IMPROVING STATISTICS INSTRUCTION: STUDENT VARIABLES, BEHAVIORS & STRATEGIES

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Abstract

The current investigation sought to identify specific variables affecting students' learning in an introductory statistics course, students' academic routines and behaviors, and the importance of those behaviors as they relate to students' success in the class. The focus was to incorporate self-regulated learning strategies within instructional strategies that promote active learning. Classroom observations, consultations with the instructor, student interviews and a survey were used to identify existing instructional practices and ongoing student variables. Students who read the text, attended review sessions, and studied in a quiet place tended to do significantly better in the course. Identifying student variables and the course's instructional constraints allowed for the development of instructional strategies which promote active, self-regulated learning strategies that the instructor can actually incorporate into the course format. Two types of strategies were developed: a teacher-centered instructional strategy and a student-centered self-regulated learning strategy. Procedures for both strategies are structured so that they interact with each other to scaffold students' development of statistical reasoning abilities.

CHAPTER ONE

Introduction

Recent educational and national policy debate has called for research that is science driven and at the same time applicable and informative for educational professionals (Education Week, 2000). A renewed focus on applied research is trying to bridge the gap between what psychologists know about teaching, learning, and cognition and attempts by instructors and educational researchers/administrators to develop quality programs and instruction. Teachers need instructional strategies that they can incorporate into their teaching style, that are grounded in research, and that address their specific needs. These instructional strategies should support students' active attempts to learn and synthesize information both immediately (in the class) and developmentally. This means implementing procedures that scaffold students' current learning and performance while creating an environment conducive to learning skills development. This puts students on the path to being as successful as they possibly can.

Comparative and descriptive literature on excellent studentship and positive academic outcomes depict self-regulated learning and strategy use as factors that differentiate effective learners from ineffective learners (Zimmerman, 1990; Zimmerman & Martinez-Pons, 1990; Zimmerman, Greenberg & Weinstein, 1994; Schunk & Zimmerman, 1998). Reviews of research on learning strategies and active, self-regulated learners suggests several ways in which students can enhance their learning skills and experiences (Schunk & Zimmerman, 1994, 1998; Flippo & Caverly, 2000; Johnson, Johnson, & Stanne, 2000). Effective learners use strategies to improve learning, and self-monitor their learning to control performance (Zimmerman & Paulsen, 1995). Skillful

self-regulators know when they are performing well and when they're not. This increased self-knowledge allows them to be adaptive, and develop valid learning skills and strategies.

Several models of self-regulated learning (SRL) have been used to increase students' learning skills. Presley and his colleagues' good strategy user model (Pressley, Borkowski, & Schneider, 1987, 1989), strategic learning models (Weinstein, 1994a, 1994b), and social-cognitive models of self-regulated academic learning (Schunk, & Zimmerman, 1994b) all incorporate aspects of self-monitoring. Self-monitoring and assistance seeking have been shown to be strategies that self-regulated learners use to optimize their learning (Lan, 1996; Zimmerman, 1989). These models share the basic assumption that students can actively regulate their cognition, motivation, or behavior. Students using various learning strategies and regulatory processes are better equipped to achieve their goals and in general perform better on learning tasks (Garcia & Pintrich, 1994; Zimmerman, 1989b). However, evidence also suggests that many students fail to self-monitor their learning process accurately and tend to over-estimate their level of success (Ghatala, Levin, Foorman, & Pressley, 1989).

Zimmerman's (1989) model of self-regulated academic learning is based on Bandura's (1986) social-cognitive theory. In this model variables affecting learning are organized into three categories. Personal, behavioral, and environmental variables all operate as interacting determinants that influence each other bi-directionally (see Figure 1). Affective and cognitive variables are lumped together within personal variables and are said to interact with environmental variables (classroom context for example) to determine behavior. For example, the continued use of a cognitive learning strategy such as rehearsal becomes self-regulated when the individual uses feedback gained through

self-observation to decide when (the identification of an appropriate setting) and how to behaviorally apply a strategy. As academic situations change, a strategy's effectiveness may decrease. These changes in effectiveness across contexts can then be self-regulated by altering the strategy (the inclusion of sub-goals and shaping in a rehearsal strategy to deal with increased memory demands), augmenting the strategy (the addition of a chunking strategy), or by choosing another strategy. Self-monitoring gives the learner an understanding of when and why strategies are effective in attaining their goals. Self-regulated learning occurs when specified strategies are used to achieve academic goals on the basis of self-efficacy perceptions and self-observation (Zimmerman, 1989).

Of the many sub-processes of SRL, self-monitoring has received more attention from researchers than others. Researchers have found that involving students in strategies like self monitoring and adaptive attributions can improve students' academic performance (Malone & Mastropieri, 1992), achievement (Schunk, 1983), time on task (DiGangi, Maag, & Rutherford, 1991), classroom behavior (Maag, Rutherford, & DiGangi, 1992), and problem-solving ability (Delclos & Harrington, 1991). Theorists and researchers from social-cognitive, volitional, phenomenological, and behavior modification perspectives all include self-monitoring as a critical component of successful interventions and theoretical models.

Various types of learning-to-learn courses have shown that incorporating a program of self-monitoring and strategy use can lead to better grades and increased graduation rates (Weinstein 1994b; McKeachie, Pintrich, & Lin 1985). While some of these interventions have been with college students (Hofer, Pintrich, & Yu 1998; Lan 1996; Weinstein 1994b) the majority have focused on K-12 students (Zimmerman, 1990; Pressley & Ghatala, 1990). Additionally, most interventions have been of an adjunct

format and focus on general strategies with little attention paid to issues of transfer. These separate, stand-alone classes have taught learning skills as a separate course outside any particular field of study or domain of knowledge.

A meta-analysis of the effects of learning skills interventions on student learning (Hattie, Biggs, & Purdie 1996) suggested that interventions should be carried out within the normal teaching context. Hattie and her colleagues found that students' learning of strategies and learning skills might be made more effective by presenting them within domain specific situations and material. However, some of their findings were based on only one or two studies.

Within the College of Social Sciences at the University of Hawaii students are required to take at least one course in introductory statistics. Students are taught the fundamentals of hypothesis testing and learn to use increasingly complex test statistics to solve real world problems. The course has traditionally been a challenge to teach. Students are often fearful of the course and the math involved, and every semester several students drop out, withdraw, or fail to pass. They often exhibit self-defeating attributions like "I'm not good at math. I'll be happy just to pass," and "I just want to pass this class so I can graduate." For many students in the college this will be the only statistics course they take. Each semester there are several students who do not pass the class and have to repeat it, sometimes at the expense of graduating in a timely fashion. As a required course for many departments, the course is crucial for many students. The college is interested in creating a course with high levels of quality teaching and learning. This can be accomplished by integrating self-regulated learning strategies that fit into the course's instructional format (instructor's current instructional strategies, practices, and goals) and at the same time promote active, self-regulation. The goal is to develop

students who can self-regulate their learning as they learn to think critically about statistics and hypothesis testing.

We initially tried to recreate the effects of self-monitoring on students' learning of statistics described by Lan (1996). In our pilot study, however, it became clear that student variables specific to undergraduates at the University of Hawaii were too different from those of Lan's graduate students. Our students failed to use the research protocols regularly, and only one student completed the forms in the manner that was intended. Given the differences in students, the teacher, and the level of the course, it was clear that getting students to benefit from self-monitoring would involve creating and adapting self-monitoring strategies specific to the class.

What students were and were not doing when they studied statistics needed to be identified. A qualitative study of student study behavior would identify important student variables and behaviors. Two models were used to guide the qualitative study. Zimmerman's (1989) social-cognitive model of self-regulated academic learning would be used to guide the investigation of student variables. Tharp and Gallimore's (1988) model of teaching as assisted performance was adopted to identify the sources and changes in sources of self-regulated learning in the statistics course (see Figure 2). Assessing the variables and behaviors affecting students' learning experiences with these models allowed for the identification and improvement of existing teaching and learning activities.

Data from classroom observations and instructor consultations were used to guide student interviews and the creation of a survey of student variables affecting learning. Interview responses were organized into themes. Survey data included 3 different (dependent) variables which were compared with students' grades (independent variable)

in the course through analysis of variance procedures. The data collected were then used to create the strategies found in the discussion section.

CHAPTER TWO

Method

Participants

This research project investigated the learning of 56 students in the introductory inferential statistics course, Statistics for Social Sciences 225, during the spring 2001. The course met for lectures twice a week for one hour and fifteen minutes and once a week for a lab session where students applied statistical concepts using the SAS program. Students in the course come from various departments including nursing, psychology, sociology, speech, and travel industry management. Most students were upperclassmen, although it was not uncommon to have several freshmen. Typically, in prior semesters about 20-30% of the students in the class fail to pass. These student are then faced with having to retake the class because it is a graduation requirement. This leads to a situation where several students each semester are taking the class for the second, third and sometimes fourth times.

Students were recruited for the project by being offered extra credit that could be applied to their final grade in the course. Students were given one extra credit point for filling out the survey and another point and a half for participating in the interview. These points were added on to their final score for the course. Of the sixty-eight students in the course, fifty-six responded to the survey and thirty completed the interview.

Consultation with Instructor

In order to develop an explicit understanding of the instructional constraints involved in the class, the investigator had several meetings with the instructor over the course of the semester. These meeting were both formal and informal. Some lasted only

five to ten minutes and occurred over lunch, while others were scheduled meetings to discuss particular topics.

These meetings involved talking about the course's design, the instructor's orientation toward teaching, and his plan for covering the material on the syllabus. In these meetings the format of exams, review sessions, lab sections, and student requirements were discussed. The meetings started prior to the beginning of the semester and continued over the course of the semester. These meetings served as an opportunity to ask specific questions, cross-reference observations from classroom visits, and clarify the instructor's perceptions of instructional constraints. On average, the meetings occurred once a week, although it was not uncommon to meet several times in the same week. One of the main functions that these meetings served was to prepare the investigator for upcoming lectures by laying out the topics to be covered in class ahead of time. This way the investigator could prepare for and plan in-class observations, schedule students to take the survey, and plan time for conducting interviews.

Class visits

Several visits to the classroom were required to understand the students' personal, behavioral, and environmental variables involved in the course. These visits occurred during both lecture days and exams. The purpose of these visits was to observe the *instructor's self-reported orientation* toward learning and the instructional strategies and methods used by the instructor. These included student-teacher interactions, the course design, and aspects of the class that might affect the implementation and use of self regulated learning strategies based on the two proposed models. The visits afforded an opportunity to identify difficult aspects of the class and to cross reference aspects of the

class with the instructor's perceptions. The course also included a weekly computer lab session run by a teaching assistant. This component of the class was excluded for two reasons. The lab was already highly structured such that possible changes or modifications would be very limited in scope and difficult to administer effectively. Also it was the desire of the instructor to have any later additions or modifications directly under his control and kept to a minimum.

Observing the interaction of personal, behavioral, and environmental variables in the class allowed for questions about specific variables to be asked or confirmed. The investigator made it a point to get to class early so students could be observed as they came in and set up or got ready for class. The investigator usually sat in the back of the class and recorded students' questions, the instructor's response, the instructor's organization of the lecture, instructional strategies used, student behaviors, and opportunities in which self monitoring and/or other self-regulated learning strategies could be incorporated. When the class was finished the investigator also waited around and observed students as they conversed and packed up their things. Pre- and post-lecture observations included observing students immediately outside the lecture room, in the hallway, and on the steps of the classroom building. On several occasions the investigator engaged in casual conversations with students if the opportunity presented itself. As the semester progressed, notes from classroom observations were reviewed and used to discuss aspects of the course with the instructor. In this way class visits were used to identify and observe functional constraints affecting learning and familiarize the investigator with specific examples of existing student behaviors and academic routines.

Surveys

Near the end of the semester students filled out a survey (see Figure 3) that asked them to rate the importance of various behaviors on a 9-point Likert scale. The survey asked students about the importance of fifteen in-class and out-of-class behaviors that may affect their learning of statistics and the survey also included six questions about their motivations for learning in the class. These questions comprised the 3 main dependent variables (DV1-in class behaviors, DV2-out of class behaviors, and DV3-motivation) that were compared with students' grades (IV) in an analysis of variance procedure. The logic here was that grades as a measure of, or proxy variable for, learning could be related to the actual behaviors students engage in during the learning process. To the extent that they are, there should be some predictive association between them. As this was not a true experiment this quantification assumes that students' learning (as measured by grades) is related to specific behaviors and skills that are identifiable (6-11 individual items comprising each dependent variable, e.g. DV1= #2, 5, 11, 13, 18, 29; DV2= # 1, 3, 4, 15, 16, 19, 20, 21, 22, 26, 28; DV-3= #8, 9, 10, 14, 17, 23, 24, 25, 27 on the following survey, see Figure 3).

Survey questions

1. How many sample problems have you done this week ?_____. This semester ?_____.
2. How many lectures have you missed this semester ?_____.
3. How many
4. times have you been in to see the instructor this semester ?_____.
5. How many times have you studied in a group for this class ?_____.
6. How many times have you asked at least 1 question during a class ?_____.
7. What department are you in ? _____.
8. Exactly where in the class do you regularly sit ?_____ .
9. How much did you like this class…

Not at all----------Very much

1 2 3 4 5 6 7 8 9

Why…_____

_____

10. Is this class challenging for you?

Not at all----------Very much

1 2 3 4 5 6 7 8 9

Why…_____

_____

11. Did you feel adequately prepared for exams in this class?

Not at all----------Very much

1 2 3 4 5 6 7 8 9

Why…_____

On a scale from 1 to 9 (1 signifying no importance--9 signifying extremely important) please rate the following statements as they apply to you and your ability to succeed in Socs 225.

In this class, How important is it for you to…

		not at all important		somewhat important		it's important		very important		extremely important
		1	2	3	4	5	6	7	8	9
12.	..take good notes.	1	2	3	4	5	6	7	8	9
13.	..come to every class.	1	2	3	4	5	6	7	8	9
14.	..get a good grade.	1	2	3	4	5	6	7	8	9
15.	..go to the lab.	1	2	3	4	5	6	7	8	9
16.	..study in a quiet place.	1	2	3	4	5	6	7	8	9
17.	..learn as much as possible.	1	2	3	4	5	6	7	8	9
18.	..listen to lectures.	1	2	3	4	5	6	7	8	9
19.	..study with other students.	1	2	3	4	5	6	7	8	9
20.	..keep track of your progress.	1	2	3	4	5	6	7	8	9
21.	..read the textbook.	1	2	3	4	5	6	7	8	9

		not at all important		somewhat important		it's important		very important		extremely important
22.	..review before the test.	1	2	3	4	5	6	7	8	9
23.	..completely understand the material.	1	2	3	4	5	6	7	8	9
24.	..do the best you possibly can .	1	2	3	4	5	6	7	8	9
25.	..do as little work as possible.	1	2	3	4	5	6	7	8	9
26.	..come to the review sessions.	1	2	3	4	5	6	7	8	9
27.	..master the statistical concepts.	1	2	3	4	5	6	7	8	9
28.	..complete the sample questions.	1	2	3	4	5	6	7	8	9
29.	..ask others for help.	1	2	3	4	5	6	7	8	9

30. If there was a way of improving your grade in this class that involved doing things differently would you be interested in trying it?_YES / NO

Why?

_____

_____

_____

_____

_____

_____

_____

_____

Figure 3. Survey used to investigate personal, environmental and behavioral variables affect student learning.

The survey also asked students how many sample problems they completed, the number of times they missed lectures, sought the instructor's assistance, studied with others, and asked questions in class. The survey included a total of thirty questions that were developed in two ways. Some questions asked students about behaviors that previous research has suggested differentiate self-regulated learners from their often less successful counterparts. Others came from initial consultations with the instructor about what he felt was important for students to do. On average, the survey required ten minutes to complete. The survey also asked students about their motivation for learning statistics and their perceptions of the course.

Students were asked to fill out the survey after they completed the second midterm but before the final. The instructor allowed the investigator fifteen minutes of class time at the end of a lecture to administer the survey. The investigator spent five minutes explaining the survey, the purpose of the study, and the informed consent sheet. Students were then required to read and sign a copy of the informed consent sheet and retain the second copy for their records. The other ten minutes was used for students to fill out the survey. Students that did not attend class that day were given a subsequent opportunity to fill out the survey prior to the interview.

The surveys were collected and the data entered into an Excel spreadsheet. After finals, students' un-weighted scores for the course were used as the independent variable for comparing the importance of in-class and out-of-class behaviors and students' motivations for learning.

Interviews

Interviews with students were conducted near the end of the semester. Students were interviewed one at a time using sixteen open-ended questions in a semi-structured interview (see Appendix A). The questions asked students to talk about their involvement in the statistics course in an attempt to identify specific academic routines and behaviors that students were engaged in while learning statistics. Some questions were very broad (... tell me about your statistics class, or tell me about the difficult aspects of this class) while others were more specific (what do you do when you encounter a problem you can't solve?). These questions were developed through consultation with the instructor and visits to the classroom to observe both lectures and exams. The idea was to get students talking about their learning behaviors in the statistics class and why they engaged in them.

The interviewer greeted the student at the office or interview room with "Hi, thank you for participating in this research." The interviewer then introduced himself and began to establish a rapport with the student, trying to make him/her feel comfortable. The student was invited to sit down and asked if it was all right to record the interview. If students agreed, they initialed the informed consent sheet that they signed during the survey portion of the research. All students consented to the recording. The interviewer began the interview by asking a broad question about the class (tell me *about your statistics class-Q#1, Appendix A). This got the students speaking about their* experiences and behaviors while allowing them to focus on what they thought was important. Using a broad open-ended question initially encourages students to respond freely and cite aspects of the class that are salient in their minds. The interviewer then

asked, "Tell about the difficult aspects of this class" (Q#2, Appendix A). The interviewer then continued through the rest of the interview schedule.

The interviewer had the option of following up students' answers to questions if explicit behaviors or motivating factors were not referenced enough. Follow up questions included, "how do you do that? , how does that help you learn? , what about doing X, do you think it helps you learn? , what else do you do?" When all questions on the interview schedule had been asked, the interviewer concluded the session by thanking the student for his/her participation and answering any possible questions the interviewee had about the research project.

Students' responses to interview questions were digitally recorded using a laptop computer equipped with external microphone and Sound Forge 4.5 software. Interviews were compiled at the end of each day and recorded onto compact discs for later transcription.

After transcription, the interview data were printed out and coded by hand using a social-cognitive framework of behavioral, environmental and personal variables. Behavioral variables included learning activities students reported engaging in both in and out of class. Environmental variables were those that the instructor or university had control over and included the text, lecture, sample problems and course format. Personal variables included both cognitive and affective variables related to learning in the course and included students' thoughts and feelings about the course material, requirements, the instructor, and learning activities. Using these broad categories as a guide to organize student responses, specific constraints and groups of variables affecting students' learning were identified. These themes and constraints were then used in conjunction with the other data to formulate proposed self-regulated learning interventions that

incorporate self-monitoring, promote active self-regulated learning, and include both teacher-centered and student-centered strategies and procedures. These are presented in the discussion section.

CHAPTER THREE

Results

Consultation with the instructor

Discussion with the instructor yielded insight into his instructional philosophy, perceived student variables, functional constraints, organization of the course, and the course's requirements. The emphasis in the class was on developing the ability to use statistics to analyze situations, make decisions, and be critical of statements regarding statistical word problems. A set of sample problems available, on reserve at the library, similar to exam questions, provided a litmus test for students as problems on the exam are no harder than problems included in the sample set. The course had two midterms and a cumulative final. The instructor noted that he usually conducted review sessions prior to the exams as long as there was student interest in attending. He was open for regular office hours or by appointment.

Exams tested students' ability to use statistical procedures to make decisions posed in word problems. The instructor focuses on real world problems, testing hypothesizes, and the application of increasingly complex statistical procedures. All sample problems, in-class examples and exam questions were developed by the instructor. Students were challenged to apply statistical tests to appropriate situations, compute statistics and make decisions based on their results. A lab section that met once a week was included to afford students the opportunity to use computer software (SAS) to apply statistics concepts with the aid of computers.

Class Visits

Observational visits to the class identified several instructional practices and functional constraints that any subsequent intervention would have to take into account. Observations were written down in a notebook and included (a) a focus on sample word problems, (b) the instructor's use of the text, (c) in-class problem solving, (d) the use of recurring examples, and (e) sources of assistance provided to students. Functional constraints included (a) a fast-paced, interactive lecture presentation that focused on using formulas to solve word problems, (b) lecture hall seating, (c) students taking a lot of notes, (d) students completing several example problems during the class time, and (e) students coming to review sessions with a fragile understanding of what they needed help with learning.

Several classes ran right up to the end of the allotted time and students found themselves struggling to write down notes while the next class was entering the room. The pace of class kept students busy throughout the entire allotted time. Students often found it challenging to write down the examples from the board, compute calculations, and still listen to the instructor's lecturing. Some students chose to sit alone so they could spread out their notes over 2 or 3 lecture hall folding desk tops while others towards the front tended to sit close together so they could look at others' notes and quietly ask each other questions during lecture. Several students were observed asking others what the instructor had just said, having missed it because they were writing down other notes or finishing calculations.

During class, students were presented with examples of problems and situations that could be addressed using statistical equations and formulas. The instructor would present the material and model the use of specific statistics and equations. Students would then be asked to solve a similar problem (usually the same problem with a

different data set) and a discussion would ensue. Most often students would need further explanations and guided help in reaching the correct answer. On several occasions students would request that the instructor repeat each example several times, and this would lead to long drawn out discussions covering several examples of the same type. This in turn compressed the time allotted for other material to be covered and led to rushing at the end of class. When it seemed that only a few students were still asking questions the instructor would request that those students needing further explanation make arrangements to see him after class or during office hours. He would then move on to the next concept if time permitted. The subsequent class would then start with a review of the last example covered in the previous lecture.

Sources of assistance other than the instructor were also noted and these were (a) the lab component, (b) review sessions, and (c) groups of students that regularly sit together. The instructor also informed the class that focusing on coming to class and working the sample problems would be a good strategy as they could make it through the class without relying heavily on the text. Students were encouraged to attend lab regularly and utilize the sample set of problems on reserve at the library

Class visits also served as an opportunity to confirm information gained through discussions with the instructor in private. Classroom observations confirmed the instructor's focus on the use of real-world examples, the use of the entire class time, sources and levels of assistance, and the minimal use of the text. Class time was dedicated to developing real world situations and examples as a venue in which statistics and statistical analysis could be used to answer a question or test a hypothesis. The instructor would pose questions throughout the class that called for students to make decisions about, (a) the application of equations, (b) the computation of equations, and

(c) the meaningfulness of statistical outcomes as they related to the hypothetical situation. Interactions between the instructor and students was substantial and dialog (series of questions and answers) between them occurred on every visit.

Prior to each of the midterms and the final, the instructor conducted review sessions. Most sessions went on for several hours and the instructor reviewed any material about which students could pose questions. On each occasion there were three or four students that asked the majority of the questions, although the rest of the class remained attentive. At a couple of points when several questions had been answered and the instructor solicited new questions, no one answered. Students, still wanting to review material, then posed blanket statements like, " Can we go over everything?" It seemed that students were aware that their understanding was incomplete or fragile but didn't know how or why.

Survey

The survey asked students questions about in-class and out-of-class behaviors as well as their motivation for learning statistics. The data were entered into an Excel spreadsheet and then analyzed using the SAS software package. The students were divided into 2 groups, successful and unsuccessful, on the basis of their final grades. There were 28 students in the successful group (A & B) and 10 in the unsuccessful group (D & F). The C students were not used in this analysis. Analysis of variance revealed a significant difference between "successful" and "unsuccessful" students (As & Bs vs. Ds & Fs) on their perceptions of the importance of out-of-class learning behaviors, Dependent Variable 3, $F(1,36) = 6.03$, $p = .0190$. Further individual analysis of variance procedures of the specific items comprising Dependent Variable 3 suggested that students' perceptions of how important it was to (a) read the text, $F(1, 36) = 5.59$, p

= .0236, (b) attend review sessions, F (1, 36) = 4.28, p =. 0457, and (c) study in a quiet place, F (1, 36) = 6.41, p = .0159, differentiated successful students from unsuccessful students.

Student Interviews

Interviews with thirty students yielded several variables, perceptions and constraints that students identified in the course. Guided by Zimmerman's (1989) social cognitive model of self-regulated academic performance, students' answers to interview questions were coded into groups of responses that reflected personal (thoughts and feelings), behavioral, and environmental variables affecting learning.

Personal variables

Students' interviews suggested several personal variables that affected their learning in the course. These included (a) a positive response to the instructor's lecturing style, enthusiasm, and availability for out-of-class help and review sessions, (b) a need for utilizing sample problems more effectively, (c) perceptions of the class as difficult, and (d)perceptions of the usefulness of the packet of sample problems at the library as a helpful component of the class in terms of learning. (Figure 4 presents examples of students' comments.)

Students reported several positive personal thoughts and feelings about the instructor and his instructional philosophy. This was reflected in statements like," He's really thorough. He knows his stuff.", and

> ...he is really, really helpful. I mean he stayed like, at the review session...four or five hours. I mean, obviously he wasn't gaining anything from it, so I thought that that says a lot for him. I mean wanting people to learn. And I was impressed

> by that. That he would, you know…and he was saying if you want to stay longer, I mean he really left it up to them or us, how much we wanted to do. So I think that that said a lot. That he wants people to learn… he tries to go and explain things for why it works. That helped me a lot.

Students also reported thoughts about using the sample problems more effectively. One student when asked what he would do differently if he had to take the class over again said,

> …I think I would just keep doing more problems and get more practice at doing them. Cause I was sort of getting the whole, you know the concept of what I was suppose to be doing, it's just that I needed more practice.

Another personal variable that was mentioned repeatedly was the perception of the class as challenging, hard, or difficult. Students said things like, "I just thought it was really, really hard. It was one of the hardest classes I ever took. Cause I'm not good in math. I did alright in the research methods but this was like way more worse.", and, "I think this is the hardest psychology class I've ever taken." Several students also stated the sample problems were the most helpful component in the class. When asked what helped them learn the most, one student interviewee responded, "What was most helpful was the sample problems that Dr. Randall provided."

Personal variables	Additional Example Quotations
Positive response to the instructor	I enjoy coming to Dr. Randall's class...he always seemed excited about teaching class. So I didn't ever feel like he had to be there, it seemed like he wanted to be there to teach and whenever I had questions or concerns he was available to answer. I thought that was a very good quality in a teacher.
Use of sample problems	I would probably, through out the semester, probably practice more of the problems, like frequently you know, maybe after lecture or something, instead of doing them closer to the test.
Perceptions of the class as difficult	Its been pretty difficult at times ... Yeah, it has been a difficult class.
Sample problems as helpful	I'd probably copy all of his notes from the library and study that more than I did the first time. Cause I didn't copy all of his answers and problems and I really bombed that first test.

Figure 4. Personal variables affecting learning as exemplified in specific quotations from student interviews.

Behavioral variables

Student interviews suggested several behavioral variables that affected students' learning of statistics. These included (a) studying the sample problems, (b) studying with others, (c) and attending lectures to take notes. (Figure 5 presents comments about behavioral variables.) Students reported studying the sample problems but needing to study them more:

> I found them (sample problems) helpful, but I found them to be more helpful after I took the exam, cause I saw the correlation between the two. And I thought ah, okay, if I had noticed that little word in the sample problems I think I would understand the test question better.

Several students also reported that studying with other students in the class was helpful and said things like,

> ...my friend and I if we have problems or if we don't understand then we'll call each other up and say well how do you do this. Like it's good for both of us cause if I know how then I can explain it to her and that helps me too and then she'll explain it to me.

Environmental Variables

Results from student interviews suggested several environmental variables that affected students learning in the class. These included difficulty keeping up with the lecture at times and perceiving the book as difficult or not helpful. Many students reported that environmental variables including the lecture component of the course affected their learning. Students said things like, "...well when I paid attention in lecture, that really helped a lot and then the sample problems really gave me a feel for what he was going to put on the exam. Another student suggested, "Maybe we could use a different book for this class, with the way Dr. Randall teaches and the way the book is, I didn't feel like it matched up very well. Student reports involving the lecture suggested

that the lecture is a crucial part of the class and in some cases students deemed it the most important, "The lectures helped a lot. That was the biggest thing in the class." However, students also reported that the fast pace of the class made it challenging to keep up, and people who missed classes found it hard to catch up.

Other helpful suggestions from the interviews involving environmental variables included (a) having a hand out with data (i.e. frequency distribution) already on it to save class time having to write every thing down, (b) having sample questions and answers on the Internet, and (c) having review sessions with more time before the exam.

Table of
Behavioral Variables Additional Example Quotations

Studying sample problems	When I was doing the sample questions, and routinely doing it, you know I can, I caught on and I can do everything. But then when the test comes…it kinda threw me off. I talked to some other people and they pretty much said the same thing. *For the final, I mostly reviewed the practice problems that he gave* in the library.
Studying with others	Um, I think studying in groups was the most helpful. Cause stuff you don't understand you can have people explain to you. It's a lot easier than going to the teacher. Usually I went to one of my classmates first. Then if we couldn't figure it out, then we'd go to Dr. Randall
Attending lecture/taking notes	…I have to admit that he gives us exercises to do in class and that really helps. …I only take notes in the lecture and I use that as a supplement to *the notes in the library. So I use the library notes first, then the* lecture notes is just figuring out what I did wrong.

Figure 5. Behavioral variables affecting students' learning of statistics.

CHAPTER FOUR

Discussion

Results from the survey suggest that what students do when they leave class significantly affects their grade in this course. Students who read the text, attended review sessions, and studied in a quiet place tended to do significantly better in the course. Students' under-utilization of the sample problems was also of concern because they are very similar to exam questions and are helpful for students in many ways. Utilized regularly, sample problems can serve as an opportunity to increase exam performance and refine strategies if students make active attempts to solve similar problems and optimize learning.

These results coupled with observations of the instructor's fast paced lecture style that focused on sample problems suggested several possible additions and changes. These include developing students' performance capacity by having them (a) establish target times as goals for solving different types of problems, (b) engage in self-monitoring of learning and goals, and (c) shaping performance within a time line to increase exam performance. This student-centered approach would be supported by including a teacher-centered procedure that strategically reinforces students' attempts to self-regulate their learning.

Tharp and Gallamore's assisted performance model of teaching (1988) theorizes that the development of performance capacity is a four-stage progression in which learning and performance are initially supported by external sources of influence (see Figure 2). This includes modeling and guided performance. As performance capacity builds and becomes more and more automatic assistance becomes internalized and less

external assistance is required for a given level of performance within a given context. In this progression performance develops to become self-regulated.

A student-centered performance-based intervention could accomplish several things important to the development of self-regulation of academic learning and performance. It would facilitate students setting proximal goals and engage them in developing ways of achieving those goals. This can be supported by the teacher's efforts to provide learning experiences and scaffold the development of self-regulation. External support for self-monitoring would decrease as the process challenges students to take charge of their learning and performance. It is important to note that some students will need more support than others and for a longer period of time. The instructor should emphasize the situational nature of performance capacity and regulation and encourage students to progress at their own rate.

The proposed teacher-centered procedures were designed to fit into the instructor's current program, interface with existing class constraints, and capitalize on students' current learning activities. This is accomplished by including strategies for increasing self-monitoring of problem solving and exam performance, scaffolding the development of self-monitoring and strategy use, predicting test questions, and setting goals. These strategies were developed so that they (a) are in line with the course format, (b) could be transformed into instructional strategies that the instructor can actually implement with minimal changes, and (c) are relevant to students existing learning skills and behaviors. Research has also suggested that self-regulation emerges from essentially two sources, social experiences and self-directed activities (Schunk and Zimmerman, 1998, p.10). In regards to increasing the self-regulation of exam performance this

implies that changes be made so that students have social experiences and self-directed activities that involve the sample problems and structured practice.

Proposed Teacher-Centered Procedures

Step 1. *Introduce sample problems as a litmus test for students' development of statistical problem solving ability.*

The first step is formalizing the use of sample problems to coincide with survey and interview findings that out-of-class learning behaviors help students succeed. This involves presenting the sample problems as a crucial component of the course and something of value. This may mean incorporating it as a part of the class for which students receive credit.

Step 2. *During the lecture students are sometimes asked to solve example word problems from the board. When this occurs, add a focus on efficiency. Time students so they can establish a baseline of their problem solving performance. Remind them that as their understanding of the concepts increases and they become more proficient at making calculations, solution times will decrease. Do this routinely and set target times for them.* Having a baseline for reference allows students to see progress and feel good about it.

Tharp and Gallimore's model of teaching lays out a progression of activities to develop performance capacity. It starts with external, teacher supported self-monitoring and goal setting. Goals should be specific and could include how long it takes to solve problems, and how many problems to solve each day/week.

Step 3. *Set up students with peer partners with whom they can engage in timed*

problem solving of the sample set from the library. Have students meet with partners weekly to go over new problems, record times, and set goals appropriate for shaping performance for the exam.

Teacher support then would be supplemented with peer support as the scaffolding of problem solving performance progresses towards becoming more internalized. Students would meet with partners or small groups of at most 3-4 students. Social pressure may need to be managed by aligning certain students to make them feel comfortable.

Step 4. *Have students predict exam questions by formulating their own questions, which they will use to test and time their partners. Be sure to encourage feedback and record keeping (collect it). Have students develop a list of problem types and record both their best and average times for solving different types problems.*

The instructor now requires students to predict exam questions with solutions. Students give each other mini quizzes using their own questions, time each other, and give feedback on other students' answers. The instructor should make sure that students are aware that solving word problems is a process at which they can improve. As they learn about increasingly complicated statistical methods the time required to solve appropriate word problems will increase. By giving them an increased number of opportunities to practice and improve they will see solution times shorten.

Step 5. *Have students calculate averages for their solution times on an ongoing basis.* This should include a mean, median and a mode for different types of problems. At this point the regulation of problem-solving ability will be increasingly internalized and self-regulated. Goals for performance capacity should be self-initiated and students practice problem solving in exam-like conditions. Less help is required from the

instructor and students are asked to calculate their average times for solving different types of problems.

Step 6. *During review sessions challenge students to complete sample problems and exchange their predicted questions. Include round-robin problem solving and a venue to raise specific questions.*

Sample questions and student generated questions would then be solved without support from teachers or peers and students would be responsible for their own self-monitoring. The focus here is preparing for exam situations and internalizing self-monitoring.

Step 7. *Provide a clock that is visible during exams for students to keep track of their progress in exam situations.* At this point very little external support should be needed by students. Students should be encouraged to transfer their learning skills to other aspects of their learning and other classes. Making sure a working clock is visible during exams ensures that students are capable of self-monitoring their performance if they need to do so. Some students may not need to do so, however. At this point the regulation of problem-solving ability will be increasingly internalized and self-regulated.

Proposed Student-Centered Procedures

Utilizing Tharp and Gallamore's assisted performance model of teaching and focusing on the development and promotion of self regulated learning, an effective match between instructional strategies, classroom constraints and the course-specific variables can be reached. A student-centered procedure that coincides with the instructional strategy previously outlined integrates students' development of self-monitoring with existing student variables and learning behaviors. The student-centered procedure lays out specific behaviors that students must engage in on a regular basis. These activities

challenge students to optimize their learning of statistics by focusing them on the sample problems and active learning. Development of performance capacity is facilitated by self-monitoring, peer review and practice. The following steps are described as instructions to the students.

Step 1. *Go to the library and pick up the sample set of word problems.*

Students start by attaining sample problems and becoming familiar with them.

Step 2. *When you sit down to work on problems, keep a watch or clock handy and record how long it takes you to solve individual word problems.* Students then start self-monitoring and practice using sample problems. Students should record self-monitoring data on a regular sheet and focus on consistency.

Step 3. *Find a partner with whom you can meet regularly (at least once a week) and record how long it takes to do individual problems from the sample set. Check your partners work to make sure they got the right answer. Challenge each other to become more proficient and discuss the factors affecting your progress. Be sure to record your times on the log sheet and try all the different types of problems.*

Here students engage in problem solving in a social setting and gain experience through observing and helping a partner. Students scaffold each other's self-monitoring and self-reflection on a regular weekly basis by providing sample problems and feed back. Students are responsible for correcting their partner's answers and justifying their predicted questions. This forces them to be increasingly analytical about statistics and engage in self-reflective practice.

Step 4. *Establish your average time for different types of problems and set goals that will allow you to be successful on the exam. Do this weekly.*

As students become more efficient at solving problems, they are required to calculate the average time required for them to solve selected problems. These goals should be realistic, attainable, and include a small stepwise progression of decreasing time limits that approaches a desired level of proficiency. Setting these types of goals gives students experience with success. Record keeping shows gains in efficiency and ability.

Step 5. *Develop your own sample problems and use them with your partner. Be sure to discuss what type of problem it is and the difficulty level with your partner after he/she has completed it.*

Predicting test questions helps students to be self-reflective and to see what they need to know for the exam. This also personalizes students' use of sample problems and requires them to engage in a self-directed activity that requires knowledge that will be tested on the exam.

Step 6. *Identify target times for different types of problems and practice until you reach your goal.*

The emphasis here is shaping performance and allowing opportunities for students to become increasing meta-cognitive and self-reflective about their ability to solve different types of word problems. Many students who do poorly on the exams are over-confident about their ability to solve statistics word problems. Setting goals to achieve prior to the exam, and practicing gives students a reasonable chance of developing the sophisticated level of understanding required to succeed in the class.

Step 7. *Be sure to plan and monitor your performance on the day of the exam. Do you have a watch? Is there a clock in the classroom? Are you familiar with the type of problems presented?*

Incorporating self-monitoring with regards to solving the word problems allows students the opportunity to engage in the learning process meta-cognitively, that is, focus on the process of learning reflectively, set appropriate proximal goals, and practice based on feed back. Aligning this strategy with Tharp and Gallimore's model, students first engage in timing how long it takes to solve problems with the help of the instructor to identify their current level of performance capacity. This is done in class as the instructor poses example problems in the context of lecture. Students are then required to engage in timing a partner's ability to solve sample problems from the reserve set. This establishes a social setting through which self-regulation and self-directed activity begins. Subsequently students progress to monitoring their own performance at solving sample problems. This is analogous to entering stage 2 of Tharp and Gallimore's progression of performance capacity and facilitates students' development as self-regulated learners. In this progression, self-regulatory aspects of self-monitoring become fossilized and habitual with continued practice. In alliance with the feedback from the surveys it is suggested that these types of activities occur regularly, in a quiet place, and at the review sessions.

To a certain extent, the development of desired behaviors can be facilitated by simply requiring the activity. Additionally, long-term development should be scaffolded with attempts by the instructor to increase students' motivation to attain their goals (target times) and the construction of specific learning environments/activities that necessitate self-regulation and self-monitoring (out-of-class peer meetings). Engaging students in explicit self-regulating strategies could compensate for students' fears and anxiety, and allow opportunities for students to be meta-cognitive and self-reflective. Refining the course's format in this way involves manipulating the learning environment.

This would construct opportunities for students to improve their statistics learning and their learning skills by undergoing a period of increasingly active, self-regulated learning (Watson, 2001).

The incorporation of these strategies and procedures could be tested over the course of several semesters. This would start with translating some of the procedures into components of the syllabus and having the instructor practice presenting and managing them in a classroom setting. Given the current baseline, over the course of 3 semesters an ABA design could be used to test the effectiveness. The experimental condition A would be comprised of the addition of the proposed student-centered and teacher-centered strategies to the course. This would add an explicit active learning component to the course that could be removed during the control portion of the ABBA design. The addition of the active learning component would include a training phase for the instructor so that he would feel confident in applying the strategies. During this phase the instructor would practice aligning the two strategies so that they could be implemented into the current program seamlessly. Subsequently the instructor would run the course with the addition of the active learning component as the experimental treatment. If significant positive changes in student variables including grades were identified, long-term incorporation of these strategies and procedures would be justified.

References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1988). Self-regulation of motivation and action through goal systems. In V. Hamilton, G. H. Bower, & N.H. Frijda (Eds.), *Cognitive perspectives on emotion and motivation* (pp. 37-61). Dordrecht, The Netherlands: Kluwer.

Britton, B.K., & Tesser, A. (1991). Effects of time management practices on college grades. *Journal of Educational Psychology*, 83, 405-410.

Delclos, V. R., & Harrington, C. (1991). Effects of strategy monitoring and proactive instruction on children's problem-solving performance. *Journal of Educational Psychology*, 83, 35-42.

DiGangi, S. A., Maag, J. W., & Rutherford, R. B. (1991). Self-graphing of on-task behavior: Enhancing the reactive effects of self-monitoring on on-task behavior and academic performance. *Learning Disability Quarterly*, 14, 221-230.

Education week. *Law Mandates Scientific Base for Research*. Retrieved on June 10, 2001, from http://www.edweek.com/ew/newstory.cfm?slug=20whatworks.h21

Flippo R., & Caverly D. (2000). *Handbook of College Reading and Study Strategy Research*. Mahwah, NJ: Erlbaum

Garcia, G.E. (1994). Assessing the literacy development of second-language students: a focus on authentic assessment. In K. Spangenberg-Urbschat & R. Pritchard (Eds.). *Kids come in all languages: Reading instruction for ESL students* (pp. 180-206). Newark, DE: International Reading Association.

Ghatala, E. S., Levin, J. R., Foorman, B. R., & Pressley, M. (1989). Improving children's regulation of their reading PREP time. *Contemporary Educational Psychology*, 14, 49-66.

Hattie, J., Biggs, J., & Purdie, N. (1996). Effects of learning skills interventions on student learning: a meta-analysis. *Review of Educational Research*, 66 (2), 99-136.

Hofer, B.K., Yu, S.L., & Pintrich, P.R. (1998). Teaching college students to be self-regulated learners. In D.H. Schunk & B.J. Zimmerman (Eds.) *Self-regulated learning* (pp. 57-85). New York: Guilford Press.

Johnson, D. W., Johnson, R. T., Stanne, M. B. (2000). *Cooperative learning methods: A meta analysis.* Retrived on May 22, 2001, from http://www.clcrc.com/pages/cl-methods.html

Lan, W. Y. (1996). The effects of self monitoring on students' course performance, use of learning strategies, attitude, self-judgment ability, and knowledge representation. *Journal of Experimental Education*, 64, 101-115.

Maag, J. W., Rutherford, R. B., & DiGangi, S. A. (1992). Effects of self-monitoring and contingent reinforcement on on-task behavior and academic productivity of learninmg disabled students: A social validation study. *Psychology in the Schools*, 29, 157-172.

Malone, L. D., & Mastropieri, M. A. (1992). Reading comprehension instruction: Summarization and self-monitoring training for students with learning disabilities. *Exceptional Children*, 58, 270-279.

McCombs, B.L. (1994). Processes and skills underlying continuing intrinsic motivation. *Educational Psychologist*, 19 (4) pp. 199-218.

McKeachie, W.J., Pintrich, P.R. & Lin Y.G. (1985). Teaching learning strategies. *Educational Psychologist*, 20, 153-160.

Pintrich, P.R., McKeachie, W.J., & Lin, Y.G. (1987). Teaching a course in learning to learn. *Teaching of Psychology*, 14, 81-86.

Pintrich, P. R., & Garcia, T. (1991). Student goal orientation and self-regulation in the college classroom. In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement: Goals and self-regulatory processes* (Vol. 7, pp. 371-402). Greenwich, CT: JAI Press.

Presssley, M., Borkowski, J., & Schneider, W. (1987). Cognitive strategies: Good strategy users coordinate metacognition and knowledge. In R. Vasta & G. Whitehurst (Eds.), *Annals of Child Development* (Vol. 5, pp. 89-129). Greenwich, CT: JAI Press.

Presssley, M., Borkowski, J., & Schneider, W. (1989). Good information processing: What it is and what education can do to promote it. *International Journal of Educational Research*, 13, 857-867

Pressley, M., & Ghatala, E. S. (1990). Self-regulated learning: Monitoring learning from text. *Educational Psychologist*, 25, 19-33.

Schunk, D. H. (1983). Progress of self-monitoring Effects of children's self-efficacy and achievement. *Journal of Experimental Education*, 51, 89-93.

Schunk, D. H. (1996). Goal and self-evaluative influences during children's cognitive skill learning. *American Educational Research Journal*, 33, 359-382.

Schunk, D. H. & Zimmerman, B. J. (1994a). Self-Regulation in education: Retrospect and prospect. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of Learning and Performance: Issues and Educational Applications* (pp. 305-314). Hillsdale, NJ: Erlbaum

Schunk, D. H. & Zimmerman, B. J. (1994b). *Self-regulation of Learning and Performance: Issues and Educational Applications* (pp. 305-314). Hillsdale, NJ: Erlbaum

Schunk, D. H. & Zimmerman, B. J. (1998). (Eds.) *Self-Regulated Learning: From Teaching to self-reflective practice*. New York: Guilford Press.

Tharp, R.G., & Gallimore, R. (Eds.)(1988). *Rousing Minds to Life*. Cambridge, England: Cambridge University Press (pp. 27-67).

Watson, D. L. (Eds.) (2001). *Learning Skills for College and Life*. Wadsworth Group: Thomson Learning Inc.

Weinstein, C. E. (1998). Presidential address. *Newsletter for Educational Psychologists*, 22. Washington, DC: American Psychological Association.

Weinstein, C. E. (1994a). Strategic learning/strategic teaching: Flip sides of a coin. In P. R. Pintrich, D.R. Brown, & C.E. Weinstein (Eds.), *Student Motivation, Cognition, and Learning* (pp. 257-273). Hillsdale, NJ: Erlbaum.

Weinstein, C. E. (1994b). Student at risk for academic failure: Learning to learn classes. In K. W. Prichard & R. M. Sawyer (Eds.), *Handbook of College Teaching: Theory and Applications* (pp. 375-385). Westport, CT: Greenwood Press

Zimmerman, B.J. (1989a). A Social-Cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, 81, 329-339.

Zimmerman, B.J. (1989b).Models of self regulated learning and academic achievement: The emergence of a social cognitive perspective. *Educational Psychology Review.*

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

Zimmerman B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. In p. Pintrich (Ed.) *New Directions in college teaching and learning: Understanding Self-Regulated Learning* (No. 63, Fall, pp.13-27). Jossey-Bass.

Zimmerman, B.J. & Martinez-Pons, M. (1988). Construct validation of a strategy model of student self-regulated learning. *Journal of Educational Psychology*, 80, 284-290.

Zimmerman, B.J. & Martinez-Pons, M. (1990). Student differences in self regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, 82, 51-59.

Zimmerman, B.J., Greenberg, D., & Weinstein, C. (1994). Self-Regulating academic study time: A strategy approach. In D. Schunk & B. Zimmerman (Eds.) *Self-Regulation of Learning and Performance*. Hillsdale, NJ: Erlbaum.

Appendix A

Academic Routines Interview Questions

Follow up questions are in italics.

1.Tell me about your statistics class.

2.Tell me about the difficult aspects of this class.

3. What do you do when you encounter a problem you can't solve?-*Does that help?*

4. How do you prepare for the final ?—*what else*?

5.When you need help what do you do?—*How does that help?*

6. Which mid-term was more difficult for you*? Tell me about it.*

7. What helped you learn the most? *Tell me about it.*

8. What do you do when you don't understand an example? *Why?*

9. Knowing what you know now , if you had to take the class over what would you do differently. *Why?*

10. Which mid-term would you say was harder? *Why?*

11. What is your objective or goal in this class? *Why?*

12. What would have made the class better for you? *How?*

13. If your friend was taking the class next semester, what would you tell them?

14. Tell me about the final. *How much time did you spend on the final?*

15. Have you taken any classes similar to this one?

16. Tell me about your studying. *Where does most of your studying take place?*