs a priority.

Students enrolled in business calculus are a diverse group. There are traditional students at all levels of classification, non-traditional students (full time students over the age of 25), veterans, and part-time students. Although the course is classified by the Mathematics Department as a freshman level course, many of the students enrolled are not freshmen. Some students change majors or move from "undecided" status to a

business major and therefore have not taken the course previously, though they may have had other mathematics courses. Some students report that they have put off taking the course because they are either intimidated by the course or they know other students who have taken the course multiple times and are afraid that they might not be successful. This information is derived from interview data from a pilot study as well as informal conversations with students attending office hours and first class day questionnaires.

Business calculus is a service course and lacks some of the rigor and content of the pure mathematics calculus. Two main differences between the courses are proof and trigonometry. In business calculus, the students are not required to complete any proofs of their own. The instructor may or may not demonstrate the proofs of certain concepts but the students are not required or expected to be able to write any proofs of their own. The second major difference is trigonometry is not covered in business calculus. No trigonometric identities are used nor are the derivatives or integrals of trigonometric functions taught. Despite these two major differences, the material is still calculus. Students are taught the concepts behind limits and continuity as well as derivatives and derivative rules such as the product, quotient, and chain rules, and integrals.

Recall that business calculus is a roadblock course. Without a passing grade in business calculus students cannot enter the school of business, and even for students who do pass, they might make such a low grade as to lower their overall gpa, which shuttles them into an uncertain status as to enrollment in the business college. However the structure of the course places high demands on the students if they are to be successful. With limited face to face interaction with the professor, the student is expected to bear the bulk of the learning. The learning activities are in the form of assigned problem sets

which are expected to be completed outside of the classroom. Since many instructors do not collect or grade the assignments, many students do not complete them (Brewer, 2009; Davidson, 2004; Jacobson, 2006).

Narrated Solution Sets/ Smart Pen/ Pencast

The technology that was used in this study is generally referred to as a "smart pen". The smart pen is a ball point pen, slightly larger than the average pen, that has a built in camera and digital recorder. When the user writes on specially made paper the camera, located in the tip of the pen directly under the point, records every stroke. Handwriting, doodles, graphics, anything that is written on the paper is recorded exactly as it appears on the page. The digital recorder allows the user to record any audio that may be occurring in the general vicinity of the pen. The pen automatically links the two data types, written and audio, together in real time. The effect is that the user can go back to the notes on the page and using the pen, replay the audio that was occurring while the writing was taking place. An example would be a student in a typical lecture, using a smart pen, the student could record the lecture while actively taking notes in class. Any time after the class was over; the student could access the audio portion of the lecture at any specific time during the lecture simply by touching the pen to the paper. Other functions include fast forward, reverse, speed-up playback, slow-down playback, volume, etc.

Another feature of the smart pen is the ability through a specific computer program to upload the files onto a computer. The handwritten notes appear on the computer screen exactly as they were written on the paper. The associated audio files are

linked to the digital images in the same way that they were linked to the paper copy. Using the mouse and pointer the files can be played back on the computer. Once the files are stored on the computer they can be uploaded to several different formats including an external website that hosts the files called “pencasts”. When a file is uploaded to the website, it is available to the user from any computer or mobile device that has internet access. The pencasts have all of the functionality of the computer or paper versions of the files. The audio and written information is linked and the files can be played back, fast forwarded, restarted, etc.

For this research, pencasts were created by the researcher/instructor. The content of the pencasts was selected homework problems from the problem set assigned to the students. Only select problems were completed. To create the solution sets the instructor worked out problems using the smart pen and paper while simultaneously narrating the solutions. Specifics of not just what steps are being taken but why the steps are being taken were included in the narration. For example, when finding the derivative of a function the instructor would carry out all steps in the process while commenting on the structure or other key aspects of the problem: “This appears to be factorable, let’s try to factor this to a simpler form…etc.” In this way, the pencasts can be used by the students regardless of the type of help they are seeking, executive or instrumental. Students seeking executive help have the answers to a limited number of problems. Students seeking instrumental help can theoretically make use of the narrated “how’s” and “whys” and the students have the ability to control the playback of the pencast so that they can stop the pencast to attempt to complete the problems on their own when they feel ready to do so. The solution sets were then uploaded to the website and a link to the solution sets

was provided to the students in the course. Once the link was posted, students were able to view the pencasts as often as they wished. There is no limit to the number of times a file can be viewed or to the length of time a file is viewed.

Purpose of Study

The purpose of this study is to determine how the incorporation of technology into the mathematics curriculum influences student perceptions of learning mathematics in a business calculus course. Incorporating interactive homework solution sets as a regular attribute of the course, is an inexpensive, easy to use technolgy that has the potential to increase students' perceived access to the instructor, increase homework completion, and potentially palliate student anxiety that might keep them from succeeding in the course.

Research Questions

The research questions for the study are as follows:

1. How do students incorporate online narrated solution sets into their study routines?
2. What are the students' perceptions of the narrated solution sets as a help resource?

Significance of the Study

This study is significant for two audiences – mathematics education researchers and mathematics educators at every level. This study will shed light on student beliefs about their own study habits including help-seeking behaviors, perceptions about their interactions with their instructors, and motivation for completing homework tasks. This information will help fill a gap in the current literature concerning college level student

homework behaviors. The technology that was be used in the study is inexpensive and easy to use, making it accessible to instructors at all levels. Since creating solution sets is something many instructors already do, creating the solution sets with a smart pen is an easy transition that creates a more dynamic artifact.

The availability of the pencasts enables students to complete the attempt-feedback-reattempt loop described by Zerr (2007). Since the answers to the assigned problems are given in the back of the textbook, students know immediately if they have the correct answer (executive help seeking). If a student has difficulty arriving at the correct answer, they can view a pencast which describes the process of finding the solution to a similar problem in their homework set (leads to instrumental help seeking). This process allows students to complete assignments they might not complete otherwise. By attempting a problem, watching a pencast and reattempting the problem students invest more effort in their homework which has been shown to directly affect achievement (Trautwein & Köller, 2003).

Pilot study data suggests students who cannot attend regularly scheduled office hours find the narrated solution sets to be a valuable resource for completing their homework assignments. Since the solution sets are interactive and students can access them as many times as needed, the time spent viewing the solution sets makes some students feel as if they are receiving one-on-one tutoring from the instructor.

Definition of Terms

Definitions of several terms used throughout this dissertation are provided here to assist the reader in obtaining a clearer meaning of specific terms as used in this document.

Smart pen. The term *smart pen* refers to a writing instrument that digitally captures the written strokes along with a digital audio file and links the two together into one interactive file.

Pencast. The term *pencast* refers to one specific file created with a smart pen that is then uploaded to the internet and shared with others.

Help seeking. The term *help seeking* refers to any activity conducted by a student with the goal of completing a set task. These activities include, but are not limited to, rereading the text or class notes more slowly, conducting an internet search, seeking a tutor, or asking a friend, teacher, classmate, or parent (Karabenick & Newman, 2006).

Learning. For this study, the term *learning* is defined as a change in behavior. Learning is realized by the student's ability to complete a task, solve a problem, or demonstrate the ability to do something they could not do before at an acceptable level.

Mathematical tasks. The term *Mathematical tasks* refer to any math related task conducted by the student during the course of the semester. *Mathematical tasks* are divided into two distinct categories: in-class tasks and out-of-class tasks. In class tasks include quizzes, tests, exams, project or independent work that takes place during the regularly scheduled class time. Out-of-class tasks include activities completed outside of

the regularly scheduled class time such as homework, attending office hours or other tutoring resources, study sessions with classmates, and projects.

Narrated homework solution set. The term *narrated homework solution set* refers to a pencast created by the course instructor in which detailed explanations of how and why each step is taken in the solution of a specific subset of problems from the assigned problem set.

CHAPTER II

Literature Review

Study Design Framework

The business calculus course which is the focus of this study is a service course for students who want to pursue a degree in the University's School of Business. Business calculus is offered through, and taught by, the mathematics department. The curriculum is catered toward the direct application of the techniques of derivation and integration to real world business contexts. For these reasons, the course curriculum is very procedural in nature. The measures of learning in the course are based on the students' ability to perform certain procedures such as, taking a derivative, or finding an integral, and interpreting the result. As defined in the previous chapter, learning in this study is a change in behavior. The students are assumed to be unable to find derivatives or integrate certain types of functions before taking the course and upon successful completion of the course; they should be able to complete these specific tasks. For many students, business calculus is required before a student is accepted into the School of Business however, regardless of acceptance; it is required for all business majors. If a student is unsuccessful in business calculus, they will be unable to earn a degree in business; hence, business calculus is a roadblock course (Adelman & Office of Vocational and,Adult Education, 2006; Suresh, 2007; Tennant, 2012; Treisman, 1992).

The standard model of instructor lectures during class and students practice outside of class, as described by Trautwein (2003) and Brewer (2009), is how this course is structured. In order to master the course material, students are expected to practice

outside of regularly scheduled class times, i.e. do homework. Although there is a paucity or research specifically focused on college student homework study behaviors (Gutarts & Bains, 2010b; Hancock, 2000), which this research hopes to inform, research has shown there are certain aspects of student self-regulation, metacognition, and help seeking behaviors that affect student study behaviors and therefore effect homework completion, amount of practice, and study routines (H. Cooper & National Council of Teachers,of Mathematics, 2008; Karabenick & Newman, 2006; Schoenfeld, 1982; Schoenfeld, 1989; Tennant, 2012; Treisman, 1992; Zimmerman & Schunk, 2011).

Although research has found that in general technology has no significant effect on student achievement (Dynarski et al., 2007), as of the time this study was conducted, there is no previous research that incorporates this specific technology in this way. Furthermore, achievement is not the focus of this study. It is theorized by the researcher that the narrated solution sets created and incorporated by the instructor can have a direct effect on student study routines, help seeking behaviors, and perceptions of help resources. The remainder of this section will present the current literature on each of these aspects of the dynamic process of student learning. The following flow chart, Figure 1, outlines the framework of this study.

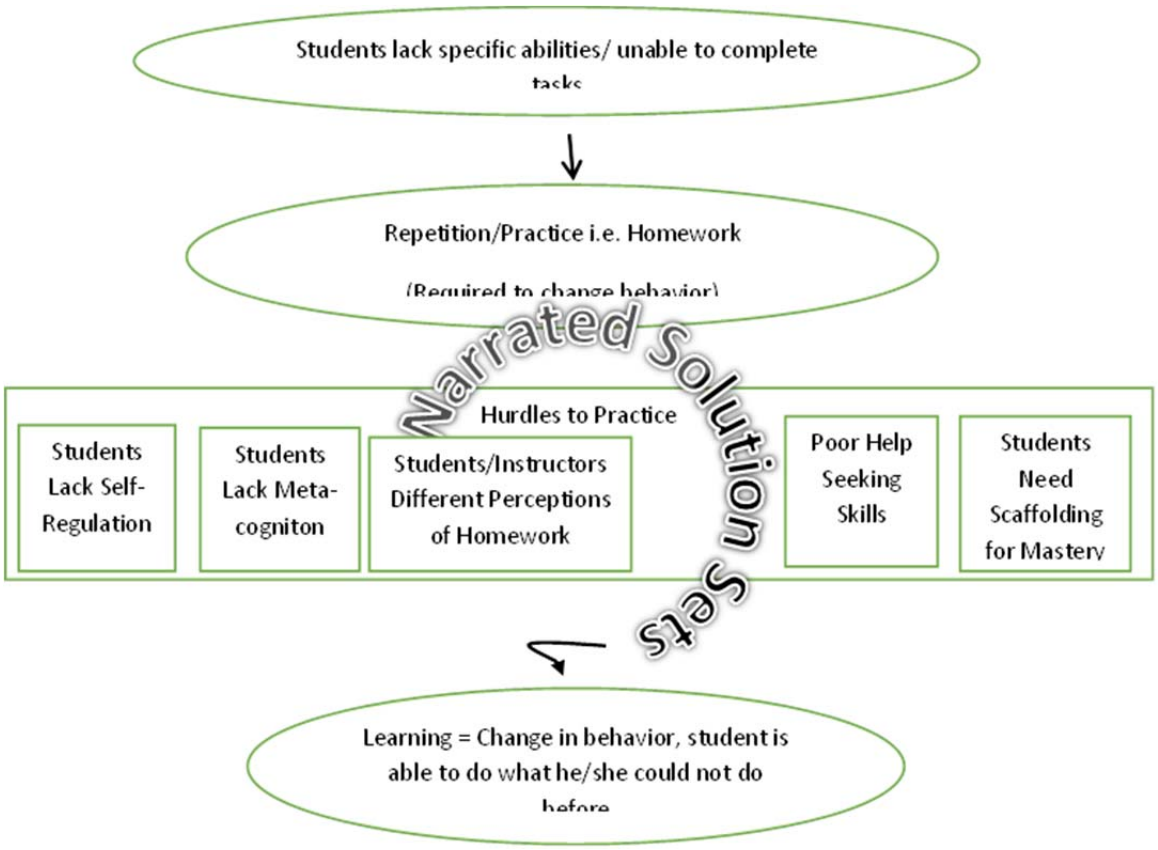

Figure 1. Study design framework for this research.

Business Calculus as a Roadblock Mathematics Course

Calculus is a roadblock mathematics course (Adelman & Office of Vocational and,Adult Education, 2006; Suresh, 2007; Tennant, 2012; Treisman, 1992). Other terms such as barrier course (Suresh, 2007), or gateway course (Adelman & Office of Vocational and,Adult Education, 2006) have been used with the same meaning. A roadblock course is a course that blocks student progress in college. Success in a roadblock course is required for a student to achieve a desired degree. Treisman (1992), identified calculus as a roadblock course for minority students at The University of California at Berkley. In his study, Treisman identified differences in study habits

between minority students and their white counterparts as a major reason for the lack of success for some students. In Treisman's study, he identified group study and homework completion as keys to success in first year claculus. One of the research questions for this research is: How do students incorporate online narrated solution sets into their regular study routines? I theorize that access to the narrated solution sets will enable students to persist in completing their homework assignments, a factor Treisman identified as important, when they might not have done so without the resource and that completing homework is important so they can progress towards the learning goals, which are to master specific derivative and integration techniques.

Suresh (2007), also identified calculus as a roadblock course, but specifically studied engineering students. Suresh noted high school academic experience, student behaviors, and perceived faculty behaviors as significantly affecting student performance in raodblock courses. The student behaviors included coping strategies, study habits, and work outside of school. Suresh found that high school academic expereince, based on GPA and SAT scores, was directly related to student success in calculus. In the study, most students had high self beliefs about their study habits. Students who worked off campus and longer hours tended to struggle with the course but at the same time persisted despite some setbacks. Many of the students claimed to know where to find help, although very few utilized their instructors office hours. Many students went to their friends for help but did not ask family or their instructor for help. The resource created in this research can help students successfully complete their homework assignments and give students access to quality help from their instructor outside of regularly scheduled times.

In a PhD dissertation, Tennant (2012), identified business calculus as a roadblock mathematics course for adult learners (students over the age of 25 working toward their first undergraduate degree). Again, study habits and perceptions of student-instructor interactions were cited as significant influences on student success. Tennant aslo identified high school preparation as a significant factor for success.

As we can see, research as clearly identified calculus and business calculus as roadblock courses for different populations of students. Furthermore, these studies have identified several factors influential to success for these students in such a roadblock course. Student study behaviors is prominent in these studies. This research seeks to address one aspect of student study skills by exploring how pencasts can mediate the difficulties students face, particularly the difficulties of successful homework completion.

Student and Instructor Perceptions of Homework at the Higher Education Level

Homework for this research is defined as any course related activity the instructor expects students to complete outside of the regularly scheduled class period. Homework is a staple of many college mathematics classrooms (Trautwein & Köller, 2003). Brewer (2009) argues that since the traditional format for college mathematics courses is lecture by the instructor during class times and homework completed by the student outside of class, the best way to positively affect changes to the traditional structure is to find ways to fit them into this traditional structure. In this way “it is more likely that these changes will be accepted and consistently used by the collegiate mathematics education community” (Brewer, 2009p. 2). Many instructors work at least a few of the problems they assign to students themselves. Working these problems using a smart pen does not

require any extra effort on their part. The only difference in creating a narrated homework solution is learning to verbalize not only the procedures you are completing but verbalizing why you are doing them in the order you are, and what features of the problem made you take that approach. All of these things occur naturally in our heads as we work the problem, though it does require some effort to slow them down and verbalize them as they occur. The time required to upload a pencast from the pen to the computer is minimal, usually no more than a minute or two, depending on the length of the session. The time required to upload the pencast and link it to the website is also minimal and with practice the entire process can easily be accomplished in less than five minutes.

Much research has been conducted examining the effects of homework on all aspects of education and learning (H. M. Cooper, 2006). However, much of the research has been focused at the K-12 level, leaving a paucity of research on homework at the collegiate level (Gutarts & Bains, 2010b; Hancock, 2000). Furthermore, most of the research on homework has been focused on its effects on achievement (Trautwein & Köller, 2003). More recent studies of homework at the collegiate level, especially in mathematics education, address the effectiveness of online homework systems (OHS) (Affouf & Walsh, 2007; Brewer, 2009; Davidson, 2004; Halcrow & Dunnigan, 2012; Hauk & Segalla, 2005; Jacobson, 2006; Lenz, 2010). There are many different OHS in use today, each with its own pros and cons. With a typical OHS, the instructor creates an assignment and sets the times it will be accessible to students. The students then log into the system and complete the assignment. The instructor has the ability to limit the times the assignment is accessible, limit the number of attempts, and various other features. The

program grades the assignment immediately and the student is given immediate feedback in the form of a grade. Depending on the program and instructor's settings, once the student receives their grade they have the option of re-working the problems that were missed. Some programs offer assistance in the form of hints or examples. Once the assignment is completed, the instructor can import the grades directly into a grade book or spreadsheet. The immediacy of the grading and feedback for students are two of the pros of using OHS. However, with this type of delivery, it is impossible to know who is actually sitting at the computer completing the assignment. There are also difficulties with the accuracy of answers and the formats in which a student may enter an answer. All of this aside, OHS are an emerging technology that seem to be getting better and more prevalent. Nevertheless, OHS are not the focus of this study.

In a study of college calculus students, Gutarts and Bains (2010b) found that there was no statistically significant difference in achievement between students who were assigned mandatory homework (collected and graded) versus students whose homework assignments were neither collected nor graded. In the latter courses, weekly, in-class quizzes were given. In their study Gutarts and Bains divided their subjects into two groups; group one was required to complete homework assignments for collection and grading, group two took weekly quizzes instead of turning in homework. The researchers surveyed the students in group two only and therefore their results could not be compared to group one, however they did report some interesting findings. First of all, the majority of students reported that they believed that college students were mature enough to complete homework assignments regardless of whether or not they were going to be collected. This was in direct contrast to other items on the survey which indicated that the

majority of students did not complete assignments that were not collected and graded. Another interesting result of the survey data was that the majority of students believed their study habits were “generally effective and consistent” (p. 241). This belief is in direct contrast to items on the survey where students reported that they would do more homework if it were mandatory. The researchers concluded that the weekly quizzes were sufficient to motivate students to at least attempt some of the homework even though it would not be collected. The business calculus courses which are the focus of this research are structured similarly to the course with weekly quizzes described in the research above. Rather than a single weekly quiz, typically there is a quiz every class day starting the second week of classes with the obvious omissions on exam days or the class meeting directly following an exam. This research theorizes that the availability of the narrated solution sets will enable and or encourage students to attempt more homework than they would without such a resource even though the homework will not be collected.

Help Seeking Behaviors of College Students

The term help seeking refers to any activity conducted by a student with the goal of completing a set task. These activities include, but are not limited to, rereading the text or class notes more slowly, conducting an internet search, seeking a tutor, or asking a friend, teacher, classmate, or parent (Karabenick & Newman, 2006). Before a student seeks help, he or she must determine whether or not they need help, what type of help they need, and what options for help are available. If the student decides to seek help, there are many factors, personal, social, and contextual, that influence the subsequent decisions that are made concerning the type of help sought and where to get help (Kempler & Linnenbnnk, 2006).

Students who seek help are often unsure of what questions to ask, leading to poor questions, or simple statements of misunderstanding (Kempler & Linnenbnnk, 2006). These statements and questions lead to simple answers that do not necessarily aid the student in solidifying their understanding. Direct or more detailed questions from students often lead to more detailed answers from instructors. In other words the quality of the questions directly affects the quality of the response. One potential benefit of the narrated solution sets is the uniformity of the response. Regardless of the quality of the question from the student, every student receives the same response. Granted this could also be seen as a drawback however, the interactive features of the software enable the student to skip over information that they do not need. Another possible drawback could be that the instructor does not, via the pencast, address some questions that might have been asked in a face to face setting.

Nelson-Le Gall (1981), identified two distinct types of help seeking: instrumental and executive. Instrumental help seeking occurs when a student seeks just enough information in order to complete a task or solidify their understanding. Executive help seeking is an avoidance tactic where students seek only the answer. Research has shown that students who regularly employ instrumental help seeking strategies become more independent when future difficulties occur (Karabenick & Collins-Eaglin, 1996; Karabenick & Newman, 2006; Volet & Karabenick, 2006). Recall that the narrated solution sets are not complete solution sets for every assigned problem. Students, who are seeking executive help, will not receive every answer to the assignment. Students, regardless of the quality of the question asked, will receive the same detailed explanation of how to solve a similar problem, which they will then need to process and apply to the

particular problem at hand. This process of reviewing the solution to a similar problem and then applying the steps to the problem at hand, it is theorized in this dissertation, to be instrumental help that is on par with attending office hours or seeking other face to face help.

Many institutions have implemented programs to assist students in various ways. The programs include supplemental instruction, collaborative learning groups, learning centers or labs, advising or mentoring, instructor office hours, and many other services are available to students. With all this help seemingly available, why do students avoid seeking the help they need? For a variety of reasons, many college students wait until they are behind or in academic trouble before they seek help (Volet & Karabenick, 2006). When students do seek help, they often choose less reliable sources of help. Although some help may be better than no help, students often ask friends, peers, siblings, or parents when an instructor or teaching assistant may be available and potentially much more qualified to provide the needed assistance (Karabenick & Knapp, 1988). Butler (1998) identified two main reasons for avoiding help: 1) help seeking that conflicts with the need for autonomy, and 2) help seeking as seen as evidence of incompetence and threat to ability perceptions. Other potential reasons for not seeking help include schedule conflicts and other responsibilities such as work or family. This research addresses many of these issues with the narrated solution sets. Students can access the solution sets without having to contact the instructor or anyone else, ameliorating the risk of being seen as incompetent. The solution sets are available to anyone at any time. All that is needed is a computer, tablet, or smartphone with internet access.

In past education research there are two well established and distinct domains that focus on what a student does when faced with a difficult task. The first is called by Zimmerman and Pons (1986) “seeking social assistance”. In this domain, students initiate efforts to solicit help from other humans i.e. peers, teachers, tutors, etc. The second domain is “information seeking”. In this domain the student looks for assistant from non-human resources. Traditionally the only non-social resources students had access to were their textbook or the library. In 1986 when Zimmerman and Pons published their research, information technologies did not exist as they do today. Zimmerman and Pons made a firm distinction between “help seeking” and “information seeking” whereby help seeking required human interaction. More current research allows for “information seeking” to be included as a type of help seeking referred to as “non-social help seeking”.

In an effort to redefine and integrate the two domains of social vs. non-social help seeking, Puustinen and Rouet (2009) claim that “information seeking” in today’s more technological world is not a distinctly different domain from social help seeking. Via online help systems, Google searches, YouTube videos, and a host of other popular technology based information systems; students can seek help without ever actually talking to another person, though they may be watching a video or listening to a narrated example being worked out. Many textbooks even have a dedicated website with a variety of resources specific to the content of the book. While this type of help is not technically human-to-human, the interactions are more dynamic than simply reading an article or some text. The authors propose a new theoretical framework where information seeking is included as a subclass of help seeking.

The transition from high school into college poses new challenges for many students. Students who were just good students in average high schools never learned how to study, or needed to seek help. Those students arrive in college, where the standard of excellence has been raised, and may hold inflated perceptions of their abilities and under-inflated perceptions of their instructors' expectations. The structure of high school where many students attend every course every day is also very different from the structure of many college curriculums. Many college courses are taught every other day or possibly only one or two days per week. The end result is that many students may need to re-evaluate their study habits and their usage of available resources (Volet & Karabenick, 2006). The 24/7 access to the narrated solution sets, if incorporated into their regular study routine, could give students a sense of interaction with their instructor with greater frequency than they would have just attending class, and is more accessible than set office hours.

Student Self-Regulatory Behaviors

Self-regulation of learning is the process by which learners cognitively assess, control, and adjust their beliefs and behaviors toward achieving their learning goals. Self-regulation has been prevalent in education research for the past couple of decades (Briley, 2007; Nonis & Hudson, 2010; Schoenfeld, 1992a; Schoenfeld, 1989; Zimmerman & Schunk, 2011). Self-regulation is closely associated with metacognition in that in order to self-regulate, students must be cognitively aware of certain aspects of their study habits. Much research has been conducted on which aspects of self-regulation are most effective.

Nonis and Hudson (2010) concluded that time on task is a dynamic aspect of student study behavior. While it might seem intuitive that more time spent studying would lead to higher achievement, Nonis and Hudson found that the quality of the time spent was more important to student success than simply the quantity. Although students may feel that they are spending enough time studying, some students are not cognitively aware that they are not learning during these times. As a result, they are unable to effectively monitor their study habits and strategies and make appropriate adjustments to achieve their desired outcomes (Zimmerman, 1990).

Many students believe that mathematics knowledge consists of disjoint and unrelated facts or procedures and as such learning mathematics equates to memorizing when to apply which known fact (Schoenfeld, 1992a; Schoenfeld, 1989). Students in one study stated that they believe that mathematics problems should be solved quickly (in less than five minutes) and there is only one correct way in which to solve a problem. In the same study, the average time students spent working on a problem before it was deemed impossible was 12 minutes (Schoenfeld, 1989). This conception of mathematics leads students to believe that knowing mathematics is equivalent to memorizing a procedure or set of facts. This conceptualization could explain why students tend to procrastinate or attempt to study by cramming before a test.

For many students these beliefs are born in their k-12 experience. Many students are able to succeed in high school with minimal effort (Balduf, 2009; W. Collins & Sims, 2006). In a small qualitative study by Balduf (2009) gifted students at a small but prestigious 4-year public college self-reported that they did not learn the necessary study skills in high school they needed to be successful in college. All seven participants

wound up on academic probation after their first year of college despite the fact that they were previously extremely high achieving high school students. In the study, the freshman class average high school GPA was 4.0, combined SAT scores between 1240 and 1440, and ACT composite scores were between 28-32. Despite this past success, the students struggled with the freedom and structure of college life.

The majority of the students in the Balduf study reported that they were not challenged in high school and therefore did not develop many of the key self-regulation behaviors identified as being necessary for success. These students did not know how to study, did not know how to take quality notes, and lacked self-discipline. Although these students did report that they studied, they often procrastinated and most studied only shortly before exams.

A key aspect of student self-regulatory behavior is help seeking. Help seeking, as described above, is a complex process. However, to be successful in completing tasks and using help resources effectively, students have to have good self-regulatory behaviors. Research has shown that procrastination is widely prevalent among college students (Corkin, Yu, & Lindt, 2011; Schraw, Wadkins, & Olafson, 2007; Steel, 2007). Procrastination is a complex issue with many contradictory reports on its effects on student success. Research has shown that some students employ what Corkin et al. (2011) refers to as active delay. Active delay is a planned procrastination whereby student study habits are planned around deadlines: test dates, project deadlines, etc. These studies have shown that some students are able to achieve success while employing these types of behaviors. In theory, the narrated solution sets could aide students in making what time

they spend studying their business calculus more productive if they have the self-regulatory behaviors needed to effectively employ them.

Technology

According to a study funded by the U. S. Department of Education in response to Congressional legislation that called for a study to focus on the "impact of technology on student academic achievement" (p. *xiii*) no statistical difference was found between control and treatment groups of students using technology resources. Furthermore, for the mathematics products used, there were no correlations detected between classroom or school characteristics. This report essentially sums up the efforts by educational researchers to connect technology with achievement. This study incorporated 45 school districts, 140 schools, 439 teachers, and more than 9,000 students. The significance of the scope of this study cannot be disregarded. Simply put, technology does not have a significant impact on student achievement (Dynarski et al., 2007).

In a dissertation study conducted in 2011, Marolt used smart pen technology in a college algebra course taught at a community college. The primary focus of the Marolt study was on student achievement with a secondary focus on student attitudes. In her study, Marolt used the smart pen along with a document camera to present lecture notes in class. Pencasts of the lecture notes were then created and made available to the students through a class web page. Marolt used a control-treatment design in which one section of college algebra was given access to the full interactive pencasts with audio, while the control group was only given access to a static document without audio or interactivity. Marolt found no significant difference in achievement between the control

and treatment groups. To answer the research questions concerning student attitudes, Marolt interviewed five participants from each group in her study. The results reported were inconclusive about the extent to which students utilized the technology and how it affected their attitudes toward mathematics. In this study, the use of the smart pen technology will be to provide the online homework solution sets to all students in two sections of business calculus. Unlike the Marolt study, lecture notes will not be provided. Also, achievement is not the focus of this study. More extensive interviews, conducted throughout the semester, as well as several other data resources were used to determine the effects of the online homework solution sets on student perceptions of not only mathematics, but their homework and their interactions with their professor.

There are many studies that consider the effects of technology based homework for calculus courses (Davidson, 2004; Gutarts & Bains, 2010; Halcrow & Dunnigan, 2012; Zerr, 2007). The majority of these studies, as well as many focusing on college algebra or developmental mathematics, focus on the effects of the online homework on student achievement. In a study conducted by Zerr (2007) the author developed an online homework suite in which students were provided with carefully scripted feedback on homework problems that were completed incorrectly. The students were then able to reattempt a similar problem to correct any misunderstandings. The program used in Zerr's study was developed by the researcher. The feedback given was in paragraph form which the student would read for themselves and attempt to incorporate in a similar problem. The feedback did not explicitly indicate the correct answer to the problem but gave either information about the problem or steps to take to solve the problem.

The feedback given in Zerr's (2007) study is static in nature. After a student submits an assignment, the computer generates a report and gives a brief technical paragraph about the problem which students are expected to then apply to a different, similar, problem. In this study, the feedback that is available to students is interactive and goes beyond technical details about the problems. Using the smart pen technology, the instructor is able to work problems in detail, while providing insight into the thought process behind the chosen method of solving the problem. Details about what features of the problem triggered the instructor to proceed in the manner in which they did, or common misconceptions or mistakes that students make and should avoid are all included in the solution sets. The answers to the selected problems are included, but the solution sets are not all inclusive. There are many problems or exercises left for the students to complete on their own. By providing details about the thought process used to solve the problems, I theorize that the solution sets will be perceived as not just a solutions manual, but as an extension of the professor that is available anytime and anywhere the student has access to a computer and the internet.

Ideally students would attempt to work homework problems, and then attend office hours or ask questions about concepts or problems they did not understand in class and then they would reattempt the homework problems. This attempt-feedback-reattempt loop as described by Zerr (2007) is crucial in the learning process at the college level. However, this interaction, especially attendance in office hours, does not often occur (Karabenick & Knapp, 1988; Karabenick, 1992; Zerr, 2007). Many online homework environments lack the feedback given by Zerr's program. These online homework environments give students only a correct/incorrect response (Hauk & Segalla, 2005)

which in many cases is contrary to the interaction that the students would receive in the presence of their instructor. One of the goals of online homework or assistance is to engage students more frequently in the mathematics than would occur otherwise. In the instance of a college course that meets two days a week, there is a five day break which occurs every week, where students may not be engaging in any mathematics activities. By providing assistance online, available at the student's request, the students might engage in mathematical activities with more frequency than they would without the assistance. If a student is unable to attend office hours and they get stuck on a problem, they might have to wait as many as five days to get any feedback.

Scaffolding/Mastery Learning

"Scaffolding is the help given to a learner that is tailored to the learner's needs in achieving his or her goals of the moment" (Sawyer, 2006 p. 11). The term "scaffolding" is attributed to Bruner, and is based on Vygotsky's *zone of proximal development.* Students need specialized help in order to understand concepts which are needed in order to solve a problem or complete a task which would otherwise (without help) be beyond their cognitive capacity and therefore impossible to complete (Wood, Bruner, & Ross, 1976). This original notion of scaffolding is based in the theories of constructivism. The intent of the scaffolding as described above is to assist the student not in finding an answer or solution, but in constructing their own understanding of the process of how to solve the problem. As can be inferred from Sawyer's definition of scaffolding, the current view is that scaffolding is the assistance provided by an expert or more knowledgeable individual in order to assist students in the completion of the task, or solving of the problem at hand. Constructing one's own knowledge is not a part of Sawyer's definition.

The potential for students to perceive that help seeking makes them appear inferior in the eyes of their instructors or classmates, regardless of the basis for this perception, prevents many students from seeking out the help they need. According to Collins (2006), “When scaffolding is provided by computers, it comes without criticism, and without others knowing that the student needed help. Computers offer a kind of scaffolding that avoids stigmatization and provides individualized instructional support” (p. 56). This individualized, anonymous scaffolding is exactly what is being studied. The two goals of this study are to determine how students incorporate the narrated solution sets into their study routine and determine what the students’ perceptions of the solution sets are.

The scaffolding provided through the online homework solution sets is structured so that students may rely on the assistance as needed. Students control their own access to the scaffolding, allowing them to use as much or as little as their understanding requires. They may return to the same file as often as needed or not at all since the usage of the solution sets is entirely voluntary. In this same manner the fading is also controlled by the student. The solution sets are made available as the material they cover is presented in class. Once a file has been made available for use by the students, it remains available throughout the semester enabling students to refer back to the files at any time.

The current effective model of mastery learning is contributed to Bloom (Bloom, 1976). The tenants of mastery learning as described by Bloom are that instruction be systematic, help is given as needed, students are given sufficient time, and the existence of a clear notion of mastery. In this approach, the information that is taught is broken down into smaller pieces called units and presented to the students. The students are then

given time and assistance as needed until the defined level of mastery is met for that particular unit. Once the desired level of mastery is achieved, the students are presented with the next unit of information. The time that is given varies greatly with each student. In an ideal situation, students progress through the units at their own pace and are presented with new units only after mastery of the previous unit is achieved.

In practice, students do not have an infinite amount of time to master units of instruction. Time is strictly controlled by the institution and instructors as well as students have to work within limits set by outside factors. In the higher education setting, time spent working on a unit is left largely up to the individual student. While courses in high school are delivered over a school year (177 days in Texas) and most school classes meet daily for 45 minutes to an hour, depending on the district, a course offered during a long semester at the institution where the study occurred meets a total of 28 times for 80 minutes per class. Clearly the scaffolding provided by the instructor and the time spent on mastering the course content at the higher education level must occur, for the most part, outside of the classroom. From the instructors' viewpoint, students have plenty of time to master the material presented in class. Students are expected to spend at least two hours studying for every hour spent in the classroom (Brewer, 2009), however whether or not the students actually put in the required time is debatable. Time spent studying is a balancing act for many students who have any number of other considerations taking up their time. Other courses, family, work, and social activities are just a few of the things that students must consider when planning time to study. When a student does spend time studying, the effectiveness of that time depends on many factors.

Modeling/Metacognition/Think Aloud

The effectiveness of the attempt-feedback-reattempt loop described by Zerr (2007) and presented above is dependent upon the students' metacognition. Although the term metacognition has a myriad of working definitions, the definition that was adopted for this study is "a student's ability to regulate their strategies for learning". In order for students to make effective use of the narrated solution sets they need to be able to not only recognize that they need assistance, but also be able to recognize where their misunderstanding is originating from.

The narrated solution sets contain detailed solutions to select problems from the students' assigned problem set. Even though they contain verbal as well as written procedures for solving the problems, the solution sets are not specific to the difficulties encountered by any one student. Therefore effective use of the homework solution sets is dependent upon the students' ability to apply what is presented to the specific difficulty they are experiencing. The majority of the problems students struggle with were different from the problems presented in a solution set. By design the solution sets do not contain every assigned problem, and the more difficult problems are left for the students to work on their own.

Students need to have some idea of what portion of a problem they are having trouble solving. Some students may need help getting started, while others may be struggling to properly simplify their answer. Many of the problems worked in business calculus require not only an application of some calculus procedure, but then a good bit of algebra to finish. Students need to be able to determine what it is they do not

understand in order to make effective use of the homework solutions. Unlike the help they may get from visiting a professor during office hours, the homework solution sets cannot look at what the student has done and provide individualized feedback for the misunderstanding of the student. The student must provide that for themselves. They must be able to apply what is presented in the solution set to what they are doing and correct their mistakes.

In order for the narrated solution sets to be perceived by students to be quality feedback, students must perceive them as useful (relevant to the task) and as providing competence support (a feeling of competence from task completion after feedback) (Rakoczy, Harks, Klieme, Blum, & Hochweber, 2013; Zerr, 2007). This research addresses these perceptions in multiple ways. The narrated solution sets are created by the students' instructor and consist of problems directly from their assigned problem sets, contributing to a sense of usefulness for students. The solution sets are narrated, and not simply stating the precise procedure, although that is also included, but consist of a narrative of the approach to the problem that the instructor is taking to solve it. The questions of "Why is the instructor doing that next?" or "How did he know to do that first?" are answered through the narration, helping students with competence support, which in turn can help students tackle future problems unassisted such as on tests where mastery is measured.

As they have been described numerous times above, the details included in the narration of the homework solution sets links them to the concepts of "teaching by telling" or "think aloud". Both of these techniques are rooted in the modeling technique of instruction. "Modeling is most simplistically defined as learning through observing or

watching others and then imitating what they do" (Nist & Kirby, 1986). The narrated solution sets model effective problem solving procedures to students. Again the details given behind why each step is taken and not just what step is taken are what make the narrated solution sets a potentially effective learning tool.

In a study by Shoenfeld (1992b), adult (college) students' problem solving strategies on unfamiliar tasks were compared to those of "expert" mathematicians. It was shown that students in general spend very little time reading and understanding a problem or task and tend to choose a solution strategy very quickly. Right or wrong the students do not deviate from their original strategy and spend most of their allotted time trying to make it work, even though it may be obvious that they are not getting anywhere. In contrast, the "expert" spends much more time, more than half of the allotted time in this case, just trying to understand the problem. The expert will then try a method that may or may not lead to a solution and will quickly abandon any attempt that leads nowhere. The expert repeats this procedure until they are confident that they know how to find the solution. Once an acceptable strategy is chosen the implementation phase takes very little time and the expert will typically verify the result.

Schoenfeld claims that this type of problem solving behavior is typical of students on unfamiliar tasks. However he states "…it is the case that such skills can be learned as a result of explicit instruction that focuses on metacognitive aspects of mathematical thinking." The details of the instructor's (expert) approach which is given verbally in the narrated solution sets can theoretically help emulate the problem solving processes carried out by the instructor.

Theoretical Basis for This Study

Recall Figure 1 that described the model for this study. Ultimately, business calculus seeks to produce students capable of finding derivatives and integrals as well as interpreting them in a business context. To reach this goal, students face many hurdles, and one of these, research suggests, is homework completion, seen as an important component of student study skills. Specifically, these hurdles impacting homework completion include: lack of self-regulation, lack of metacognition, differing perceptions of homework, poor help seeking skills, and the need for scaffolding in order to master the necessary skills. This section will further address the theoretical basis of this study as well as how the pencasts are theorized to address these hurdles.

The researcher employed a pragmatic interpretive framework using philosophical assumptions from a pragmatism paradigm as described by Creswell (2012, p.28-29). Following the pragmatism paradigm, multiple sources of data were collected. Surveys, document analysis, interviews, and statistics about frequency of use were employed in this research. The business calculus course is a service course taught in the mathematics department as a pre-requisite for entrance into the universities' school of business. The course does not replace any other calculus course taught in the mathematics department and does not fulfill the prerequisite requirements for any higher level mathematics courses. The curriculum for the business calculus course is set by the department and most instructors adhere to the set curriculum with only slight deviations. Limits, derivatives, and basic integration with direct applications to business applications are the main components of the curriculum. Students are expected to be able to find derivatives and integrals and interpret the meaning of the values they find. In this sense the course

has a very behaviorist feel. Although, behaviorism is not currently viewed as the best approach to education in general, there are instances where courses are still being taught in what could easily be called a behaviorist setting.

For this study the researcher adopted a definition of learning as follows; learning will be indicated by a students' change in behavior. Students who can show that they are capable of performing certain procedures (find a limit, take a derivative, evaluate an integral, etc.) at a 70% accuracy level will be considered to have "learned" the material. Learning defined in this way is frequently employed in university-level mathematics courses, allowing the results of the study to be helpful for a wide-range of college-level instructors who might find the research informative and relevant to their classroom contexts. This is in contrast to research that assumes some other definition of learning and that might challenge the "status quo" in undergraduate mathematics. Yet, because this project seeks to demonstrate the effectiveness of an intervention easily incorporated into a traditional setting, it makes sense to define learning thusly.

Business calculus is taught assuming a certain mastery of algebraic topics and therefore the typical course starts with the concepts of limits. The progression then flows through continuity and derivatives using the definition of derivative and a four step process to find derivatives of constant functions. Next the students are introduced to basic rules and properties of derivatives such as the power rule, product and quotient rules, and chain rule. Finally, students are introduced to integration. Indefinite and definite integrals are covered as well as the Fundamental Theorem of Calculus and integration by substitution. Integration by parts is rarely, if ever, covered. This is a normal course outline for many calculus courses. The information, like many subjects in mathematics, is

presented in a way that students need a solid understanding of the beginning material before they can master the ending material. The concept of a derivative is based on the concept of limit. Although one might be able to find or compute a derivative, understanding and interpreting what the result represents is impossible without some understanding of a limit. It is impossible to anti-differentiate a function and understand the result if you do not understand the derivative that yielded the function in the first place.

The course design is such that the information is presented in small amounts with the focus on how and why the mathematics works at each step. A limited number of examples are worked out in class and the students are expected to practice the procedures outside of class. Since class time is fixed, the instructor has to choose between working several examples quickly or just a few examples in more detail. The more detail that is given, the fewer the number of examples can be completed. On the other hand, working through many examples requires the instructor to move quickly and many students cannot follow every step or the instructor skips steps that may seem trivial or obvious to an expert but are not so for a novice. For these reasons, the in class instruction does not provide students with all of the scaffolding they need in order to successfully understand the material, or complete the homework assignments.

Traditionally there are multiple resources students can use to get the assistance they need to complete the assignments and therefore have more opportunity to learn the material. In theory, for this research, the instruction and examples given in class are insufficient for the average student to acquire the requisite knowledge at a 70% level. Therefore, by completing the out-of-class tasks the student has more opportunity to learn

the material. Instructor office hours, student assistance centers, homework labs, friends, and family are available to most students. However, the availability alone is not enough to ensure all students use these resources. Many students have scheduling conflicts that prevent them from seeking help from their instructor or attending a lab. Students also fail to seek help from their instructors because they feel they will be perceived negatively by someone who evaluates their work. Though students may utilize one of the available resources other than their professor the assistance they receive may not be equivalent to the assistance they would have received from the instructor (W. Collins & Sims, 2006). Karabenick (2011b) describes the difference between formal and informal sources of help for students. Formal sources include teachers or instructors, quasi-formal sources include a graduate or undergraduate teaching assistant, and informal sources include friends, family, or other students. Although the formal sources of help may be more knowledgeable and have more useful information, they may be less available than an informal source. Furthermore, students are often reluctant to seek formal help (Knapp & Karabenick, 1988). Fear of being judged incapable, harboring negative perceptions of the approachability of their instructor, or simply misunderstanding the structure of office hours are some of the many reasons students do not seek formal help. In this research, I theorize that the seemingly anonymous usage of the online solution sets will result in more students using this resource than other forms of help. Although the solution sets will be generic and every student will see the exact same file, the individual interactions will vary by student. Since the files are interactive and students can watch them as many times as needed, replay the same part, skip ahead, or possibly view all or only part of each solution set, the result will be a much more personal experience for each individual.

The online solution sets are created by the instructor and consist of problems directly from the students assigned homework set. For this reason I argue that the online solution sets are a formal source of help. The narration that occurs in the pencasts not only covers the procedure or algorithm but includes rationales and thought process that occur while deriving a solution.

Many mathematics problems have multiple ways to go about solving them. Students who use informal sources of help to solve their homework problems are often presented methods that differ from what was presented by the instructor. For a student who is unsure about the method presented in class by the instructor, seeing a different approach can possibly add to the confusion. Also, as often occurs in any college subject, students taking notes in class are concentrating on writing down everything that is written by the instructor and not necessarily focusing on what is being said. Students often miss key information because it is given verbally in class and not written on the board. Often times when solving a mathematics problem on the board, the results of steps taken by the instructor are what is written down and the reasoning or rationale for taking the step, or possibly the step itself, is only stated. Students frequently get lost between steps, or miss the rationale for a step and are left wondering how the solution went from one line to the next. Students are often reluctant to speak up during class and let the instructor know that they do not understand a specific step or concept. Time constraints can also force instructors to keep moving rather than stop and give a more detailed explanation, or perhaps they are unwilling to repeat something they feel they have already covered. In either case the student is left to fill in the gaps outside of class. At this point the student has a series of decisions to make: Do I need help? Will I actually seek help? If so, from

where or from whom? With each decision, more questions arise: Is the help I need or seek available at a convenient time? Are the resources I choose willing to help? Is the help satisfactory? There are many thoughts, questions, and judgments students make in the process of seeking help (Kempler & Linnenbnnk, 2006). Previous experiences can also factor into a student's decision to seek help and the type of help they seek. For instance an experience with a previous instructor may affect whether or not a student seeks formal assistance. Theoretically, the online homework solution sets are completely neutral, make no judgments about a student's competence or ability and are readily available and willing to help anytime and anywhere the student is connected to the internet. With more and more students using smartphones, tablet computers, and other similar devices, the accessibility is virtually limitless. The online homework solution sets can be viewed from any such device.

This study is concerned with how students incorporate narrated solution sets into their study routines. It has been shown that calculus is a roadblock mathematics course and student study behaviors, including homework completion and help seeking, directly affect student success. It is theorized in this study that the narrated solution sets can assist students in completing their out of class assignments and potentially serve as a non-threatening help resource. The second research question can assist instructors in crafting learning resources for their students. If we can better understand student perceptions of this resource we can possibly assist more students in successfully completing business calculus.

CHAPTER III

Methodology

Research Design

In this mixed methods design, quantitative data in the form of survey instruments, documents, and frequency use data was combined with in-depth longitudinal interviews to determine what effects incorporating narrated solution sets into the curriculum in business calculus have on student perceptions of their mathematics course. By collecting data from multiple sources, the researcher hoped to get a clear insight on not only whether or not students use the narrated solution sets, but how they use them and how they perceive their interactions with them.

The technology that was used in this study is generally referred to as a “smart pen”. The smart pen is a ball point pen, slightly larger than the average pen, that has a built in camera and digital recorder. When the user writes on specially made paper the camera, located in the tip of the pen directly under the point, records every stroke. Handwriting, doodles, graphics, anything that is written on the paper is recorded exactly as it appears on the page. The digital recorder allows the user to record any audio that may be occurring in the general vicinity of the pen. The pen automatically links the two data types, written and audio, together in real time. The effect is that the user can go back to the notes on the page and using the pen, replay the audio that was occurring while the writing was taking place. An example would be a student in a typical lecture. Using a smart pen, the student could record the lecture while actively taking notes in class. Any time after the class was over; the student could access the audio portion of the lecture at

any specific time during the lecture simply by touching the pen to the paper. Other functions include fast forward, reverse, speed-up playback, slow-down playback, volume, etc.

For this research, pencasts were created by the researcher/instructor. The content of the pencasts was selected homework problems from the problem set assigned to the students. Only select problems were completed. To create the solution sets the instructor worked out problems using the smart pen and paper while simultaneously narrating the solutions. Specifics of not just what steps are being taken but why the steps are being taken were included in the narration. The solution sets were then uploaded to the website and a link to the solution sets was provided to the students in the course. Once the link is posted, students are able to view the pencasts as often as they wish. There is no limit to the number of times a file can be viewed or to the length of time a file is viewed.

In this study, the population was two sections of business calculus comprising a total of 88 students registered on the first class day. One section meets three days a week (MWF) for 50 minutes at 9 am and the other section meets two days a week (TTH) for 80 minutes at 12:30 pm. The initial surveys were given the first day of class and no mention of the pencasts was made until the first one is uploaded.

The pencasts were uploaded starting the third week of the semester. The instructor gave a short demonstration of the pencasts and how to access and use them in class. The pencasts were uploaded a few days after the sections were covered in class. Typically the instructor waited at least two days after a section is covered and homework assigned before uploading the associated pencast. The exercises covered in the pencasts are

detailed in Table 1. The method for selecting the exercises included in the pencasts is detailed in the next section.

Table 1
Assigned problem sets and problems included in associated pencasts

Book Section	HW Assignment	Pencast Problems
2.5 Exponential Functions	1, 29-33, 35, 37, 43, 45, 47, 53; use a calculator to work 3-17, 21-25	29, 31, 33, 35, 37, 43, 47
2.6 Logarithmic Functions	1-19, 21-25, 27-33, 43-49, 79, 81, 83	43, 47, 79, 83
10.1 Introduction to Limits	1-15, 21-37, every other odd 43-57, 71, 73, 75, 79	47, 51, 65
10.2 Infinite Limits and Limits at Infinity	1-7, 9, 13, 17, 19, 21, 25, 29, 31, 35, 39, 47, 51, 69, 73	9, 13, 17, 31, 35, 39, 43, 70, 74
10.3 Continuity	11, 13, 19, 23, 27, 29, 33, 35, 39, 45, 47, 77, 83	23, 29, 33, 37, 83
10.4 The Derivative	1, 3, 5-25, 27, 31-37, 41, 61, 63, 65, 67, 69	9, 19, 66
10.5 Basic Differentiation Properties	1-55, 57, 59, 63, 71, 73, 81, 83	15, 19, 25, 37, 43, 49, 53, 82
10.7 Marginal Analysis in Business and Economics	1-11, 13, 15, 17, 19, 25, 29, 33, 43	No Pencast; Group Project
11.1 The constant e and Continuous Compound Interest	1-39, odd	33, 35
11.2 Derivatives of Exponential and Logarithmic Functions	1-57, odd	15, 19, 23, 51, 55, 57
11.3 Derivatives of Products and Quotients	at least every other odd 1-81, 81-89 odd	1, 5, 9, 13, 17, 25, 27, 41, 45, 53, 67, 77
11.4 The Chain Rule	at least every other odd 1-70, 71-99 odds	1, 7, 17, 25, 33, 43, 51, 55, 59, 67, 71, 91, 93

Table 1 continued

Book Section	HW Assignment	Pencast Problems
11.7 Elasticity of Demand	at least every other odd 1-59, 63, 65, 69, 73	No Pencast; Group Project
12.1 First Derivative and Graphs	1-25 odd, 27-39 every other odd, 63-67 odd, 79-85 odd, 89, 91, 97	19, 27, 37, 79
12.2 Second Derivative and Graphs	1-33 odd, 85, 89, 91: 43-63 find pertinent info but use a calculator to graph, don't sketch	7, 15, 19, 25, 33, 43, 51, 87
12.3 L'Hopital's Rule	1-55, odd	1, 23, 35, 54
12.5 Absolute Maxima and Minima	1-61, odd	11, 17, 33, 51, 57
12.6 Optimization	1-11, 15, 17, 24, 27, 32	No Pencast; Group Project
13.1 Antiderivatives and Indefinite Integrals	1-24, 35-72, 83-95	1, 5, 11, 41, 47, 53, 57, 61, 69, 72, 83
13.2 Integration by Substitution	1-36, 49-65, 67-75	1, 13, 23, 27, 49, 61, 67
13.3 Differential Equations; Growth and Decay	1-11, 19-25, 41-47, 53-71	1, 19, 53, 63
13.4 The Definite Integral	17-47, 55, 67-71	17, 37, 67
13.5 The Fundamental Theorem of Calculus	5-39, 49-53, 61-85	5, 13, 25, 37, 61, 79

Choosing Pencast Problems

Ultimately the choice of which problems are worked in detail in a pencast is a subjective decision made by the instructor. However, the problems included are not randomly chosen and there is a specific thought process behind choosing the problems. The textbook which is used in business calculus at the university where the study was conducted (chosen by the department, not the instructor) divides the chapters into sections and has a set of related exercises at the end of each section. Each exercise set is divided into four groups; A, B, C, and Applications. Groups A, B, and C are further

divided into different objectives. Each of these groups cover similar objectives, but the exercises become progressively harder with A being the easiest group and C the hardest group. The Applications section is all word problems applying the skills introduced in the section to real world scenarios from a wide range of topics including business, finance, marketing, medicine, construction, etc.

Depending on the topic and the types of problems included in the exercises, choosing which problems to include in a pencast can be relatively easy or somewhat involved. Some objectives are very conceptual and do not require the student to carry out a procedure to solve. An example of this would be looking at the graph of a function and determining where the derivative of the function would be equal to zero. Other objectives are procedural and require the student to carry out a specific set of steps to solve the problem. An example here would be given a function, find the derivative of the function. Due to the nature of the pencast resource, the exercises which require the student to carry out a specific procedure are more easily demonstrated using the technology. For this reason, the procedural problems are typically the ones chosen to be included in a pencast. Ideally, the instructor would want to include at least one problem from each objective, and each difficulty group. However, in practice this is not always possible. Some of the objectives have very few problems included in them and working any for the student may not leave any or many for the student to practice on their own. On the flip side, the objective may contain so many problems that only working one does not adequately cover the range of skills needed to work all problems in the section. In this case the instructor may choose to work several of the problems in the objective, still leaving plenty of practice for the students.

To work application problems or to not work application problems, that is the next question. This is, once again, a subjective decision made by the instructor. The business calculus course is a service course where procedures, not theory, are the focus. The application problems are the direct usage of the procedures taught, and hopefully learned, which are the goal of the course. Should the students be left to struggle and work through these exercises or should they include a help resource like the pencast? In this study, a few application problems were worked. They were not the focus of the pencasts.

Occasionally throughout a semester a student will email the instructor and request a specific problem be worked via pencast. This is very encouraging from the instructor's standpoint because it implies that the student is in fact working on their homework. For this reason it is often difficult to decline the request. The question then arises; how does the instructor decide whether or not to acquiesce to this request? This is again a subjective decision made by the instructor, but factors included in the decision are; who the student is, which problem they are requesting be worked, and which problems have already been worked. Who the student is relates to the scaffolding discussed earlier. Only the instructor knows if the student needs the assistance they are requesting or maybe they just need a little more time to work it out themselves. The specific problem may be one that was assigned for a specific purpose by the instructor; perhaps it will be included on a future quiz or test. Suppose a student is asking about exercise 17, but 17 is procedurally equivalent to 15, and 15 has been worked out already, then the instructor might refer the student to the solution presented for 15 and ask them to try to apply the steps to 17. On the other hand, if the student is asking about an application problem and no similar application problems have been worked, perhaps it would be good to provide a one

exercise pencast addressing the student's questions. The benefit of answering the question with a pencast is that it can then be posted on the course website for the benefit of the other students in the course.

Instruments

Three survey instruments were developed and administered during the semester. The first survey contains demographic items and general information about the students' study habits. The demographic information collected included previous mathematics course work, classification, and major. General study habit information included frequency and duration of study sessions, help seeking behaviors, and resources employed. The midterm and exit survey were more focused on the students inclusion of the narrated solution sets into their study routines and their perceptions of the resource. Each instrument was delivered face to face in a group setting during the students' regular class times. Incentives of extra credit, in the form of a daily quiz grade, were offered to the students who chose to participate in the survey instruments. Students who chose not to participate in the surveys were given an alternate assignment so they may have an opportunity to receive the extra credit. See Appendix A, B, and C for the survey instruments.

Documents collected included, mid-term evaluations, and end-of-term evaluations. Pilot data suggests that some students don't fully engage in the course until after the first exam. Some students who do not perform as well as expected on the first exam begin to attend office hours or seek out other resources after the realization that

there current study routine is not adequate. On the flip side, there are high performing students who do well on the first exam who do not utilize many, if any, outside resources.

Although the researcher is the instructor of record for the course, he is a Doctoral Teaching Assistant and not a member of the faculty. For this reason, the instructor is required to deliver mid-term evaluations to the students in the course. The evaluation form consists of eight Likert-scale type questions and two open ended prompts, see Appendix G. The open ended prompts are generic in form. They simply ask the students to describe any behaviors they find particularly beneficial, or particularly detrimental. The form is a standard form used by the department for all teaching assistants. Pilot data shows that even though there is no specific prompt about the narrated solution sets, students often mention them on these evaluations. End-of-term evaluations are completed by students for all faculty and teaching assistants in the mathematics department. Similar in form to the mid-term evaluations, they include a standard set of Likert-scale questions followed by open ended prompts, see Appendix H. Both evaluations are anonymous and optional.

The frequency use data is collected automatically by a built in feature of the online learning environment used by the university. Instructors are able to create sites, available only to students enrolled in the course, where course information can be disseminated. Resources can be posted for download by students, files can be shared, and there is a grade book feature, forums, and many other tools. This site is where the links to the narrated solution sets were posted. A tool called Site Stats, which is built into the program, keeps statistics on which resources are used and by whom. It records how many times a particular resource is accessed as well as who accesses which resources and how

often. This information was used to triangulate the data collected by the survey instruments.

Interviews

Interview candidates were selected purposefully from demographic data collected on the first survey instrument. Due to the high drop rate, four to five participants from each section were selected with the intention of having at least two participants from each section make it all the way through the course. Since the population of students in the course is so diverse, participant selection was purposeful to try to capture insight from the different types of students. Tennant (2012) found that there are differences between non-traditional students and traditional students in terms of not only how they study, but resource usage, motivation, and previous mathematics experience. For these reasons the researcher selected traditional and non-traditional students. The researcher is also interested in differences in traditional students at different levels (classifications).

The initial interviews took place during the first two weeks of the semester. In these interviews the participants were asked to describe their math story, their motivation for taking the course, their expectations of success in the course, and their study habits including help seeking and resource usage. There was no mention of the narrated solution sets by the researcher in this initial interview. See Appendix D for the interview protocol.

The second interviews took place mid-term. This interview focused on student perceptions of the class and their resource usage, with special attention brought to the narrated solution sets. See Appendix E for the interview protocol.

The exit interview was conducted at the end of the regular semester. This interview focused on the students' perceptions of the course in general as well as to ascertain whether the students' perceptions changed over the semester and if so, what was the cause of the shift in perception. Detailed accounts of how the students incorporated the narrated solution sets were obtained in these interviews. See Appendix F for the interview protocol. After all interviews were completed, the researcher chose four participants, two from each section, to analyze in depth and include in this study.

Data Analysis

Following the tenants of the pragmatic world view outlined by Creswell (2012), on which the theoretical framework for the research is based, multiple sources of data were collected. The data collected addresses the problem outlined in the introduction and "…focus on the practical implications of the research…" (Creswell, 2012, p. 28). Surveys, interviews, field notes, and frequency use data for the pencasts were collected.

Frequency use data was generated through a feature of the online classroom software used by the university. The "Site Stats" tool is built into the software and includes a report application which allows instructors to create custom reports which include the frequency of resources accessed, which users accessed which files, the frequency in which users accessed files, and even the time of day in which files were accessed. The frequency use data addresses research question one; How do students incorporate narrated solution sets into their study routine? By analyzing the frequency in which students access the files compared to attendance in office hours and responses to

survey instruments, along with the time of day students access the files, light can be shed on the question of how students incorporate the resources available to them.

Survey data was collected from all willing students present in class on the days the surveys were delivered, the first day of class, around midterm, and an exit survey at the end of the semester. The data collected from the surveys was qualitative in nature; short-answer responses to open-ended questions. Upon completion of each round of surveys, the researcher transcribed the student responses into a Microsoft Excel workbook.

After transcription, the responses were printed and the open coding process began. Starting with Section A, all of the answers to the first question were read. In this first read-through, certain commonalities between different respondents were noted in the margins of the printout. These commonalities became the initial themes. These themes were written down and assigned a color at random. The responses were then re-read and specific aspects of each response that fit into a theme were highlighted the associated color. Many responses were multi-colored. Next, the responses from Section B were read. The researcher attempted to reconcile the initial themes from Section A to the responses from section B. This did not work completely and new themes emerged from Section B.

Next, the researcher considered all the themes generated from both sections and refined the themes, axial coding, and categories of the themes were generated. The responses from both sections were read through once again and highlighted according to the refined themes generated during the axial coding process. This selective coding process resulted in many responses being multi-colored, meaning the students' responses

were cross-themed. This process was repeated for each open ended question on the surveys.

Once the themes were finalized, see Table 4 in Chapter 5, a detailed description of the themes was developed which included examples from the responses. This detailed description was given to two independent colleagues along with approximately 20% of the raw data for each section. These colleagues then coded the raw data according to the descriptions generated by the researcher. Each used a similar system of color coding as the researcher though the colors were different for each individual. After the independent raters coded the raw data, the researcher compared the original coding to that of the others. The inter-rater reliabilities were 88% for one rater and 95% for the other, which is greater than 90% agreement overall.

Interview data was collected via digital audio recorder. The audio files were then uploaded to a computer and transcribed. The transcriptions were then analyzed using a case study analysis. During the analysis, each case was considered individually and commonalities and contradictions were noted. Next, each case was analyzed looking for similarities and differences between the cases. Finally, each case was considered using the themes developed in the open coding analysis of the exit survey data. In this way a detailed account of how each of the four participants incorporated and perceived the narrated solution sets was created.

In this study four students were selected to participate in three in-depth longitudinal interviews with the researcher. On the first day of class, all students completed an initial survey which included demographic information. Based on the

results of this survey the researcher purposefully selected the four student participants. On the consent form signed by each student in the two courses, there was an option for the students to acknowledge whether they would be willing to participate in an interview. Naturally, this was the first criteria used to select the students to participate in the interviews. From the students who agreed to be interviewed, the four participants were selected based on their responses to the initial survey prompts. Although gender was not a specific criterion, one male and one female were selected to participate in the interviews from each section. The names of the participants have been changed to protect their identities.

Maria is a 21 year old senior. She is majoring in marketing and business calculus is a required course for her degree plan. She is a full time student with a part time job. She lives in the same town as the university just a few blocks off campus. One of the prompts on the initial survey asks the students to “name one thing you are proud of”. Maria stated in response to this prompt that she is proud of being a first generation college student from humble beginnings.

Maria feels that she was not adequately prepared by her high school teachers for the rigors of undergraduate mathematics. She struggled to pass the pre-requisite course for business calculus. Maria took business algebra, an acceptable pre-requisite course, twice and failed to pass it both times. The semester before this study took place Maria took and passed college algebra, which fulfilled her pre-requisite requirement.

Steve is a 27 year old single father classified as a junior. He has transfer credits from a local community college and his last mathematics course was college algebra,

taken a year and a half ago at his community college. Steve is a part time student, enrolled in only nine hours, and works approximately 30 hours per week. He lives in a neighboring city approximately 35 miles from the University. He commutes to campus only on days when he has scheduled classes which are on Tuesdays and Thursdays this semester.

Steve says that high school mathematics was “very challenging but I passed my courses”. He considers mathematics to be hard, but gets a level of satisfaction when he is able to have success in the subject. Steve fits almost perfectly to the description of the “adult learner” described by Tennant (2012). Steve is over the age of 25, has dependent members of his household, commutes to school, works outside of school, and has not been enrolled in a math course in the last year and a half.

John is a 19 year old business major. He is a traditional sophomore student enrolled full time. He attended a different state university his freshman year, pursuing an interest in sports, but found it did not suit him. He was raised in a small town adjacent to the one where this university is. He lives at home and commutes about 15 miles to school. John took college algebra and pre-calculus as a freshman. He works outside of school, but he is employed by a family friend and has a very flexible schedule.

John describes high school mathematics as “easy”. Although he is required to take business calculus as part of his degree, he claims to “love math” and shows desire to learn the material. John believes what he learns in this course will be very important to his future courses and career, in his words “I expect my major to be filled with it”. John enjoys working challenging problems and gets satisfaction from solving problems that he

was not sure he could. John's least favorite thing in mathematics is "not being able to solve a problem".

Stacy is an 18 year old traditional freshman student. She lives on campus and does not work outside of school. Stacy describes her high school mathematics courses as "basic and easy to understand". However, she describes mathematics in general as "difficult yet rewarding". Stacy took two different mathematics courses as a senior in high school. One of the mathematics courses she took was a dual credit college algebra course taught by a teacher from the local community college. According to Stacy, the instructor for the dual credit course incorporated many video lessons from Khan Academy and did not use many direct teach methods. Stacy did not feel that she learned very much from this course. Despite her feelings, Stacy did earn the prerequisite credit and was able to enroll in business calculus during her first semester in college.

Stacy is enrolled in what is called the Business Learning Community (BLC). In the BLC students are co-enrolled in the same core courses and housed on the same floor of the dormitory. The BLC has scheduled study times where members meet and work in groups. Many students are enrolled in the same sections of their core courses, but Stacy says that do to registering later than most students, she is taking the same courses, but not the same sections as the other members of her cohort. There are many business calculus courses offered each semester and therefore there are many different instructors. Stacy was the only member of her cohort that was enrolled in one of the sections taught by the researcher this semester.

These four students represent a cross section of the diversity of the population the business calculus courses where the research took place. The University where the research took place is recognized as a Hispanic Serving Institution and therefore has a higher than average population of Hispanic students. Both Maria and Stacy represent this population. In the courses being investigated in this research, there are students from diverse backgrounds as well as all classifications enrolled. Traditional as well as non-traditional students are represented. Transfer students, adult learners and veterans are enrolled in these courses. Several of the students enrolled are taking business calculus for a second or even a third time.

With multiple modes of data collection, a purpose is often to “triangulate” results. That is, to determine whether the various modes “agree”. This is especially helpful when qualitative data is being collected. The time required to conduct, transcribe, and analyze interview data prevents the researcher from being able to get the level of detail derived from an interview from every potential subject in a study. Incorporating multiple modes of data collection and multiple sources of data enables the researcher to “see the whole picture”. This research will report on findings where the modes of data generally agree with one another. But it is also important for the research community to know when certain modes of data generated unique responses or even contradictory responses. This research will also report on findings that seem especially divergent because this might indicate that a certain data collection mode is better suited to generating certain responses or just that students are conflicted on a certain construct.

CHAPTER IV

Results

The goal of this research study is to determine to what extent students incorporate narrated homework solutions sets into their regular study routine and what affect the solution sets have on student perceptions of their mathematics course. This mixed methods study employs both qualitative and quantitative data sources. This chapter presents the finding of this study. The results are presented in two sections each corresponding to one of the research questions:

1. How do students incorporate online narrated solution sets into their study routines?
2. What are student perceptions of such a resource?

This study took place in two sections of Business Calculus at a major University in Texas. Both sections, here after referred to as Section A and Section B, were taught by the researcher. Section A met three days per week Monday, Wednesday, and Friday (MWF) at 9am for 50 minutes and Section B met twice a week on Tuesday and Thursday (TTH) at 12:30 for 80 minutes. Survey data, frequency use data, documents, and interview data was collected. The exit survey data was collected via a face-to-face, paper and pencil survey administered in-class at the end of the semester. This survey contained six open ended questions about students' use of the narrated solution sets. 54 students completed the exit survey, 30 from Section A and 24 from Section B.

The researcher, who was also the instructor of record for the two sections of business calculus considered in this study, kept a record of office hour attendance for the semester.

Office hours were offered five days a week from 10 am until 12 noon. Students could request other times by appointment, which a few students did. Students were asked to sign their name and date on a log kept by the instructor in his office. From this log, a total of 29 different students attended office hours at some point during the semester. The first date of attendance was on August 25 and the last day a student attended was December 5. The majority of students attended office hours, at most, one day per week. Overall, there were 92 student visits to office hours for the semester. Table 2 displays the statistical summary of office hours attendance.

Table 2
Student attendance in office hours

	Frequency of Office Hour Attendance	Number of Students
	1	9
	2	6
	3	5
	4	1
	5	4
	6	1
	7	1
	9	1
	10	1
Totals	92	29
Median	2	
Mean	3	
Mode	1	

The students in the courses involved in this research study were required by the University to complete two sets of classroom evaluations. One evaluation was given around midterm and the other evaluation was given at the end of the semester. Both evaluations were anonymous. On the midterm evaluation, students responded to 8 Likert-

style questions and two open ended questions. Appendix G displays the mid-term evaluation form. The end of semester evaluation also contained 8 Likert-style questions and one open ended question. Appendix H shows the end of course evaluation. Both evaluations are generic forms used by the Mathematics Department in all courses taught by graduate assistants.

Frequency use data was collected automatically by the University's online classroom environment. Each time a student accessed a file, a log was created detailing which student accessed which file and the date and time of the access. In total 19 files were created and up-loaded to the course website for Section A, and 18 files were uploaded for Section B. Not every student viewed every file; however, each file was accessed multiple times. In Section A, each file was accessed an average of 20 times and the 19 files were opened a total of 383 times by students. In Section B, each file was accessed an average of 29 times and the 18 files were opened a total of 527 times by students. Table 3 details the total accesses by file for each section. Approximately 50% of the accesses occurred between the hours of 8 pm and 8 am, when face to face campus resources such as office hours or tutoring centers were not available.

Four students were interviewed by the researcher, two from Section A and two from Section B. Each interviewee participated in three interviews, an initial interview at the beginning of the semester, a mid-term interview, and an exit interview at the end of the semester. The initial interview took place before the students had been exposed to the narrated solution sets and was used to gain insight on student background and past study habits. The mid-term and exit interviews were used to investigate how the students were using the narrated homework solutions and their perceptions of the course.

Table 3
Total accesses per file

File	Accesses Section A	Accesses Section B
Ch 10.1	25	29
Ch 10.2	17	32
Ch 10.2 app	12	17
Ch 10.3	23	20
Ch 10.4	26	32
Ch 2.5	16	31
Ch 2.6	13	0*
Ch 10.5	13	9
Ch 11.1	26	32
Ch 11.2	32	26
Ch 11.3	29	35
Ch 11.4	23	40
Ch 12.2	20	34
Ch 12.3	20	25
Ch 12.1	25	28
Ch 12.5	12	27
Ch 13.1	13	37
Ch 13.2	20	42
Ch 13.5	18	31
Total accesses	383	527
Average accesses per resource	20	29

Note. Ch 2.6 was not uploaded to the Section B website.

Student Study Routines

This section will discuss the results of the data collected concerning the research question: How do students incorporate the narrated solution sets into their study routine? For this study a "study routine" refers to any act of engagement with course material outside of class time, i.e. doing homework, reviewing course material before or after completing homework, reviewing for a test or exam, etc. This research question addresses how students interact with the narrated solution sets during these study times.

The midterm survey contained an open ended question asking student to describe their typical interaction with the solution sets. 25 of the 65 students who responded to the open ended question mentioned that they typically studied in the evening or late at night. For this study the researcher adopted a definition of "at night" as being between the hours of 6:30 pm and 2 am. Analysis of the frequency use data supports the students' claim with approximately 50% of all file accesses occurring "at night."

Open coding analysis of the exit survey data resulted in four main themes of how students incorporate the homework solutions into their study routines: extra lecture, review, during homework, and after homework. Table 4 defines each of these four themes in detail. The remainder of this section will be divided into four parts, one for each identified theme, presenting the results of the data collection from each data source which supports each of these four themes. The themes represent a global view of student study routines in the two sections of business calculus studied in this research. Following the data presented on the four themes will be a detailed description of the study routines of the four cases generated by the face to face interviews.

Table 4
Themes generated by exit survey data

Theme	Description	Examples
Extra Lecture/Before HW	Students' use of the HW solutions is described as either independent of HW completion i.e. as an extra lecture covering the material or occurs before they start the HW	"I viewed them before I did the HW." "They were very useful, because it was very similar to being in class lecture (but at my own pace)." "I used them before like a personal lesson."
Review	Students' use of the HW solutions is for review purposes before an in-class test or exam. Specifically linked to the tests or exams, not reviewing previous sections for HW assistance.	"They helped me study for tests." "I often used them as a review resource before the tests. I will use them all again before the final."
During HW	Students' use of the HW solutions is described as a during HW completion to help understand a concept or figure out how to solve certain problems.	"Did not know how to work-out problems." "In all cases I was stuck on a problem so I went to see how it was worked out." "I used it as a walkthrough for the questions I struggled with."
After HW/Check answers	Students' use of the HW solutions is to check their answers or check their procedures.	"I was looking for answers to homework…" "To check problems after I do them and look for formulas."

Note. Some responses were coded with multiple codes, i.e. "Before and if I got stuck" would be coded as both Before HW/extra lecture and During HW.

Before homework/extra lecture

The extra lecture theme refers to students who report watching the narrated solution sets before they begin the homework assignment or specifically as an extra lecture. Some students use the solution sets as a make-up lecture when they miss class or to clear up any misunderstandings from the in class lecture. 18 of the 54 exit survey respondents report this type of usage. Sample student responses include “I viewed them before I did the homework”, “I would try and watch all of them before I started my HW”, and “Sometimes I would view the solutions before I started my homework. If I had no idea what I was supposed to do in that section, I would more than likely look at the HW solutions first.” Several students comment on the homework solutions as a “personal” lecture. These students mention the ability to control the pace of the lecture by pausing and rewinding as need be to better understand the material.

One of the students who participated in the face to face interviews, Maria, describes her use of the online homework solutions; “Yeah, actually I go to it first, watch it, and then attempt the problems. I watch it to help me refresh what it is I’m about to do, then try to do them, and then if I can’t, I go back.” Maria is a full time student who also works part time. She often does not have the opportunity to work homework problems the same day the material covered by that section is presented in class:

Researcher:	You might watch a file in the middle of the afternoon between classes or something and not do the homework until that night?
Maria:	Yeah. Sometimes I just watch the videos just so I could keep it fresh in my mind.
Researcher:	You may or may not do the homework even that same day?
Maria:	Yeah.

Maria's use of the online homework solutions is cross themed. She not only uses them as a refresher before attempting homework but also refers back to them while working on her homework.

Review

The review theme refers to students who watch the homework solutions sets specifically for the purpose of reviewing the material before a test or exam. "I often used them as a review resource before the tests. I will use them all again before the final", "I usually view all of them in the upcoming days before the test", and "I viewed all of them right before an exam" are examples of student responses from the exit survey that indicate they are using the homework solutions as a test review. 12 of the 54 respondents report this type of usage.

Figure 2 displays the total number of accesses of online homework solutions by date for Section A. This section met three times a week at 9 am. The figure shows four distinct clusters of occurrences of activity. The first cluster occurs around the dates of September 26 through September 27. The first course test was given on September 27th. Usage then drops significantly until the next spike around October 23 through October 24, which coincides with the second course exam administered on October 25th. Then the usage drops again until December 1st and December 2nd. The third course exam was administered on December 2nd. Finally there are usage peaks on December 8 and December 9, which coincide with the final exam date of December 9th.

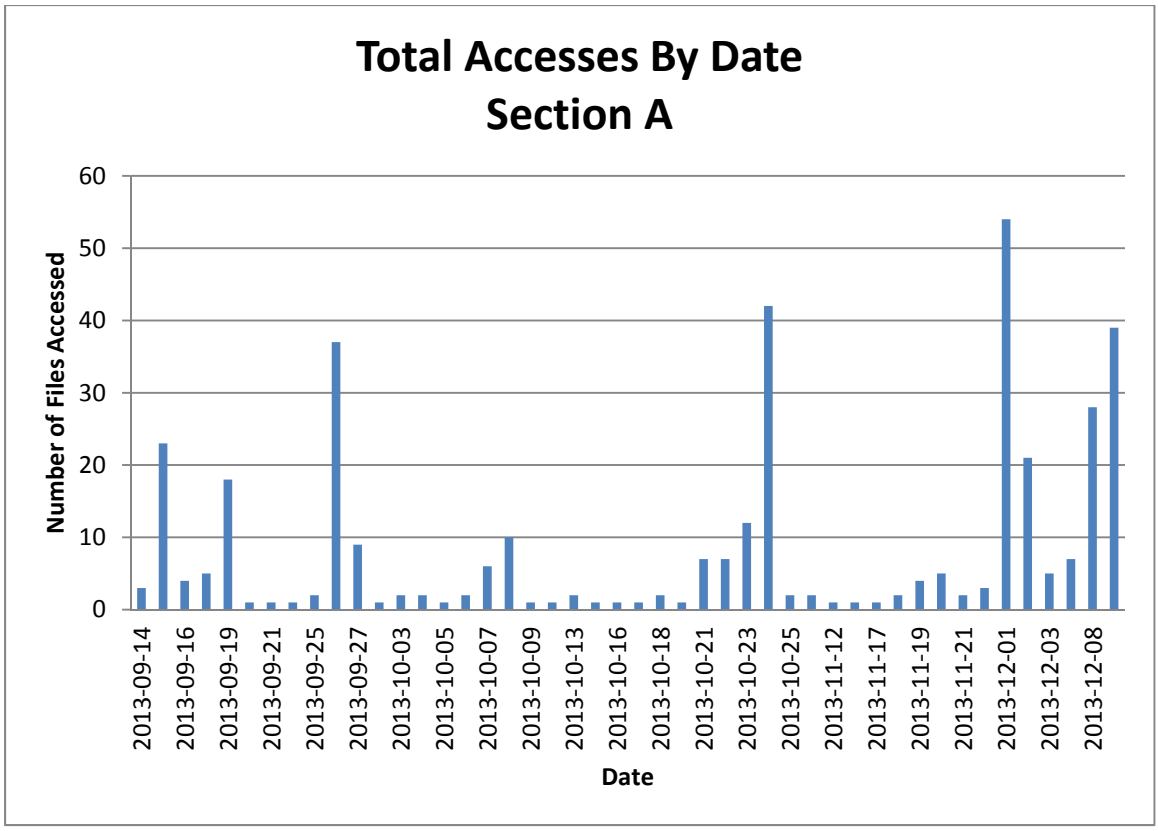

Figure 2. Total number of files accessed by students in Section A by date.

The peaks are considerably higher than the total number of files, which indicates multiple students are accessing multiple files. It is interesting to note that in each case, there are relatively few students who are accessing the files. There were 10 students who accounted for the nearly 40 file accesses of the first major peak on September 26. The peak on October 24 of just over 40 accesses was created by 15 students. The December 1 peak of over 50 accesses was accomplished by 11 students. It makes sense that the number of accesses would increase with each test since the tests were cumulative in nature and therefore the students reviewing for the test would have more sections to review on test 2 than on test 1 and likewise from test two to test 3. The final exam peaks on December 8 and December 9 represent six students who opened the files nearly 70 times.

Section B met twice a week at 12:30. Looking at the frequency use data for Section B reveals a very similar trend to what was observed in Section A. Figure 2 displays the total number of files accessed by date. One major difference between Section A and Section B is that the majority of file accesses for Section A occur the day before a test or exam, the exception being the final exam which was given on December 9 for section A. However, 38 of the 39 accesses on December 9 occurred between midnight and 4 am. Section B accesses tend to cluster around the days leading up to a test or exam as well, but the peaks occur on the actual day of the test instead of the day before.

Figure 3 displays the total number of files accessed by date for Section B. It is clear to see that there are four clusters of activity. The first cluster occurs from September 25 until September 26. This cluster coincides with the first course test which was administered on September 26. The next cluster occurs from October 22 until October 24. This cluster coincides with the second course test which was administered on October 24. The third cluster occurs on December 22 and December 23. This cluster coincides with the third course exam which was administered on December 23. The final cluster occurs from December 10 through December 12 which coincides with the final exam which was administered on December 12.

As was seen in Section A, the peaks are considerably higher than the number of files which indicates that multiple students are accessing multiple files. It is interesting to note that the numbers of students who are accessing the files on these peak dates are similar to the numbers seen in Section A. The first peak on September 26, of nearly 40 file accesses, was completed by 10 students. The second peak of nearly 40 file accesses that occurred on October 24 was achieved by 12 students. The third peak on December 3

of more than 80 file accesses was created by nine students. The final exam cluster of nearly 80 accesses on December 11 and December 12 was created by 7 students.

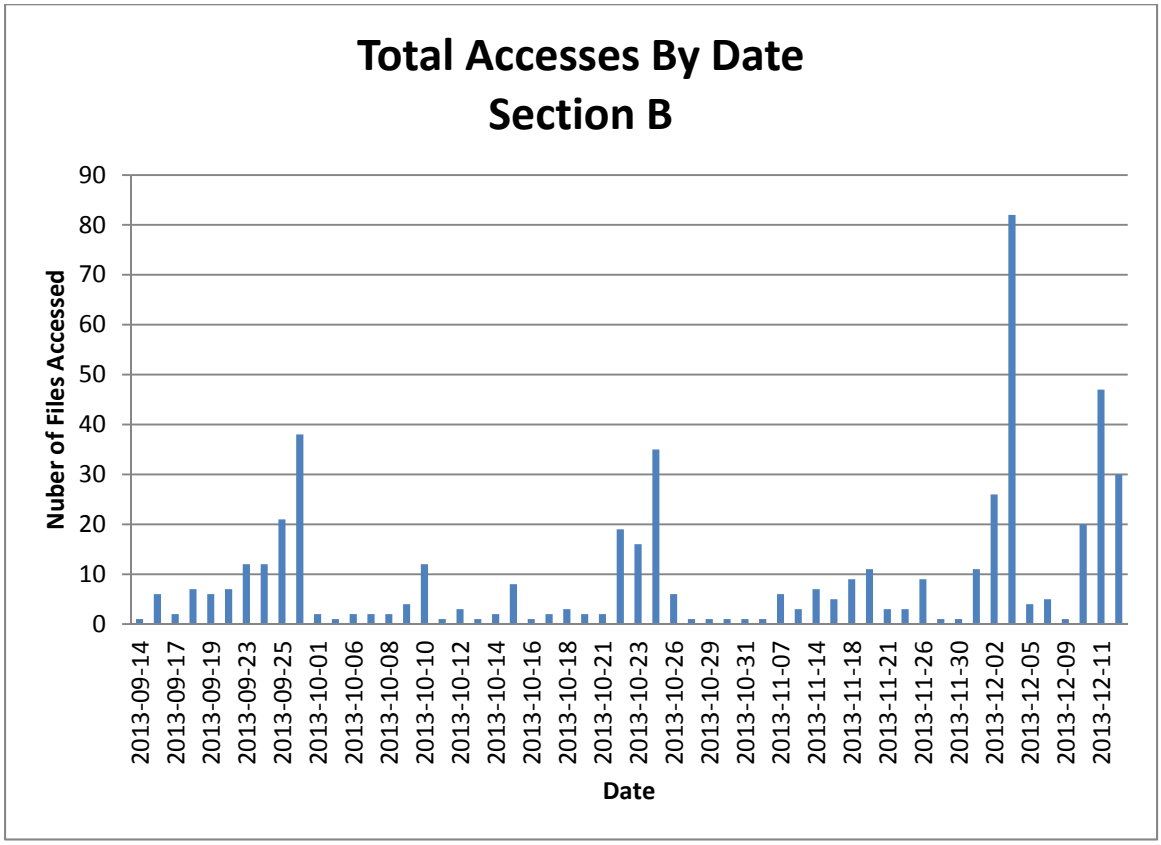

*Figure 3.*Total number of files accessed by students in Section B by date.

It is evident from Figures 1 and 2 that students are not regularly accessing the homework solutions. It appears that they are waiting until the test to access the files. These trends imply that student use of the narrated homework solutions is intended as a study aide to prepare for the tests.

John, a student enrolled in Section A who participated in the interviews, stated in his exit interview: “The ones that I didn’t look at I’ve gone back and looked over and that’s probably going to be one of my main sources of studying for the final [exam]. It’s one-on-one time basically.” John is a strong student who attended office hours regularly.

His use of the solution sets is cross themed. He used them regularly while working on homework and as a study resource.

Stacy, a student enrolled in Section A who participated in the interviews, is enrolled in a learning community at the University where the study took place. As part of the learning community she has regularly scheduled study sessions with other members of the community. During the middle of the semester, the group became fragmented and did not meet as regularly as they did at the beginning of the semester. As the end of the semester drew near, the learning community began to feel pressure to catch up on their studies. Stacy said this in her exit interview:

> Yes, even yesterday because their test is on Wednesday next week and they're all freaking out about finals. We're all back together trying to work on it again. They're bringing back the videos [narrated solution sets], but for a while there we were just, I think it started two weeks before thanksgiving break we just started falling apart, literally our whole crew just stopped caring. We just had a bunch of other assignments we were doing for other classes. That's the way it just fell apart, but now they're starting to come back and be like "do you have this section?" [A narrated solution set covering that specific section].

The impending exam is the catalyst that is spurring the students to access the files and study their coursework. The goal is to review the material or catch up specifically to be ready for the test in the very near future. The review for the exam and then put it off until the next exam cycle that Stacy describes is evident in Figures 1 and 2. The three peaks described above that correspond to the regular course tests are each followed by a steep drop in accesses of the files.

During homework

The during homework theme refers to students who use the homework solutions while working on their homework assignments. 35 of the 54 respondents reported using the homework solutions in this manner. Sample student responses include "in all cases I

was stuck on a problem so I went to the solutions to see how it was worked out", "viewed it as I needed throughout homework", and "I would view them while doing my homework. I used them as a guide."

John, a student who participated in the face to face interviews describes his use of the online homework solutions while completing his homework;

> We'll open a section, say 11.3, we'll set it up on the big screen and if we don't understand something or one of the problems related to one that you've done on there, then we'll look at that a couple of times and try to figure out what we did wrong or what it was we weren't understanding.

John typically studies with a friend who is in the same class. He does not watch the entire pencasts from beginning to end, but views only the parts where he needs help in understanding specific homework problems. He interacts with the homework solutions by stopping, starting, jumping to specific problems he needs assistance with, and reviewing the solutions multiple times.

The high number of students, who claim to use the solutions as an aide to completing their homework, 65%, and the trend of accesses evident in the frequency use data shown in Figures 1 and 2, suggests a study pattern for the majority of the students in the courses. Since homework was not required to be turned in, it seems students were putting off their homework assignments until right before the tests. This type of usage would also fit with the students whose responses were cross themed from the before homework/extra lecture and the during homework themes. Students who wait several weeks from when material is presented in class until they start studying would likely need an extra lecture or review of the process before they started studying and then would likely need to refer back during the course of study.

After homework/check answers

The after homework theme refers to students who report using the homework solutions after they completed their homework assignments as a means to check not just the answers to the problems but to also check the procedure they followed to see if it is similar to the procedure that I used on similar problems in the solution sets. 3 of the 54 respondents on the exit survey reported this type of usage. Sample responses include "after my homework was completed to check if I used the right procedures to get the correct answers", "I would do the homework and then look to see if I did the problem right or see how to work it if I did not know how", and "to check problems after I do them and look for formulas."

Although the number of students reporting this type of usage is relatively low, it suggests a certain mindset of the students and the goals of their study routines. The problem sets assigned in the courses consisted of odd numbered problems presented at the end of each section of the text book. The answers to the odd numbered problems are printed in the appendix of the text book. It is possible that the student arrived at a form of the answer that was mathematically correct but different from that of the typically more simplified version presented in the text, in which case the online homework solutions may show the answer they have and how to simplify it. Another possibility is that the student is trying to ensure that they are following the same procedure that was presented in class and is presented on the homework solutions, even though there are often multiple ways of arriving at a correct solution. The following is an in-depth look at how the interview participants incorporated the narrated solution sets into their study routines.

Maria

Maria is a senior student looking to graduate. She is a full time student who works part time. She is a first generation college student who is proud of the fact that, despite a few setbacks, she has been successful in her college career so far. Business calculus is a required course for her degree plan and a prerequisite course for other classes she needs to graduate. She typically works evening or night shifts and does the majority of her mathematics studying at night after work. Maria finds her bedroom to be a distracting place to study. Typically in the evening after a long day of school and work she is tired and if she tries to study in her room she will be tempted to just go to sleep. If she is working at home she makes it a point to move to the living room or she will go to the library on campus.

In the previous math courses that she has taken at the college level, Maria relied heavily on the internet as a help resource. YouTube and Google are the main websites she has used. She has gone to the on-campus tutoring centers but finds that they do not give her the attention or depth of understanding she is seeking. The University supports an on-campus tutoring center that employs student tutors who float around tables where students can work on their assignments and get help as needed. A common complaint is that the help that is given tends to be "non-elaborated" whereby the student receives an answer or other short explanation rather than a conceptual response that helps their understanding. Maria stated in her initial interview:

> I would go to the [University's on-campus tutoring center]. But there too, it's not very…if you want to learn something in depth, it's not a good place to go. It's just good if there's one problem, they'll help you. That's how I feel. And I have been there several times, but it was only for specific problems, they can help you with those.

When Maria uses the internet for help she typically starts with a Google search on the general subject matter of what she is studying, the “distance formula” for instance. The results of the Google search would result in a large number of YouTube videos on the subject. Maria would then select a video and start watching. “I really like the YouTube videos because you can always pause them. If you don’t like the way that that person is teaching you or something, you can always look for another one.” Although the problem being demonstrated on the video is not the exact same problem Maria is working on, she can watch part of the video and then pause it while she applies what she saw to the problem she is working. “And you can pause it and write down what they are doing compared to the problem you’re doing and just go from there, step by step by step.”

During the semester that the research was conducted, Maria continued with a similar study routine to what she described for her earlier math courses. She typically studies calculus at night after work, around 9 pm. Her class schedule has breaks between courses of 1 to 2 hours at a time but she typically uses those times to work on her assignments for her other courses. Occasionally she will access one of the online homework solutions, during the day, as an extra lecture to keep the information fresh in her mind. “…I try to put calculus in between those breaks to where I get a taste of it so when I go home, I go ‘Oh yeah, I remember working on this’.” When asked how often that actually occurs she replied, “It’s happened a couple times but not a routine.”

Maria’s use of the solutions, as described in the previous section, is cross themed according to the themes derived from the exit survey analysis. Her primary use is before homework/extra lecture. However, she does occasionally refer back to the solution sets while working on her assigned problems.

> Since the first thing I do is watch the video, I work the problem, and I'm still listening and then I'm trying to keep up, but then if I see the concept is not really staying, then I'll pause it and replay just a little bit. Hear it out again. Then finish that problem. Then start again doing the next problem with you, keeping up, then if I have to make sure I understand the problem I'll go back. It's not like I'm just listening because I have to work them out with it and then I do those problems [the problems presented on the homework solution set]. Then I do the homework.

Maria reported on the exit survey that she typically views the solution sets "before I begin my homework…to help me refresh my memory." In response to a different question from the exit survey Maria states that she "used the videos [pencasts] as a guide to follow steps in certain problems. I typically viewed it only before I began the homework or only watched the videos [pencasts] with no book work."

Maria accessed the solution sets 39 times throughout the semester. Maria's accesses are much less frequent than Steve's. There tends to be many days in between the days when she accesses the files. However, when she does access the files, she accesses many of them. This suggests, as she mentioned in the interviews, Maria does not study daily. When Maria studies her mathematics, she studies for several hours at a time. Each pencast is between 15 and 45 minutes long and they probably average close to 30 or 35 minutes in length. If Maria watches a pencast all the way through, as she claims in the interviews and on the exit survey, she must be spending several hours studying at a time. Table 5 shows Maria's total accesses by date and section.

Maria has incorporated another tutoring center on campus, similar to the one run by the University, but housed in and run by the Mathematics Department. The Mathematics Department's on-campus tutoring center also employs student tutors that float around answering student questions. It is specific to mathematics and the tutors are hired based on their performance in their math courses and are typically specialized in

Table 5
Maria's total file accesses by date and section

Student	Access Date	Total number of accesses	Section
Maria	2013-09-18	1	Ch 10.1
Maria	2013-09-19	1	Ch 10.1
Maria	2013-09-24	1	Ch 10.2
Maria	2013-09-25	1	Ch 10.1
Maria	2013-09-25	4	Ch 10.2
Maria	2013-09-26	1	Ch 10.1
Maria	2013-09-26	1	Ch 10.2
Maria	2013-09-26	2	Ch 10.2 App
Maria	2013-09-26	1	Ch 10.3
Maria	2013-09-26	1	Ch 10.5
Maria	2013-10-16	1	Ch 11.3
Maria	2013-10-23	1	Ch 11.1
Maria	2013-10-23	1	Ch 11.2
Maria	2013-10-23	1	Ch 11.3
Maria	2013-10-23	1	Ch 11.4
Maria	2013-11-14	1	Ch 11.4
Maria	2013-11-14	1	Ch 12.2
Maria	2013-11-14	1	Ch 12.5
Maria	2013-11-18	1	Ch 12.1
Maria	2013-11-18	1	Ch 11.4
Maria	2013-11-18	1	Ch 12.2
Maria	2013-11-18	1	Ch 12.5
Maria	2013-11-18	1	Ch 13.2
Maria	2013-11-18	1	Ch 13.1
Maria	2013-11-19	1	Ch 13.2
Maria	2013-11-19	1	Ch 13.1
Maria	2013-11-25	1	Ch 13.1
Maria	2013-12-02	1	Ch 12.1
Maria	2013-12-03	1	Ch 12.1
Maria	2013-12-03	1	Ch 11.4
Maria	2013-12-03	1	Ch 12.2
Maria	2013-12-03	1	Ch 12.5
Maria	2013-12-03	1	Ch 13.1
Maria	2013-12-12	1	Ch 13.1
Maria	2013-12-12	1	Ch 13.5

certain areas. The Mathematics Department's tutoring center is a smaller facility than that of the University and students report getting more personal and in-depth assistance than what is available from the larger center.

> Typically I go in there to work on calculus because I know everyone there is doing math. I feel more comfortable going and doing my homework inside there,

> so if I need help I'll just raise my hand and they'll come. But, they're not open at 9 [pm].

Despite her previous reliance on Google and YouTube for assistance in her mathematics courses, Maria used these resources less during this course. "I use the videos [pencasts] more because it applies directly to me and the problem I'm doing rather than some other problem that's similar to it." The availability of the homework solutions is another reason why she incorporates them into her study routine. The online homework solutions are available anytime a student has access to the internet. They work on any computer, tablet, or smart phone. The online homework solutions are directly applicable to the students' course. It is their instructor working the problems directly from their book and assignment. The student does not have to sift through many videos returned in a Google search. They can go directly to the section they are working on and find an example of a problem they are having trouble with. Maria states:

> I like that you have access to it anytime you want, whenever you are around a computer, and you know where to go directly, rather than looking for something. Because sometimes when you Google that they'll send you some stuff that has nothing to do with what you were asking for. Because they are customized to what you're learning in class. That's why I use them more than YouTube or Google.

Maria echoed these sentiments on the exit survey "I used less YouTube for step by step details, but still attended the [Mathematics Department's tutoring center]."

Regardless of the fact that Maria's study routine is not very regular, she has an ideal scenario in her head of what the "ideal" college student would do to be successful. She is critical of herself and her abilities because she does not fit her own image of a successful student. Because she feels compelled to work and attend school, she is either tired or feels that she has mismanaged her time and is therefore unable to live up to her

own ideal. She stated: “If I were the ideal college student I would use them more often.” When asked how would the ideal college student use them, she replied:

> After class when you get home, look at the video [pencast], do your homework, if you can’t figure it out, go back to the video, try to work out the problems, and then just do a little bit, and the next day review those problems that you did the day before, look at the video again, so do a little every day, or at least every other day, but it doesn’t happen like that.

Steve

Steve is a single father who works and goes to school. He commutes to campus and because of family and work duties, does not spend much time on campus outside of class times. He is enrolled in nine hours of course work. He describes his high school mathematics experience as “very challenging” but points out that he was successful. He typically uses multiple online resources when studying. When he accesses the online homework solutions, it is typically because he is stuck on a problem and is trying to figure out where he went wrong or what he is missing. Technically classified as an adult learner, Steve fits the mold described by Tennant (2012) to a tee. He works 30 hours a week, is the sole provider for a 7 year old daughter, commutes from a neighboring city, is a transfer student, and has not taken a math course in over a year.

Whenever possible, between classes, or if he is on campus early, Steve likes to work in the University’s on-campus tutoring center. He likes to be able to talk about the problems and rationalize through not only his work but others’ work as well.

> I haven’t been to the [Mathematics Department’s on-campus tutoring center] yet, but an atmosphere like that, I would definitely prefer. If I could go to that even when I’m in my town, and I have an extra hour, 30 minutes, that’d be so awesome. To be able to go somewhere and be able to sit down with a group or just one or two people and do the same stuff.

Steve would prefer to study in a group, his situation makes it hard for him to find time and study companions.

Steve has used Khan Academy in the past to help him understand certain concepts that he is studying in his classes. His typical use is broad overview and basic understanding of the concepts. He reports that he has had trouble finding specific topics that he is working on;

> I tried that and I find that really hard to find. To be able to find that on Khan Academy, I end up watching ten minutes of the tutorial and I'm like "Crap! That doesn't tell me anything." That's a little frustrating for me.

One of Steve's biggest concerns when it comes to studying, especially seeking help, is being judged. He told a story, that occurred the same day as the initial interview took place, about the difference between two tutors in the University's on-campus tutoring center, one who took time and made sure he understood what he was doing and another who;

> …looks at me for a second and maybe he's not judging me or anything like that but just his demeanor and the way he explained it to me, I just felt like, "Oh, gosh. I should have probably already known that, maybe I won't ask that kind of question again"… Being judged, that's one of the main reasons why people don't seek help, because they don't want to be judged.

Being judged is such a strong feeling for Steve that it prevents him from going to office hours to seek help from his professors. He believes that if he presents his misunderstandings to his professor the professor will question whether he belongs in the course at all, and possibly take action to see if Steve should be placed in a different course. Steve admits that he has never actually experienced that type of situation however; the fear and doubt created by the thought are still present. The fear of being judged transcends help seeking outside the classroom and prevents Steve from asking

questions in the classroom as well. “You feel like you are going to be judged if you ask the questions.”

Similar to Maria’s image of the ideal college student, Steve has an idea of what he thinks it takes to be successful in his courses. He believes that he needs to crack the book open every day just to keep the material fresh in his mind. He admits that there are times when he may attempt to study, but he just cannot get into the right frame of mind and after only a few minutes he has to put it down and do something else. Although he understands that that is a normal occurrence, he feels that when he does reengage with the material, he has to go back to the beginning:

> Whenever I do just look at it for five minutes a day and then the next day I try to do some homework, I have to go all the way back to the beginning and start all over. If you do it every day, you can start from where you left off.

As the semester progressed, Steve’s study habits changed from his previous routines. He used Khan Academy less often. There were two specific reasons for this change; the first was that the format and search functions on the Khan Academy website were changed to a format that was harder for him to navigate. The second reason he gave was “I also felt like I had yours [the homework solutions] so that was more specific to the actual homework that I was working on.” Although he used the online homework solutions regularly, he was frustrated with his abilities in algebra. Although the solutions contain detailed descriptions of the process for solving sample problems from the assignment, the focus is on calculus and certain details about the algebraic simplifications are occasionally omitted. Steve felt as though he understood the calculus and the techniques he needed to apply to find the solutions however; he would often get hung up on the simplification part of the process, which is very algebra-heavy. His lack of a solid

algebra foundation and the necessity of a solid algebraic foundation to be successful in calculus combined to cause Steve a certain level of stress in the course. On the exit survey in response to a prompt inquiring about whether he would attempt more problems after viewing a problem on the solution sets, Steve reported "Yes, but the algebra of the problem usually changes."

Steve studies best in a group setting as stated previously. His first study partner dropped the course and he did not find another until late in the semester. His fear of being judged by students who are younger than him prevented him from openly seeking help from classmates. In his exit interview Steve stated about finding a study partner among his classmates:

> I was thinking about that, but then I was like, "well they're probably just so ahead of me in algebra, it just wouldn't work. I just feel like I'm not benefitting even if I study for this class because it's just like I am so far behind or I just don't understand it. You get a little envious, yes definitely. The thing is, they just did algebra maybe a semester ago.

Steve spent a lot of time studying for this course. He never felt as though he was gaining independence with his work. When he would study he would have several resources available to him, the book, the online homework solutions, possibly a study partner. When it came time to take a test, even though he had done the work, put in the time to prepare, he was not confident of his abilities without the crutch of the resources. In his midterm interview Steve described this situation as follows:

> A lot of the time, I work out problems, but I'm constantly looking at references and stuff. I'm getting it and everything, but I'm thinking "is this really going to retain in my head for a test?" Probably not. I'm going to want to look at a reference material to be able to do well on the test and I do that when I'm studying too. Things like, well yeah, I kind of have a pretty good grasp on it, but maybe I really don't.

His lack of confidence in his abilities and his constant fear of being judged plagued Steve the entire semester.

Steve reported on the exit interview that his usage of the solution sets was also cross themed like Maria. “Usually, I viewed the files when I first get stuck. I also would do the problems with the video cast [pencast] before starting the homework.”

The frequency use data shows that Maria and Steve have different study patterns. The majority of Steve’s accesses occur singularly. He studies fairly frequently with his accesses occurring somewhat regularly every few days, which fits with his interview data where he stated that he tries to look at his course work almost daily to keep the material fresh in his mind. Although he may open several different files on the same day, he only opens each file once. On the day of the second test he opened four files; however he never opens more than two files on the same day any other time. This suggests that aside from trying to cram for the second test, Steve does not spend more than an hour or two in any study session, which is consistent with what Steve reported in the interviews and the exit survey. Table 6 shows Steve’s total accesses by date and section.

Table 6
Steve's total file accesses by date and section

Student	Access Date	Total number of accesses	Section
Steve	2013-09-16	1	Ch 10.1
Steve	2013-09-16	1	Ch 10.2
Steve	2013-09-17	1	Ch 10.2
Steve	2013-09-24	1	Ch 10.2 App
Steve	2013-10-01	2	Ch 10.4
Steve	2013-10-04	1	Ch 11.1
Steve	2013-10-14	1	Ch 11.3
Steve	2013-10-18	1	Ch 11.4
Steve	2013-10-23	1	Ch 2.5
Steve	2013-10-23	1	Ch 11.1
Steve	2013-10-24	1	Ch 11.1
Steve	2013-10-24	1	Ch 11.2
Steve	2013-10-24	1	Ch 11.3
Steve	2013-10-24	1	Ch 11.4
Steve	2013-11-19	1	Ch 12.2
Steve	2013-11-19	1	Ch 13.2
Steve	2013-12-02	1	Ch 13.1
Steve	2013-12-12	1	Ch 10.1
Steve	2013-12-12	1	Ch 10.2

John

John is a traditional sophomore student who attended another state university in Texas before transferring to the university where the study was conducted. John is a full time student who works construction for a company owned by a family friend, who gives him very flexible hours; so that he can take whatever time he needs to ensure he takes care of his school obligations. John is a strong mathematics student who enjoys the subject.

John usually attempts to study daily after his classes let out and before he goes to work. He is enrolled in morning classes and his classes are over before noon three days a week. He usually heads home after class, has lunch, and then studies for an hour or two before he leaves for work. On Tuesday and Thursday, he has an 8 o'clock course and then a five hour break before his next scheduled class. He typically will use that break to

focus on his school work. When asked if he studies after work, he says he cannot because he is simply too tired. Of the time John spends studying mathematics, about half of that time is spend studying alone and the other half with a study partner who is a friend and enrolled in the same class.

John's preferred help resources coming into business calculus are his instructors' office hours and help from his peers. He gets frustrated when he is working homework and is having difficulty with a particular concept or problem and there is no immediate help available. He describes his frustration as follows:

> …Yes, getting stuck midway through a problem. You know if you're sitting right there with a teacher, all it would take is that one little push or that one little hint to get you over the edge to solve the problem. That's probably the most frustrating point for me, in math.

John will typically reach out to a fellow student for help with what he is struggling with. If he is not working with a friend, he will use a smart phone to take a picture of his work and send it to friends or colleagues and ask them to help him fill in what he is missing.

In the meantime, John will continue with the assignment and try the next problems in the set. By continuing to work on other problems, John has found that he can often figure out what he was missing or not understanding previously by relating it to a similar problem.

> I usually go on to the next problem just not to think about it. Ninety percent of the time if I don't think about it and come up to a problem that's a little bit different in form, but has the same concept I can figure it out by doing a different problem.

For problems that persist and he is unable to find the answer to, John will seek help from his professor. When asked about the on-campus tutoring centers, he says he does not use them.

John had a negative experience in an on-campus tutoring center at the first university he attended. "…Actually I've had bad experiences with Math Labs. I've tried it once at [the other university] and really didn't like it…if I can't figure it out, I usually come to the teacher." John's explanation of what occurred during his negative experience in a math lab (block quote below) highlights several possible issues that can occur when students seek help from outside resources. The individual, who was trying to help, was using a different approach from what John's instructor presented. John was already unsure of the concepts and having to try to process a different approach caused more confusion for him.

> I went in there and the teacher that I had helping me just knew one way to solve a problem. What I was taught was different and he's trying to explain it to me like that and, of course, I'm not understanding because it's new material to me and he's not wanting to change the way he is doing it to help me out because just trying to teach a concept. That's not going to help me.

This experience has limited the help resources John will use. Even though he studies on campus during the day when the tutoring labs are available, he does not use them. In the past, he has changed his daily routine to be able to attend his professors' office hours. At his previous university, John's schedule conflicted with his professor's regularly posted office hours. John would wake up early in the morning around 6 am so he could get 30 or 45 minutes of access to his professor before his classes started. He would get up early five days a week if he was having difficulty with a concept.

During his midterm interview, John described how he incorporated the online homework solutions into his study routine. He likes the convenience of the solution sets as opposed to coming to office hours:

> I like them. It's very helpful other than coming in for office hours, it just makes an easier way, instead of having to come in and if I'm doing homework at 9

> o'clock at night it's not feasible for me to email you or text you and be like "Hey can you help me with this problem?" There is something on there that I can relate to a problem I'm having trouble with. It's an easy access to help.

John uses the homework solutions as a substitute for office hours. He still attended office hours but says that he did not attend as often as he would have had the resource not been available. John specifically mentions on the exit survey that he accessed the solutions at times "when the instructor was not available."

When asked about other internet resources he has used, John says he has tried to use YouTube, but has had similar experiences as reported by Maria and Steve. The YouTube videos often do not relate directly to the problem he is working on and often lack depth or detail in the solution presented:

> YouTube is like a broad demo-fied simple version, whereas the homework solutions are more in depth, it relates to the homework, that exact homework that you are looking to get help with. It's not like you have to take the information and try to fit it into a section. It's that section for those particular problems and that's what is really helpful.

In a typical study session, John will access the pencast associated with the section he is working on, he will not necessarily start the pencast but he has it open and ready if he needs it. As he works through a problem set, he will view only the parts of the pencast that he needs, if any. As is often the case, if John has trouble with a specific problem, it is probably not the exact problem that is covered in the solution set. In these cases John will attempt the problem that is covered in the solutions, and if he struggles with it, he will play the pencast and work along with it. Upon completing the problem with the solution set, he will then pick out another problem from that section of the assigned problem set and attempt to solve that problem as a way to ensure he understands the concept. Before moving on, he will go back and attempt to work the original problem

he was struggling with. John reported on the exit survey that he had viewed all of the files posted and many of them multiple times. He states that he viewed the files "as I needed throughout the homework." John accessed the solution sets "to understand a concept I was having trouble with."

John stated on the exit interview that "most of the times the problem worked on the solution sets could help out with many other problems on homework." Sometimes, John cannot find a problem on the solution set that he can relate to a problem that he is struggling with. This occurs most frequently with the "Application Problems" section which consists of real world word problems. The solution sets contain limited numbers of these application problems. When the help John needs is not available from the solution set, and he cannot solve the problem with help from his study partner, he attends office hours. In his exit interview, John stated:

> I probably came less [to office hours] just because, like I said, 9 times out of 10 it [the homework solutions] usually gave me what I needed. It was basically the same thing that coming in to office hours gave me except that actual physical one on one time getting help. But when I usually came in it was just, it was something on the homework solutions that I wasn't getting or it wasn't quite explaining to me what I needed to do.

John's responses to the exit survey indicate that he incorporates the narrated homework solutions sets while working on his assigned problem sets. His comments during the interviews show that not only does he use them while working on his assignments, but also as a review resource. These responses indicate that John is cross themed in his usage of the solution sets, not before and during like Steve and Maria, but during and review.

Stacy

Stacy is a traditional freshman student in her first semester in college. She took college algebra (the prerequisite course to business calculus) as a dual credit course in high school. She does not work outside of school. She is enrolled in the business school learning community. Being a member of the learning community means that she lives in a dorm where all the students on her floor are co-enrolled in their courses and they have regularly scheduled group study times that each student is supposed to attend.

Stacy is only enrolled in one class, business calculus, on Monday, Wednesday, and Friday (MWF) from 9 – 10 am. She has a much busier class schedule on Tuesday and Thursday. She typically attempts to work on her assignments, any which require her to do something more than just read, on MWF and tries to complete any reading assignments between her classes on Tuesday and Thursday. At the beginning of the semester, she would typically start working as soon as she returned to her dorm after class on MWF. She worked until lunch, took a lunch break, and then continued until she had completed her assignments. She would work in a common area outside of her dorm room where there were desks for the students.

When Stacy runs into difficulty with her assignments, she first attempts to find someone in her learning community to help her. She worked with another student who had a solutions manual to the text book and would use it to help he work through problems. She says of the solutions manual “It reassures me. Instead of having to wait for someone to check my work, I can just open the book and say, OK, I’m fine right now. It’s convenient.” When asked if there was anything she did not like about using the solutions manual she replied:

> Sometimes they, I guess it's skipping steps. Like they'll have a square and then it will be gone and it will be just like in a different form. I like to see work shown, because that's the way my teacher taught me in high school.

Stacy prefers to look at the solutions manual to asking other students or friends for help; "…they're doing the same thing I am, but it doesn't necessarily mean they're doing it right."

Stacy said that she has attempted to use the internet as a help resource, but says "…it just confuses me more." The online resources she has used do not present the problems from her book and are not her teacher. Like John, when trying to learn a new concept Stacy gets confused by trying to understand multiple methods or different approaches and different vocabulary used by different people that is different from what she was presented in class. One of Stacy's high school math teachers incorporated Khan Academy videos as her main instruction delivery method. The online instruction without in-class support left Stacy feeling as she was not being taught. She did not receive a good grade in that class and now has a negative perception of Khan Academy; "…I am totally against Khan Academy. I hated it."

As the semester progressed, Stacy found that her study routine began to change. She spent less time studying in general, and began putting off her business calculus homework.

> At the beginning of the year I was studying several times a week for several hours with our study groups. Now it's just getting easier and easier to kind of just put it off and not go. On our floor, we have scheduled study hours because I am in the learning community. They are no longer taking attendance, so it makes it easier not to want to go. I study less.

Though she admits to studying less, when she does study she incorporates the online homework solutions into her routine. Since all the students in the learning community are

co-enrolled, they are taking the same courses, not necessarily the same sections or instructors, but they are all taking business calculus.

When working in the learning community study groups, Stacy has introduced the online homework solutions to other students who do not have access to that particular resource, since they are in a different section.

> It helps other students as well, not only me. If we can't get it together and they are like, "With my teacher I just really don't get it." Then I can show them like, "Well, my teacher has this video", and it's easier for them to see. We can go back and see where we messed up because it's step-by-step. It's kind of easier for us to figure out where we went wrong with those videos.

Stacy does not watch the videos straight through. She jumps to the problem she is having difficulty with and only watches the parts she is having difficulty with. She can typically set up the problems and since the answers are given in the back of the book, she is specifically looking for the procedures in the middle.

Sometimes Stacy will study individually. Sometimes her schedule conflicts with other students in her study group, or she may just be up in the middle of the night. Stacy relies on the online homework solutions when she is up at odd hours and wants to try to get some work done. "If I don't have anyone to ask, I'll go straight to the videos, because that late, no one's really up."

Toward the end of the semester, after being somewhat lackadaisical about their work, Stacy and the other students in her learning community began to feel the pressure of the end of the semester and final exams. Where initially they would access the files as needed to help understand a specific problem, their use of the solution sets became more of an extra lecture or review. "…I started watching the videos more to try to catch up on the homework. I started watching it just to see examples." Other students from the

learning community would also approach her, as mentioned previously in the Review section, to ask for access to her course website so they could view the homework solutions even if Stacy was working on a different subject.

Stacy reports on her exit survey that she "used them [homework solution sets] in many ways." Most of the time she is having difficulty with a specific problem and will refer to the homework solution sets to assist her in completing the problem. Stacy also reports on the exit survey that "in my study group, we review lessons before starting homework by watching the videos [pencasts]." This usage is similar to that reported by Steve and Maria and is cross themed between the during and before homework themes.

Note on Frequency Use Data

The data presented which was generated by the frequency use data contains a few nuances. First of all, there is a slight discrepancy between some students self-reported usage as reported on the exit survey and what the frequency use data reports. For instance, a few students reported that they viewed a couple files throughout the semester, but the frequency use data shows that they did not access any files. It is entirely possible that, as with Stacy and her learning community colleagues, that the students did in fact view a file, but it was accessed by a different student's account. Students who are studying in groups may all view a solution set from one individual's computer. In this case many students would have viewed the file, but the data would not show that it was accessed by all of the students in the group. For these reasons it is possible that the total number of accesses to the narrated solutions sets as shown by the frequency use data could be lower than the actual usage.

Another discrepancy comes from the interview data. John reported that he had accessed almost every file and many more than once. However, his usage data shows that he only accessed five files from his account. When asked about the discrepancy, John was adamant that he had accessed more files. Again, it is possible that the frequency use numbers may be lower than the actual usage.

CHAPTER V

Discussion

From the results reported in the previous chapter a few things are clear; (a) students do incorporate the narrated solution sets into their study routines, (b) there are a variety of different ways in which students incorporate the solution sets, (c) the frequency in which students incorporate the solution sets also varies, and (d) students like the resource for a variety of reasons.

More than 90% of the students who completed the course accessed the solution sets at some point during the semester. Students reported accessing the solution sets in order to (a) refresh or remind them of what procedures or material would be needed to complete the assigned problems in a certain section, (b) assist them in understanding a procedure or where they were having trouble working a problem, (c) to check their work, and (d) as a review for an upcoming test.

Students access the solution sets at all times during the day and night with approximately 50% of accesses occurring after 8 pm and before 8 am. Some students access the files regularly, while others only access them the day before a test. Overall, the students who incorporate the resource into their study routine do so because they find the resource to be convenient, informative, and helpful to their help seeking goals.

In this chapter I will discuss the results of the research study and the findings as they inform the literature on the subject. I will also bring to light the delimitations of the study and address the implications for teaching and future research.

Conclusions

Student study routines

Education research literature is inundated with studies about all aspects of homework. Studies have been conducted focusing on students, teachers, parents, administrators and community expectations, perceptions and beliefs (H. Cooper, 1989). However, the vast majority of this research has been focused at the k-12 level leaving a paucity of research focused on collegiate level homework (Gutarts & Bains, 2010b; Hancock, 2000). Further complicating the issue, many of the existing research studies conducted at the collegiate level are focused on student achievement (Trautwein & Köller, 2003) and not necessarily on student behaviors. Gutarts and Bains (Gutarts & Bains, 2010b) claim that many college mathematics students equate homework completion to studying and therefore believe by completing an assigned problem set, they have met expectations. With this in mind, this study was designed to determine how students incorporate narrated solution sets into their regular study routines.

From the frequency use data presented in the previous chapter it is clear that students do in fact use the solution sets. All of the files that were made available to students were accessed multiple times throughout the semester. Since the assessments in this course are comprehensive in nature, the solution sets posted early in the semester covering the initial course material were accessed by students, not just at the beginning of the semester, but periodically throughout the semester, especially right before the final exam.

Looking at Figures 1 and 2 in Chapter 4, it is clear to see that the majority of accesses occurred either the day before, or the day of a course test. This surge of activity suggests several possible motives for students' usage of the solution sets. One possible motive for accessing a solution set right before a test is that the student is reviewing the material presented in the solution set to prepare for the test. In this scenario, the student is assumed to have completed the assigned problem set covering the problems on the solution set and is simply reviewing the material. The problem with this assumption is that, on the exit survey, many students claim that they watch the solution sets before they begin working on their assigned problems. If students believe that studying in mathematics means working the assigned problems as Gutarts and Bains (2010) claim, then the data collected in this study would suggest that many of the students are waiting until the day before, or the day of, the test to begin studying.

Although it appears that the solution sets were accessed on a fairly regular basis, the individual student accesses were random at best. A student might access the solution sets one day and then not again for a week or a month. Other students might access the solution sets two or three days in a row and then not again for a week or a month. Many students only accessed the files the day of, or day before, a test. This behavior is consistent with what was observed in the literature on self-regulatory behavior (Balduf, 2009; Corkin et al., 2011; Schraw et al., 2007; Steel, 2007).

The assigned problem sets were not collected or graded. Although, the instructor employed daily quizzes covering the assigned problems from the sections covered in the previous classes, it appears students did not fully engage with the assigned problems until right before an exam. In their study, Gutarts and Bains (2010) found no statistical

difference in achievement between students who were required to complete and submit homework to those who did not have to submit their homework, but were given in-class quizzes. The authors reported that students in the latter group self-reported that that they did not typically complete assignments that did not have to be submitted.

Students who wait until the day before a test to begin studying are faced with another difficulty. Each solution set is anywhere from 15 to 45 minutes long and they average 30 to 35 minutes in length. Each course test is not only cumulative, but covers 5 to 6 sections of new material. If students are watching the complete pencasts, even without any stopping or rewinding them, there is potentially three hours of material to view. From Table 1 in Chapter 3, it is easy to see that the solution sets contain relatively few problems compared to the number assigned. There simply isn't enough time for a student to watch a pencast and then work through the rest, or even a significant part, of the remaining problems for five or six sections the day before a test.

If we assume that the students are waiting until the day of the test to engage with the course material, as was self-reported by participants in the study conducted by Balduf (2009), it seems reasonable that the students would view a solution set prior to attempting the problems. Much of the material the students need to study was presented in class weeks beforehand. If the student has not been diligent in keeping up with the course material, they might want to see a few examples worked out, as a refresher, before they began the assignment. On the other hand if the student had in fact completed the assignment weeks ago, it would also seem reasonable to want to view some examples as a study guide.

This data paints a vivid picture. Students are waiting to engage with the assigned problem sets and are not attempting the problems on the same day or in many cases the same week they are presented in class. This is consistent with Schraw et al. (2007) who found that "students maximize the efficiency of their study time through a carefully orchestrated cycle of procrastination and cramming." Rather than attempting the problem sets when the information and examples are fresh in their mind, students are waiting to engage with the material. The solution sets were not posted the same day as the section they cover was presented in class. The theory behind this decision was that students would have an opportunity to engage with the material and attempt some problems on their own, before any assistance was given. If the solution sets are posted immediately students could, theoretically, simply copy the procedure outlined in the solutions without actually thinking critically about the problems or their own cognition.

This delay in posting the solution sets could have contributed to students' plans to procrastinate. As mentioned by Schraw et al. (2007) and Corkin et al. (2011) some students employ active delay strategies whereby their procrastination is not due to seemingly negative traits, like laziness, but as a strategic plan of how to maximize the effectiveness of their study. For these students, the fact that the resource was not immediately available could have increased the likelihood that they would put off working the problem sets until the resource became available. Since many students responded on the exit survey that they did not attempt the assigned problems until after they had watched the pencast covering that section and the solutions were not posted until several days after the material was covered in class, students have likely forgotten what was presented in class and do not know how to begin the problems as evidenced by

Stacy's account of her and her colleagues in the learning community who got behind during the semester. Looking at Table 5 from Chapter 4 which lists Maria's file accesses, it is clear she is also not engaging with the course material immediately after it is presented in class.

Collins (2006) suggested that when scaffolding is provided by computers, there is no judgment associated with it. The student does not have to worry about being perceived as inferior. While it may be debatable as to whether or not students can effectively scaffold help resources for themselves, it seems that some students were able to incorporate the resource as needed. John and Stacy were able use the narrated solution sets in this manner. The narrated solution sets consist of problems from the students' textbook, worked out by their instructor, and contain audio explanations from their instructor. For these reasons, I believe the solution sets are a type of scaffolding. The results of this study support Collins' statements.

While it is true that many students reported using the solution sets in multiple ways, relatively few students cite as a review (12 out of the 54) compared to the ones who claim to use it either before (18 out of 54) or during homework completion (35 out of 54). Altogether, the data seems to suggest that the students are not engaging with the material until right before a test.

A few students claim that they use the solution sets in order to check their solutions. This usage is somewhat interesting in that the answers to the odd numbered problems are printed in the appendices of the textbook. Since the assignments consist of odd numbered problems, the students can easily verify whether or not their answer is

correct. Which poses the question; why would students use the narrated solution set, which contains relatively few answers, to check their work and not just use the book? When asked about this, Stacy, a student who participated in the face to face interviews, claimed that even though her answers may be correct, it was possible that it was a coincidence. What she meant was that she believed that it was possible for her answer to be correct even though she followed an incorrect procedure to obtain it. This is certainly a possibility in mathematics. However, it seems likely that if a student was using an incorrect procedure the chance of arriving at the correct answer would be very low and as such a "false positive" would be rare. Working several problems from a solution set using an incorrect procedure would likely end in several incorrect answers. The students' need to reassure themselves that they are in fact following a correct procedure could be caused by any number of factors. This usage speaks to the findings of Schoenfeld (1989, 1992). Students believe that not only is there one correct answer, but that there is only one correct procedure that they must follow in order to successfully arrive at that answer. This usage could possibly be investigated further in future research.

Another way students claim to use the solution sets is as a guide or aide while they are working on their assigned problems. Some students claim that when they confront a difficult problem, they look to the solution sets to help them figure out either how to approach the problem or insight into what they may doing wrong. John and Stacy both report using the solution sets in this way. Many students specifically mention accessing the solution sets when other resources, such as the instructor, or on-campus tutoring centers are not available. Typically, instructors' office hours are held a couple of days per week, for an hour or two, sometime between 9 am and 5 pm. The on-campus

tutoring centers are generally open continuously from 9 am until 7 or 8 pm but vary slightly depending on the day. The frequency use data supports the students' claim that they are studying when the other resources are not available with approximately 50% of accesses occurring between 8 pm and 8 am.

As evidenced by Maria working independently after work, John's peer-tutoring of a classmate, and Stacy's use of the solutions with her study group in the learning community, students incorporate the solution sets whether they are studying alone or with peers. This suggests that the students believe the solution sets are a semi-formal resource when help seeking. Karabenick (2011a) differentiated between formal resources (instructor or other expert) and informal resources (peers, family, etc.). Students do not incorporate the solution sets while they are working with the professor during office hours and none of them mentioned using the solution sets while at either of the on-campus tutoring centers. Actually, the opposite was more the norm. If a student did not understand a concept after viewing a pencast, for the most part, they would then seek outside assistance. This indicates that the students feel the solution sets are a good place to start when seeking help.

The attempt-feedback-reattempt loop described by Zerr (2007) is the process where students attempt an assignment, get feedback on what they did incorrectly, and then reattempt either the same assignment or a related one. It was theorized in this study that the narrated solution sets could provide some feedback to students working on their assigned problem sets. From the interview participants, John is the only one who active completed this type of study pattern. Stacy engaged in this manner, to a degree. In her study group, Stacy and her peers would use the collective knowledge of the group and

incorporate the solution sets as needed. It is not clear to what extent Stacy and her group reattempted similar problems after watching a pencast problem. Maria and Steve did not engage in this type of behavior at all, at least not with the solution sets. Furthermore, this loop would seemingly take some time for a student to actively engage in it. It does not seem that there would be enough time to fully engage in the attempt-feedback-reattempt loop the day before or the day of the course test, which is when the majority of accesses of the solution sets took place.

The results of this study indicate that students incorporate narrated solution sets into their study routines. It also gives insight into what exactly those study routines are and how students make use of available resources. Students study at all hours of the day and night. They study independently and in groups. Some students actively seek help from any of the available resources while others are more selective as to which resources work best for them. Regardless of when, where, or with whom they study, the majority of the students in this study incorporated the narrated solution sets into their study routines.

Student perceptions

Along with the myriad of ways in which students incorporate narrated solution sets into their study routines, this research explored student perceptions of such a resource. The narrated solution sets are a resource provided by the instructor for the purpose of helping students complete out of class assignments (homework). Although there is still a debate over the effectiveness of homework, it is still the norm in many college courses (Trautwein & Köller, 2003). Furthermore Treisman (1992) connected group study and homework completion to success in first year calculus courses.

It is clear from the results of this study that students like the narrated solution sets. The frequency of use, combined with the responses to the exit survey suggests that students see the resource is a positive light. The statements on the evaluation forms also suggest students like the solution sets.

The goal in implementing the narrated solution sets as a resource in a business calculus course was to enable students to have more access to a quality resource to aide them in completing out of class assignments. The second research question guiding this study is focused on determining how students' perceive the solution sets compared to other available help resources. For many different reasons, relatively few students regularly attend instructor office hours (Karabenick & Knapp, 1988; Karabenick, 1992; Zerr, 2007). Students may be seeking help, but more often than not, it is not from their instructor (Karabenick, 2011a).

From the results presented in the previous chapter, it appears that the majority of students in one capacity or another incorporated the narrated solution sets into their study routines. The number of students who accessed the solution sets is far greater than the number of students who attended office hours. There are several reasons for this difference. One reason reported by many students on the exit survey and by the interview participants is the convenience of the solution sets. 50% of file accesses by students occurred when other outside resources were not available. Of course the internet is available during these times and students could have accessed other internet resources instead. However, the students claim that they did not access other resources. The direct connection to their assignment, their instructor, and ease of access of the solution sets influenced student decisions of which resources to choose. Research has shown that

students actively avoid seeking help from the instructor for any number of reasons (Butler, 1998; W. Collins & Sims, 2006; Knapp & Karabenick, 1988). Many of the reasons students avoid seeking formal sources of help is centered on the need for autonomy and the potential of being perceived negatively by the instructor (Karabenick, 2011a). While it is possible that the number of accesses of the solution sets is caused solely by the convenience, ease of access and direct connection to the assignment, as described by Steve and Stacy, there is another potential explanation. One student reported explicitly on the exit survey that the solution sets were a source of help that was void of judgment. The student did not have to worry about being judged or "feeling dumb" because they asked the same question multiple times.

Many students, on the exit survey, stated they used the other internet resources less often than they had in the past once the narrated solution sets were posted. Maria and Steve both gave detailed accounts of why they preferred the solution sets to the other internet resources they have relied upon in the past. Maria used to rely on Google searches and YouTube videos, but found that the specificity of the solution sets to what exactly she was working on caused her to not access those resources as often, if at all. Steve, like Maria, said that the specificity of the solution sets was a reason he used Khan Academy less. Steve also mentioned that Khan Academy had updated their website and he found it less intuitive and harder to navigate. The ease of access of the solution sets, the fact they were all located in a single folder on the course website and labeled according to the chapter and section they covered made finding a specific resource very easy.

A few students, including John and Stacy, claimed that the solution sets were similar to one-on-one interactions with the instructor. They liked the fact that the solution sets were not just problems from the textbook, but that they were narrated by the instructor. John has had negative experiences in the past when seeking help from individuals other than his instructor. He believes that it is important for the solution sets to be created by the instructor of the course. Since different individuals use different approaches, different terminologies, or simply have different personalities, there is a connection to the instructor through the solution sets. This affects his perception of the resource. For all of these reasons, the first place John sought help during this course was the solution sets, only if the solution sets did not contain the specific help he was looking for, did he then attend office hours. Although he still attended office hours occasionally, he claims that the solution sets helped 9 out of 10 times, and he did not need to attend office hours after viewing them.

The solution sets can potentially be used by students as a substitute for outside assistance. Sometimes the substitution is necessary because of the lack of available resources as described above. Other times, as in John's case, the solution sets provide whatever help the student is seeking. For Stacy, who generally studied in a peer group, the solution sets combined with the collective knowledge of the group enable her to answer the majority of questions she had difficulty with. Stacy could only remember one instance when the solution sets were not enough and her group sought help from an on-campus tutoring center. From the results of the study, many students are able to meet their "goals of the moment" (Sawyer, 2006) by accessing the solution sets. Whether they are seeking instrumental (just enough information to solve the problem) or executive (just

looking for an answer) help is not clear however, many students are satisfied with what information they are able to obtain from the solution sets. Other students are not as able to apply the information presented in the pencasts to other problems.

Maria and Steve have a difficult time attempting to apply the procedures presented in the solution sets to other problems on their assignment. While to an expert, all of the problems in a subsection of a problem set may be “the same” each problem is slightly different in how it is solved. For instance, one problem might need to be factored before attempting to take the derivative, while another problem in the section might be rational in nature and need to be simplified before proceeding. While the devil is in the details, the overall procedure is the same. Although modeling a similar problem is a type of scaffolding teachers regularly employ (Quintana, Shin, Norris, & Soloway, 2006), this research shows that not all students can apply the procedures demonstrated on one problem to a different problem, regardless of how similar the instructor believes the problem to be.

In designing and implementing this resource, the theory was that sample problems from each section of the assigned problem sets would be presented. I chose what I believed to be representative problems that demonstrated the general procedures needed to successfully complete the assigned problems. The most difficult or challenging problems were generally not included on the solution sets. I believe that in order to really learn the material and understand how to solve the problems, the students need to engage with the more challenging problems on their own. I feared that if I included every problem from the assigned problem sets or if not every problem, the most difficult problems, the students would not really attempt them. I feared as soon as they ran into

difficulty with the problems, they would turn to the resource and essentially copy the procedure or solution without ever really thinking critically about the problem.

The results of the study show that a few students did successfully apply the procedure from the solution sets to other problems they were having difficulty with. However, the majority of the students mention that they simply did not attempt the more difficult problems they encountered. Furthermore, the students overwhelming response on the exit survey stated that they wanted the resource to include more problems worked out. This is especially true for the Application problems section which consisted of real world word problems. Relatively few of these types of problems were assigned and since I did not want to answer all or even the majority of these problems for the students, very few were presented on the solution sets.

It has been my experience through five years of teaching in public schools and five years teaching as a graduate instructional assistant, that many students avoid working word problems. Since very few of these types of problems were presented on the solution sets and since the assigned problems were not collected and graded, I believe many students simply did not attempt these problems. Even though the students were told repeatedly during class that the application problems would be a significant part of the course tests, it seems the students did not attempt them. Perhaps in future research a comparison could be made between courses which employed varying percentages of assigned problems completed on the solution sets.

Students also included statements on the exit survey and in the face-to-face interviews they would prefer the solution sets to be structured in a way that they would

represent the problems which would be included on a test. These students essentially wanted the solution sets to be a test review. Students primarily using the solution sets as a review, as indicated by usage frequency and timestamps of file access, was addressed in the previous section. The idea that the solution sets needed to be a better review for the exam is contrary to the instructor's purpose of posting the solution sets. The solution sets were intended to be a study aide to assist students in completing the assigned problems sets which would, in theory, better prepare them for the class assessments. The solution sets were not intended as a stand-alone test review. As mentioned above, the solution sets do not contain many of the higher level questions from the assigned problem sets that would be considered good test questions. The solution sets were intended to assist the students in solving the more difficult problems by demonstrating the approach, procedures, and thought processes that went in to solving similar problems. If students are not working the assigned problem sets and are simply watching the narrated solution sets, as the frequency use data suggests, then they are not adequately preparing for the in-class assessments.

Collins and Sims (2006) note that many college students "were simply good students in un-challenging high schools" (p. 207) and subsequently did not develop the appropriate study and help seeking skills needed to be successful in higher education. The seemingly less structured college environment along with the assigned problem sets not being collected, could possibly have lulled students into believing that they do not need to study very much. Collins and Sims (2006) also mention that often students wait until they experience some form of negative feedback, i.e. a poor quiz or test grade before they actively seek help. A couple of students did mention that they did not fully engage until

after the first test. However, the frequency use data does not support this type of engagement. The trends of usage seem to be fairly consistent throughout the semester. There does not appear to be a significant increase in solution set usage after the first test. Student beliefs of their study habits as well as their help seeking beliefs could be addressed more definitively in future research.

The results of this research study suggest that not only do students incorporate the resource into their study routines, they like the resource. Many students report using the resource either exclusively or at least as a first option when help seeking. The number of total accesses combined with the consistency of file accesses throughout the entire semester suggests students find the resource to be useful.

Summary of Findings

Considering the flow chart for the design of this study, the following conclusions can be drawn about the effects incorporating narrated solution sets into the business calculus curriculum. (1) Some students, as evidenced by John and Stacy, are able to use the solution sets as a “think aloud” resource as described by Schoenfeld (1992b). For these students the solution sets allow them to get over the metacognition hurdle keeping them from successfully completing their task. (2) Many students use the narrated solution sets as a semi-formal help resource. Responses from the exit survey along with the interview data demonstrate that students use the resource to either replace or augment other help resources such as the internet or on-campus tutoring. It is a non-judgmental resource available to students when other resources are not. This certainly affects students’ ability to overcome the help seeking hurdle. (3) Some students are able to

employ the narrated solutions as a scaffolding resource. The direct connection to their instructor and assignment, help students fill the need for scaffolding and assist them in jumping the scaffolding hurdle. (4) The narrated solution sets do not change student perceptions of homework. While instructors may perceive homework as practice for mastery, students see it more as a means to pass the test. The student responses from the exit survey suggesting the resource might be a better test review is evidence that students are not completing their homework as a means to better conceptualize the course material. Instead they seem simply to want to know what to do for the impending test. (5) Finally, students incorporate the narrated solution sets into whatever their current study routine happens to be. There is no evidence in this study that the students' routines were changed as a result of having access to the resource. Many students still procrastinated, many worked either late at night or early in the morning. The solution sets do not necessarily enable students to hurdle their own lack of self-regulation.

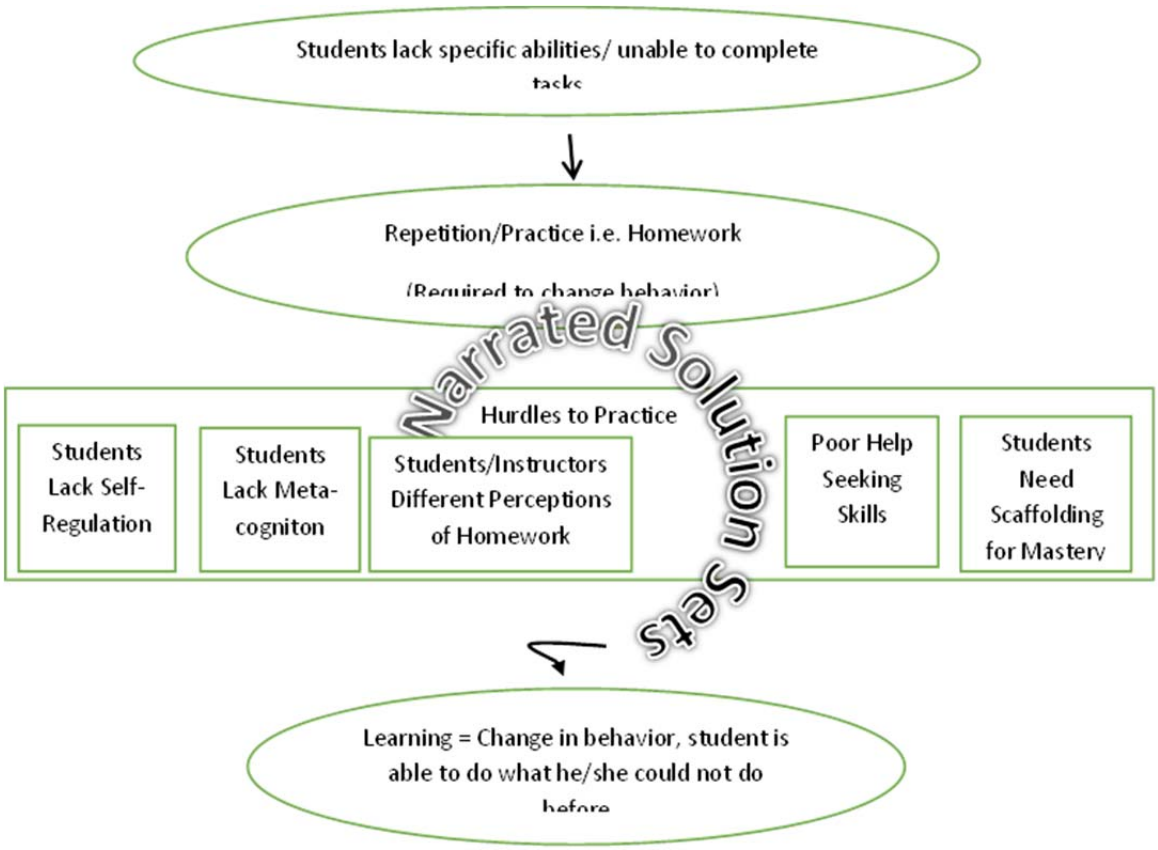

Figure 4. Study design framework for this research.

Delimitations of the Study

This study was conducted in two sections of a business calculus course in a major university in Texas. The researcher was the instructor of record for both sections. Since the researcher/instructor was a doctoral student at the time the study was conducted, university policies dictated that he could only be employed half-time which is equivalent to teaching two sections. While there are many sections of business calculus taught each long semester, the researcher chose to focus the study on these two sections.

Due to the high drop rates historically associated with this course, the researcher chose to not use a control-treatment design in order to maintain the highest possible

number of participants. A comparison could have potentially been conducted between the two courses taught by the researcher and other courses being taught the same semester, this was also decided against.

The researcher is the only instructor of record who incorporates this type of resource into the course curriculum. Part of the theory behind student usage of the resource is the connection of the resource to the instructor of the course. This means that the other instructors would have to incorporate a similar resource that they created to be a good comparison. Simply giving students from a different instructor's course access to the solution sets created for the study would not be an accurate comparison. The resource for those students would be a different experience than that of the students in the researchers sections. That type of interaction is beyond the scope of this dissertation research.

Implications for Teaching

This study demonstrates that narrated solution sets are a resource that students not only incorporate into their study routines, but perceive as a quality help resource. The low cost of the smart pen combined with the ease of use of the technology make these resources accessible to many mathematics instructors. Including narrated solution sets into the curriculum is equally easy and does not have any other associated costs. Since many instructors already incorporate some degree of solutions for students into their curriculum, the narrated solution sets used in this study fit into the traditional structure as described by Brewer (2009). For these reasons the narrated solution sets are a worthwhile learning tool that instructors can implement.

There are several things to consider before implementing this resource. First, the instructor needs to consider the purpose of the resource. As has been demonstrated here, students use the resource as a study guide for assessments. If this is the intended purpose, the resource needs to be comprehensive in that respect. It is completely at the discretion of the instructor, but the pencasts could be organized differently than they were for this study. Pencasts could be created which addressed related problems from different book sections, or a specific review resource could be created.

Some instructors may want to include all of the assigned problems, or as was done in this study, just a few. Since the solution sets contain detailed explanations of each problem presented, similar to going over a detailed example in class, the length of the pencast must be considered. A detailed presentation of every problem assigned may take too long to create for every section, which would make the resource a burden on the instructor. Student access to the resource must also be considered. At the university where this study took place, there are numerous 24 hour computer labs for students. While internet and computer access at this university is almost assumed, it might not be the case at every institution.

While usage of the resource by students may be a reasonable expectation, gains in achievement or changes in student behaviors is not. Students incorporate the resource into whatever study habits they currently have and do not necessarily adjust their study habits because of access to this resource. Although some students may perform better after accessing the resource, accessing the resource does not in any way guarantee student success.

During the semester following this research study, I taught two more sections of business calculus. I implemented the narrated solution sets, with a two notable modifications, into these courses as well. The first modification I made was to upload the pencast covering a section as close to the day it was covered in class as possible. Typically I uploaded the resource either the same day, or the next morning after a section was covered in class. I did not change the pencasts in any way, they were the same files used in the research study.

The second modification I incorporated was to attempt to inform the students about my expectations for their use of the resource. I tried to describe how I expected them to use the resource and explain why simply watching the pencasts the day before an exam was not a solid study plan. The files created for this research were intended for students to use as a guide to work more difficult or challenging problems. Sharing the trends found in the usage, specifically concerning procrastination may also be beneficial to students.

Future Research

This research is easily adapted to other mathematics courses. College algebra, business algebra, and calculus are just a few courses where this type of resource may be beneficial for students. Beyond mathematics, the narrated solution sets could be incorporated into several of the other sciences as well. Introductory chemistry, as mentioned by Stacy, and beginning physics are courses where there are procedural aspects of the course material where this resource may be incorporated.

Comparing the student usage from different instructors who create their own versions of the resource would be important to determine what impact the interaction of the instructor with the students has on usage of the resource. Similarly, having an instructor incorporate solution sets created by someone else into their class and looking at student usage and perceptions of the resource when it was not directly connected to their in-class instructor would be interesting.

As more online resources become available and textbook companies increase the amount of internet based resources available to students it would be interesting to compare the students' perceptions of these outside resources that are still connected to their course through the textbook to the narrated solution sets created by the instructor.

This research gives some insight into college student study routines. While there is currently limited research about specific study habits of college students, there exists a bounty of research on what students should do to be successful. As mentioned in the introduction, homework completion, contact with the instructor outside of normal class times, and student study routines all impact student performance. However, the pencasts used in this research did not change any of the students' study habits. Students continued to study whenever and wherever they have in the past. An important goal of future researchers should be to determine what exactly students are doing with their time. When are they studying, how are they studying, with whom, etc. The answers to these questions could enable educators to not only teach students the content of the courses they are taking, but also how to be better, more successful, students.

Summary

Narrated solution sets created with smart pen technology are a resource that is easily adapted to most instructors' curriculum. The technology is inexpensive and easy to use. Furthermore, incorporating this type of resource does not require the instructor to step outside of their normal routine, as many already create some form of solution sets for their students.

Students like many aspects of this type of resource. The convenience and availability of the resource enable students to incorporate it during times when other resources are not available. The specificity and direct connection to their assignment and instructor, influence student help seeking behaviors. Students will regularly employ the solution sets over other online resources such as, YouTube or Khan Academy. For some students, the solution sets can substitute their need to attend office hours or seek other help resources. Overall, the majority of students accessed the resource multiple times during the semester and many reported they would either like to see the resource used in other courses.

APPENDIX SECTION

Appendix A

Initial Survey

Answer the following questions as honestly as you can. Give a little thought to the questions and give detailed answers (brief but detailed).

Name: Major: Age:

Classification: Freshman Sophomore Junior Senior

Transfer student? Y N Former Military? Y N Work outside of school? Y N

Name one thing you are proud of:

What was the last math course you took? (Approximate date and institution):

Why are you taking MATH 1329?

What are your expectations for this course?

High school math to me was…

Math to me is…

My favorite thing in math is…

My *least* favorite thing in math is…

Appendix B

Midterm Survey

With 1 being **most** and 4 being the **least**, rank the following in order of where you believe your mathematics leaning occurs:

_____ In-class lecture/ instruction

_____ Completing homework outside of class (independently)

_____ Working with a classmate or peer (either in or out-of-class)

_____ Working with a personal tutor (office hours, SLAC, private tutor, etc.)

In the space below, describe your usage of the online homework solutions. Include things like the time of day, setting (in a group, by yourself), which files or how many of the files you have accessed, etc.

Appendix C

Exit Survey

Please answer each question or complete each statement with as much detail as possible. You may use the back side of either page if you need more space to write.

Did you use the online homework solutions? (circle one)	Never	A couple of times	Many times

If you answered "Never" on the question above, please tell us why you did not use the solutions.

If you answered either "a couple of times" or "Many times" please answer the following questions:

1) How many of the online homework solution files posted by the professor did you view? Did you view any of the files more than once?

2) What prompted you to view the files? Were you stuck on a problem, did you view them before you started your homework, etc.

3) What was your goal in viewing the files? Were you looking for an answer? Were you looking to see a procedure? What did you expect to get from viewing a file? Were you satisfied with the results?

4) After viewing the files, did you attempt to solve similar problems from the homework?

5) How did having access to the online solution sets affect your help seeking?

6) Are the solution sets something that you would like to have available in other courses? Why or why not?

7) If you were teaching a similar course would you implement a similar resource? What would you do differently?

Appendix D

Initial Interview Protocol

Date:

Interviewer: Jake Hammons

Interviewee:

Interview Number: 1

Location: Time:

Script: This interview is for research for my dissertation. No personal information will shared with anyone outside of the research group. If any part is published, all identifiable information will be removed.

Questions:

1. Tell me your math story.
    a. Have you always felt that way about mathematics?
    b. When did you develop your current attitude or perception towards mathematics?

2. Tell me about your mathematics experiences in college.
3. What is your regular study routine?

4. Where do you go for help?

5. What help resources are you aware of?
    a. Which of those resources have you used?
    b. Do you consider any of the resources to be superior? Why?

6. Why are you taking this course? Have you taken it before?

7. What are your expectations of this course?

8. How do you plan to meet the goals you have for this course?

Appendix E

Mid Term Interview Protocol

Date:

Interviewer: Jake Hammons

Interviewee:

Interview Number: 3

Location: Time:

Script: This interview is for research for my dissertation. No personal information will shared with anyone outside of the research group. If any part is published, all identifiable information will be removed.

Questions:

1. In the first interview you stated _____ about your expectations for this course.
2. What are your impressions of the availability of the narrated solution sets?
    a. When did you first start using them?
    b. How often do you use them?
3. Describe a typical help seeking episode.
4. Compare the solution sets to other help seeking resources you utilized this semester i.e. office hours, on-campus tutoring centers, etc.

Appendix F

Exit Interview Protocol

Date:

Interviewer: Jake Hammons

Interviewee:

Interview Number: 3

Location: Time:

Script: This interview is for research for my dissertation. No personal information will shared with anyone outside of the research group. If any part is published, all identifiable information will be removed.

Questions:

5. In the first interview you stated _____ about your expectations for this course. How have those changed over the course of the semester?
6. Tell me about your experience in this course this semester.
7. What are your impressions of the availability of the narrated solution sets?
    a. When did you first start using them?
    b. How often did you use them?
8. How would you augment the method of incorporation of the solution sets used by the instructor?
9. Describe a typical help seeking episode.
10. Compare the solution sets to other help seeking resources you utilized this semester i.e. office hours, on-campus tutoring centers, etc.

Appendix G

Midterm Evaluation Form

Mathematics Instructional Assistant/Teaching Assistant Midterm Evaluation

Instructor: _____

This questionnaire is completely confidential, and your honesty is greatly appreciated.

The Major objective of this survey is to aid in improving teaching effectiveness. Your responses provide valuable feedback to instructors, administrators, and other students. Please respond honestly and fairly. Consider the semester up to this point and try not to focus on isolated incidents. Circle the response that most accurately reflects your opinion.

Section 1: Course Instruction

So far this semester, the instructor…	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Is well-prepared for class.	A	B	C	D	E
2. Shows a thorough knowledge of course material.	A	B	C	D	E
3. States class objectives and student expectations.	A	B	C	D	E
4. Is receptive to students' questions and comments.	A	B	C	D	E
5. Shows genuine concern for the quality of his or her teaching.	A	B	C	D	E
6. Models effective critical thinking skills.	A	B	C	D	E
7. Provides an opportunity for guided practice.	A	B	C	D	E
8. Provides an environment for creating my own understanding.	A	B	C	D	E

Section 2: Open Comments

Please respond to the following questions. Use the back of the page if necessary.

9. What aspects of the content and instruction for this course are the best? Why?

10. What could the instructor do to improve the course content and or his instruction? Why?

Appendix H

End of Course Evaluation Form

TEACHING EVALUATION

Thank you for taking the time to answer this questionnaire. Your responses will be given to the instructor only after grades have been turned in. Do not write your name.

COURSE: _____ SEMESTER &YEAR: _____ INSTRUCTOR: _____

I. Bubble in your responses to question 1-8 on the scantron:

1. Were the exams graded and returned within two weeks? A) yes B) no opinion C) no
2. Was the instructor usually available during the office hours? A) yes B) no opinion C) no
3. Was the instructor prepared for class? A) yes B) no opinion C) no

Use the following scale on the statements below:

A) Excellent B) Very Good C) Good D) Acceptable E)Unsatisfactory

4. The organization of the course was ___
5. The instructor's skill in communicating information effectively was ___
6. The instructor's skill in helping me think for myself in this course was ___
7. Overall, this instructor was ___
8. Overall, this course was ___

II. Describe the performance of your teacher in this course. Please give specific comments and/or suggestions about whatever you think is important. Use the back of this page if needed.

III. Circle the appropriate response.

a. Student class: Freshman Sophomore Junior Senior Other
b. Expected grade: A B C D F
c. Number of classes missed: 0-1 2-4 5-7 8-9 10 or more

REFERENCES

Adelman, C., & Office of Vocational and,Adult Education. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* ().US Department of Education. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED490195&login.asp&site=ehost-live

Affouf, M., & Walsh, T. P. (2007). An assessment of web-based homework in the teaching of college algebra. *International Journal for Technology in Mathematics Education*, *14*(4), 63-68. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ847747&site=eds-live&scope=site; http://www.tech.plym.ac.uk/research/mathematics_education/field%20of%20work/IJTME/volume_14/number_four.htm#one

Balduf, M. (2009). Underachievement among college students. *Journal of Advanced Academics*, *20*(2), 274-294.

Bloom, B. S. (1976). *Human characteristics and school learning.* McGraw-Hill.

Brewer, D. S. (2009). *The effects of online homework on achievement and self-efficacy of college algebra students.* ProQuest LLC). *ProQuest LLC,* (ProQuest LLC. 789 East Eisenhower Parkway, P.O. Box 1346, Ann Arbor, MI 48106. Tel: 800-521-0600; Web site: http://www.proquest.com/en-US/products/dissertations/individuals.shtml) Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED513252&site=eds-live&scope=site; http://gateway.proquest.com/openurl?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&res_dat=xri:pqdiss&rft_dat=xri:pqdiss:3366157

Briley, J. S. (2007). *An investigation of the relationships among mathematical beliefs, self-regulation, and achievement for university-level mathematics students.* (Ph.D., The University of Alabama). *ProQuest Dissertations and Theses,* Retrieved from http://search.proquest.com/docview/304891721?accountid=5683. (304891721).

Butler, R. (1998). Determinants of help seeking: Relations between perceived reasons for classroom help-avoidance and help-seeking behaviors in an experimental context. *Journal of Educational Psychology, 90*(4), 630.

Cipra, B. A. (1988). Calculus: Crisis looms in mathematics' future. *Science, 239*(4847), 1491-1492.

Collins, A. (2006). Cognitive apprenticeship. In R. K. Sawyer (Ed.), *The cambridge handbook of the learning sciences* (pp. 47) Cambridge University Press.

Collins, W., & Sims, B. C. (2006). Help seeking in higher education academic support services. In S. A. Karabenick, & R. S. Newman (Eds.), (pp. 203-223). Mahwah, NJ US: Lawrence Erlbaum Associates Publishers. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2006-03631-008&site=eds-live&scope=site

Cooper, H. (1989). Synthesis of research on homework. *Educational Leadership, 47*(3), 85-91. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ398958&login.asp&site=ehost-live

Cooper, H. M. (2006). *The battle over homework: Common ground for administrators, teachers, and parents. third edition* Corwin Press. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED495321&login.asp&site=ehost-live; http://www.corwinpress.com/booksProdDesc.nav?prodId=Book228931

Cooper, H., & National Council of Teachers,of Mathematics. (2008). *A brief history of homework in the united states. research brief.* ().National Council of Teachers of Mathematics. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED505965&login.asp&site=ehost-live; http://www.nctm.org/news/content.aspx?id=13798

Corkin, D. M., Yu, S. L., & Lindt, S. F. (2011). Comparing active delay and procrastination from a self-regulated learning perspective. *Learning and Individual Differences, 21*(5), 602-606.

Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches* Sage.

Davidson, A. (2004). An examination of the effects and costs of instruction that relies on computer-assisted instruction for delivering and managing homework assignments in college calculus courses.

Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., Campuzano, L., . . . Javitz, H. (2007). Effectiveness of reading and mathematics software products: Findings from the first student cohort.

Gerhardt, J., Vogel, J., & Wu, C. (2006). Why do I have to take calculus? *Director,* , 07.

Gutarts, B., & Bains, F. (2010). Does mandatory homework have a positive effect on student achievement for college students studying calculus? *Mathematics & Computer Education, 44*(3), 232-244. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=54353645&site=eds-live&scope=site

Halcrow, C., & Dunnigan, G. (2012). Online homework in calculus I: Friend or foe? *PRIMUS, 22*(8), 664-682. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ988265&site=eds-live&scope=site; http://dx.doi.org/10.1080/10511970.2012.694015

Hancock, D. R. (2000). Impact of verbal praise on college students' time spent on homework. *The Journal of Educational Research, 93*(6), 384-389.

Hauk, S., & Segalla, A. (2005). Student perceptions of the web-based homework program WeBWorK in moderate enrollment college algebra classes. *The Journal of Computers in Mathematics and Science Teaching, 24*(3), 229-253. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=507963120&site=ehost-live

Jacobson, E. (2006). Computer homework effectiveness in developmental mathematics. *Journal of Developmental Education, 29*(3), 2.

Karabenick, S. A., & Knapp, J. R. (1988). Effects of computer privacy on Help-Seeking1. *Journal of Applied Social Psychology, 18*(6), 461-472.

Karabenick, S. A. (1992). *Help seeking in college classrooms: The role of perceived teacher support and teacher effectiveness in the student questioning process.* (). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED345627&login.asp&site=ehost-live

Karabenick, S. A. (2011a). Classroom and technology-supported help seeking: The need for converging research paradigms. *Learning and Instruction*, *21*(2), 290-296. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ908868&login.asp&site=ehost-live; http://dx.doi.org/10.1016/j.learninstruc.2010.07.007

Karabenick, S. A. (2011b). Methodological and assessment issues in research on help seeking. In B. J. Zimmerman, & D. H. Schunk (Eds.), (pp. 267-281). New York, NY US: Routledge/Taylor & Francis Group. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2011-12365-017&site=eds-live&scope=site

Karabenick, S. A., & Collins-Eaglin, J. (1996). *Relation of perceived instructional goals and incentives to college students' use of learning strategies.* (). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED394421&login.asp&site=ehost-live

Karabenick, S. A., & Newman, R. S. (2006). *Help seeking in academic settings: Goals, groups, and contexts* Lawrence Erlbaum Associates. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED493786&login.asp&site=ehost-live; http://www.erlbaum.com/ME2/dirmod.asp?sid=28807ECF50FE49F0837125BE640E681F&nm=&type=eCommerce&mod=CommerceProductCatalog&mid=CD22EA0F118949C09A932248C040F650&tier=3&id=3D5207EA31B146738B500EB6B5A3A85E&itemid=0-8058-5219-0

Kempler, T. M., & Linnenbnnk, E. A. (2006). Helping behaviors in collaborative groups in math: A descriptive analysis. In S. A. Karabenick, & R. S. Newman (Eds.), (pp. 89-115). Mahwah, NJ US: Lawrence Erlbaum Associates Publishers. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2006-03631-004&site=eds-live&scope=site

Knapp, J. R., & Karabenick, S. A. (1988). Incidence of formal and informal academic help-seeking in higher education. *Journal of College Student Development, 29*(3), 223-27. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ378553&login.asp&site=ehost-live

Lenz, L. (2010). The effect of a web-based homework system on student outcomes in a first-year mathematics course. *Journal of Computers in Mathematics and Science Teaching, 29*(3), 233-246. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ896824&site=eds-live&scope=site; http://www.editlib.org/p/32318

Nelson-Le Gall, S. (1981). Help-seeking: An understudied problem-solving skill in children. *Developmental Review, 1*(3), 224-246. doi:10.1016/0273-2297(81)90019-8

Nist, S. L., & Kirby, K. (1986). Teaching comprehension and study strategies through modeling and thinking aloud. *Reading Research and Instruction, 25*(4), 254-264. doi:10.1080/19388078609557884

Nonis, S. A., & Hudson, G. I. (2010). Performance of college students: Impact of study time and study habits. *Journal of Education for Business, 85*(4), 229-238.

Puustinen, M., & Rouet, J. (2009). Learning with new technologies: Help seeking and information searching revisited. *Computers & Education, 53*(4), 1014-1019. doi:http://dx.doi.org/10.1016/j.compedu.2008.07.002

Quintana, C., Shin, N., Norris, C., & Soloway, E. (2006). Learner-centered design: Reflections on the past and directions for the future. *Cambridge Handbook of the Learning Sciences,* , 119-134.

Rakoczy, K., Harks, B., Klieme, E., Blum, W., & Hochweber, J. (2013). Written feedback in mathematics: Mediated by students' perception, moderated by goal orientation. *Learning and Instruction, 27*(0), 63-73. doi:http://dx.doi.org/10.1016/j.learninstruc.2013.03.002

Sawyer, R. K. (2006). *The cambridge handbook of the learning sciences* Cambridge University Press New York.

Schoenfeld, A. H. (1992a). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. *Handbook of Research on Mathematics Teaching and Learning,* , 334-370.

Schoenfeld, A. H. (1992b). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. *Handbook of Research on Mathematics Teaching and Learning,* , 334-370.

Schoenfeld, A. H. (1982). *Beyond the purely cognitive: Metacognition and social cognition as driving forces in intellectual performance.* (). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED219433&login.asp&site=ehost-live

Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education, 20*(4), 338-355. Retrieved from http://www.jstor.org/stable/749440

Schraw, G., Wadkins, T., & Olafson, L. (2007). Doing the things we do: A grounded theory of academic procrastination. *Journal of Educational Psychology, 99*(1), 12.

Steel, P. (2007). The nature of procrastination: A meta-analytic and theoretical review of quintessential self-regulatory failure. *Psychological Bulletin, 133*(1), 65.

Suresh, R. (2007). The relationship between barrier courses and persistence in engineering. *Journal of College Student Retention: Research, Theory & Practice, 8*(2), 215-239. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ744661&login.asp&site=ehost-live; http://baywood.metapress.com/link.asp?target=contribution&id=3QTU6EELHQHFXYF0

Tennant, A. (2012). *Adult student learning behaviors in a roadblock mathematics course.* (Ph.D., Texas State University - San Marcos). *ProQuest Dissertations and Theses*, Retrieved from http://search.proquest.com/docview/1323178876?accountid=5683. (1323178876).

Trautwein, U., & Köller, O. (2003). The relationship between homework and achievement—Still much of a mystery. *Educational Psychology Review, 15*(2), 115-145.

Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. *The College Mathematics Journal, 23*(5), 362-372.

Volet, S., & Karabenick, S. (2006). Help seeking in cultural context. *Help Seeking in Academic Settings: Goals, Groups, and Contexts*, , 117-150.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving*. *Journal of Child Psychology and Psychiatry, 17*(2), 89-100.

Zerr, R. (2007). A quantitative and qualitative analysis of the effectiveness of online homework in first-semester calculus. *The Journal of Computers in Mathematics and Science Teaching, 26*(1), 55-73. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=507944550&site=ehost-live

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*(1), 3-17.

Zimmerman, B. J., & Pons, M. M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, *23*(4), 614-628. doi:10.3102/00028312023004614

Zimmerman, B. J., & Schunk, D. H. (2011). *Handbook of self-regulation of learning and performance* New York, NY ; London : Routledge : Taylor & Francis Group, 2011, c2011. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=cat00022a&AN=txi.b2187486&site=eds-live&scope=site