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Promoting Active Studying: The Study Challenge

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Synopsis

We explore using a "Study Challenge" to help students become active studiers in mathematics courses. We describe how a Study Challenge works and how we implemented it in calculus and differential equations courses. We discuss qualitative reactions from students who accepted the Study Challenge, which suggest that this might be a useful tool for students to add to their exam preparation toolbox. Finally, we offer some suggestions for implementing a Study Challenge within the mathematics classroom.

1. Introduction

The purpose of this article is to serve as a preliminary exploration of active studying and a concurrent attempt to remove some of the negative feelings associated with the word "study." In the following we will demonstrate the potential of active study habits through student responses to the effectiveness of the Study Challenge. Additionally, we hope this paper will inspire other educators and provide them helpful suggestions for promoting active studying within their classrooms.

Overheard in the Math Lounge:

Prof α**:** *Hi Prof* β*, how's everything? You look a little worried.*

Prof β**:** *Oh, I'm trying to think of a way to help my students with the upcoming exams… Any ideas?*

Prof X: *You gotta get them really scared, and then they'll study for sure…*

Prof α**:** *Well maybe, but why don't you try what I did: tell them NOT to study.*

Profs B and C: *WHAT?*

Prof α**:** *Yes, I gave them the Study Challenge! Here's how it works: I said to them… You're nervous; it's almost time for your first midterm examination in calculus, and you're not sure if you're ready. What do you do? Do you tell all of your friends how much you need to study and then you hole up in the library to diligently go through your notes and review past homework? You would, but there's just one wrinkle. I am extending a challenge to the class: in the lead up to the examination, don't say the word "study!" Instead, focus on concrete tasks that you can do to get ready. So you recalibrate your plans and aim to crank through your derivatives tonight and then work through several problems dealing with critical points tomorrow night to be sure you're on top of things…*

Prof β**:** *This is starting to sound more interesting! So tell me more, how did you implement it?*

Prof α**:** *I gave the Study Challenge to three classes…*

In the spring of 2008, Professor α, aka Christopher Storm, instituted a Study Challenge to his Calculus II and Ordinary Differential Equations classes in order to help his students to become more active studiers. Storm continued to use the Study Challenge in future courses; in this article we will refer to a Calculus I course he taught in the Fall of 2008.

In each course, before the first midterm examination, Storm discussed the difference between more passive forms of studying, such as reading notes, and more active forms of studying, such as solving problems that focus on a particular issue in the course. After this brief discussion, he issued the challenge. The Study Challenge is very simple. Students who accept the challenge are forbidden to say the word "study" in the lead-up to an exam.

For instance, instead of telling a friend she is going to study, a student might say "I have to go work 10 chain rule problems to get ready for my calculus exam."

A sample Study Challenge handout introducing the challenge is included in Appendix A. Readers will see on the handout a long list of other things that students might say instead of the word "study." The handout aims to serve as a concrete study guide that will lead to active studying. It directs students to solve problems on topics that could be on the exam. All of the sentences are in active voice, and the handout overall stresses to the students that the real purpose of the challenge is to study in an active way as opposed to a passive way.

Before we move forward, we should put in a word on our institutional context. All of the courses that we discuss took place at Adelphi University. Adelphi enrolls approximately 5,100 undergraduate students. There is not a graduate program in mathematics at the University. Adelphi is a commuter campus with over half of the students living away from campus. The undergraduate mathematics major enrolls between 20 and 30 undergraduates each year. There are more women than men completing the mathematics degree. The vast majority of the majors are planning a future career as mathematics teachers. Since many of the students are commuters and are subject to many time pressures, we feel it is particularly important that they develop effective skills at studying. The Study Challenge arose as a means to address this concern.

The idea of the Study Challenge has appeared, without the qualitative discussion we provide here, in the *Teaching Time Savers* column of *FOCUS*, the newsletter of the Mathematical Association of America [15].

Prof X: *Whose cockamamie idea was that?*

Prof α: *Well, let me give you some background.*

2. Background

In 1989, in a report titled *Everybody Counts*, The National Research Council listed seven key transition points which would dominate subsequent research within mathematics education [14]. We see Transition 2 as a pivotal point, which is at the heart of current research in student-centered learning:

> **Transition 2:** *The teaching of mathematics is shifting from an authoritarian model based on "transmission of knowledge" to a student-centered practice featuring "stimulation of learning."*
>
> *In both schools and colleges, classrooms of passive students who are expected to sit and absorb rules which appear as arbitrary dicta on high are gradually giving way to learning environments that:*
>
> - *Encourage students to explore;*
> - *Help students verbalize their mathematical ideas;*
> - *Show students that many mathematical questions have more than one right answer;*
> - *Provide evidence that mathematics is alive and exciting;*
> - *Teach students through experience the importance of careful reasoning and disciplined understanding;*
> - *Build confidence in all students that they can learn mathematics.*

The National Research Council also pointed out explicitly that memorization and doing rote exercises are not sufficient to facilitate deep learning of mathematics [14]. One key that may lead to deep learning, as Pólya also asserts in [13], is through active mathematical problem solving.

Charbonneau *et al.*, in their article titled "Developing Habits of Mind' in a Mathematics Program" [4], define the inherent habits of the human mind to be: creativity, work ethic, thinking interdependently, critical thinking, lifelong learning, and curiosity. Instructors must encourage effective study techniques that build off of these inborn traits. Pólya shows that creativity, critical thinking, and curiosity is built through the act of problem solving [13]. One problem solving technique, which is woven within the Study Challenge, is "problem posing." According to Brown and Walter:

> Since we cannot begin without choosing a starting point, perhaps we should dignify this step by calling it Level 0 of our strategy. Our next set (Level I) was to list some attributes. We then asked, "what if each attribute were not so; what could it be then?" (Level II). We then used these new alternatives as a basis for asking new questions (Level III). Then we selected some of our new questions and tried to analyze or answer them [3, page 64].

Within a student-centered environment, students are constantly developing new questions. True studying occurs when students can ask, and answer, "Pólya-type" questions.

Many papers have been written regarding the implementation of student-centered learning. We especially point out [7, 10, 12, 16], all listed in the references, as work that influenced our approach to the topic.

Prof X: *Oh, um, okay, I see. It does have some foundation of sorts... Now I am getting kind of curious. So you had an interesting experiment in mind. Was it hard to implement?*

Prof α: *Oh, let me tell you about that.*

Prof X: *Please do!*

3. Methods

In this section, we address the composition of the classes studied, the materials that we used to collect our qualitative information, and the procedures we used throughout our exploratory examination of the Study Challenge.

3.1. The Courses

Calculus II at Adelphi is offered in both the fall and spring semesters. The course begins with anti-derivatives, proceeds through definite integrals and integration techniques (integration by substitution, by parts, and by partial fractions), includes some applications to area and volume problems, and concludes with a treatment of sequences and series (through power series).

Classes met twice a week for one hour and forty minutes. There were two midterm examinations and a final examination. Homework was assigned nightly and completed online.

Storm typically lectured in the course, while making frequent use of "clickers" (in-class response systems) for classroom voting. Clicker questions were designed to challenge the students and identify misconceptions that could then be addressed via class discussion and by the instructor as necessary.

Adelphi's differential equations course is a first course in ordinary differential equations. Up until Spring of 2008, it had been offered in the Fall and Spring semesters and was a requirement for the major. Beginning in the Spring of 2008, it became an elective for the major, though that did not seem to significantly change enrollment. Storm taught the course from a dynamical systems viewpoint, beginning with first-order differential equations and progressing to systems of differential equations. Topics further along in the semester included forced harmonic oscillators, linearization, and Laplace transforms.

Classes met twice a week for one hour and fifteen minutes. There were two midterm examinations, a final examination, and three substantive writing assignments in addition to nightly homework assignments.

Storm made regular use of clickers in this course as well. Unlike in the calculus course, the questions in this course tended to be conceptual in nature and came before the topic was introduced.

Finally, the Calculus I course in Fall 2008 met three days a week for seventy minutes. The course was similar in structure to the Calculus II course described above.

3.2. Participants

In Spring 2008, forty students enrolled in Calculus II and all completed it. Among them, nineteen had declared a mathematics major, seven had declared a physics major, six had majors in other science disciplines, and the rest were undecided or in business related majors.

Twenty-six students enrolled in the differential equations course; twenty completed it. Of those twenty, thirteen were majoring in mathematics, six were majoring in physics, and one was majoring in computer science.

The Calculus I course enrolled thirty-two students, of which fifteen were declared mathematics majors, eight were declared science majors, five were declared computer science majors, and two had not declared a major.

Table 1 below lists the size of each class and how many students accepted the Study Challenge on each exam.

	Class size	Midterm I #	Midterm II #	Final #
Calculus I	33	23	27	26
Calculus II	40	26	26	22
Diff. Equations	21	13	15	16

Table 1: Enrollment and acceptance rates for the Study Challenge.

3.3. Materials

We collected our data in a very simple manner. At the end of each examination, the students were asked the following question for one extra credit point:

"Did you accept the Storm Study Challenge?
Any honest answer will earn the credit."

In addition, on the final day of class, students were asked to voluntarily complete a survey with questions about how they studied for examinations in the course. The full survey can be found in Appendix B.

3.4. Procedures

Students were told about the study and that their participation was entirely voluntary.

We collected our data in the simplest manner possible. While grading the examinations, the instructor recorded the response to the extra credit question regarding the Study Challenge. However there were some nuances.

In some cases, students left comments about how they did or did not accept the challenge. Some students who indicated that they had accepted the challenge left comments that indicated that they had missed the deeper point and studied in a very passive manner. These responses were marked as a yes with an asterisk so that we could examine their responses separately.

Our major source for the qualitative discussion which follows came from an anonymous survey that the instructor gave out on the last day of classes, which is included in Appendix B.

Prof β: *Wow, that sounds neat! So how did it work out?*

Prof X: *Yeah, did they all get As?*

Prof α: *Well no, actually there wasn't much of a difference in the exam scores of those who took the Study Challenge and those who didn't but. . .*

Prof X: *HAH! I told you it was a cockamamie idea! Fear, that's what you need!*

Prof α: *Well, true, there really wasn't a big difference in the grade distribution, but the qualitative measures and student comments were really positive.*

4. Qualitative Discussion

Based upon the student responses to the anonymous survey at the end of the three courses, we were able to study student attitudes towards the Study Challenge. Here we share some of our observations.

Using the Post-Course Survey, we initially broke the students into groups based upon their survey responses. Students who did not take the Challenge or who took it for only one test ($n = 21$) differed significantly from those who took it more than once ($n = 56$) with respect to Question 2 ("*When studying for exams in this course, did you find that you worked more problems than usual, the same number of problems as usual, or fewer problems than usual as part of your study routine?*"). The first group reported working fewer problems ($t = -2.63$, $df = 52$, $p < 0.01$) as part of their exam preparations than the second group. There were no other statistically significant differences between the groups, although trends were in the direction reported below.

However, when analyzing students' overall responses to the survey questions, we found that students who worked more problems while preparing for an examination also felt that they used their time more effectively (Question 4: "*Do you feel that you used your study time in this course more effectively, as effectively, or less effectively than in previous courses?*") ($r^2 = +0.43$, $p < 0.01$). When estimating how much time students in this group spent doing various activities (Question 3), these students indicated that they spent significantly less time reading class notes and reviewing classroom voting questions ($r^2 = -0.35$, $p < 0.01$). They also indicated that they spent more time solving new problems ($r^2 = +0.23$, $p < 0.05$).

Finally, 37% of all of the students who filled out the survey reported that they had changed the way they studied for other courses. Those who reported this also reported that they spent more time reworking problems from class and from homework as part of their examination preparation strategy ($r^2 = +0.032$, $p < 0.01$), which provides some measure of verification for these students' claim of changing their study habits in other courses.

Through student responses to the extra credit question at the end of each examination, we also have information linking student performance to whether or not they accepted the study challenge. We did not pursue statistical analysis of this data set, as we are leery of trying to make claims based upon examination scores with such relatively small sample sizes.

Prof β: *So why do you think you had the positive outcomes that you did?*
Prof α: *I'm not sure... but look, there's Psych Prof Sue, let's go ask her!*
Prof X: *What's she doing in the Math Lounge?*
PsychProf Sue: *Well...*

Let's look at the Challenge from the standpoint of learning principles derived from the field of cognitive psychology. From this perspective, our observations are somewhat surprising. In many ways, the initial instruction given to initiate the challenge "Don't say the word *study*!" resembles a technique known as *thought suppression* [1]. Thought suppression is known to frequently have paradoxical effects; the "Don't think of..." mental command frequently leads to an increase, rather than a decrease, in thoughts of the type prohibited by the command, as in the classic White Bear' studies conducted by Wegner [17]. Lewis Carroll, writing in 1893 in *Curiosa Mathematica* (as cited by [17]) said:

> Again and again I have said to myself, on lying down at night, after a day embittered by some vexatious matter, I will not think of it any more!... It can do no good whatever to go through it again. I will think of something else!' And in another 10 minutes I have found myself, once more, in the very thick of the miserable business, and torturing myself, to no purpose, with all the old troubles.

Given this history, one may expect the same paradoxical results to have occurred in the current study. Indeed, some of the students' comments did seem to suggest this, as illustrated by one student who said "It is very hard not to say study especially during finals week. So I really didn't accept the challenge." Moreover, it is possible that the lack of significant difference in grades between the two groups of students is due to the group of students who did not accept the challenge subconsciously following some of the Challenge guidelines, prompted by the same thought suppression and power of suggestion (cf. [11]) mechanisms that may have influenced the students who did accept the Challenge, thereby reducing differences between the groups. That is, the Challenge may have acted with both groups as a subconscious reminder to study more!

Some literature (most notably [1]) suggests that the paradoxical results associated with thought suppression are the result of increased anxiety produced by trying to suppress thoughts. With this in mind, it is somewhat less surprising that many (in fact most!) of the students seemed to associate the Challenge with positive emotions. It is likely that this is due to a major feature of the Challenge: the inclusion of alternative activities. This inclusion could and probably did reduce rather than increase anxiety. The alternative activities had several important characteristics. First, they were concrete: "Do 20 partial fraction problems." As a result, students did not have the added anxiety-producing responsibility of determining what specifically to study, how to study it, or how many problems to work as part of studying for it. Ideally, in the future, such decisions/criteria will be based on a student's internalized ability to know what one knows, but the Challenge's alternative activities are a good first step, especially in lower level classes.

Second, to a large extent the alternative activities encouraged and promoted active learning. Active, self-initiated involvement in the learning process is known to be necessary for all forms of successful learning perceptual [6], motor [8], and higher-order abstract learning [discovery learning] [9, 2]. Indeed, stimulating active studying was the primary goal of the Study Challenge.

Finally, the alternative activities included explicit encouragement of cooperative learning. In many situations, students studying as part of a group achieve greater learning because the additional social component of being in a group is motivational [5] and conscientious students may assume greater responsibility in the learning process. In addition, students who are preparing to be mathematics teachers (the vast majority of majors at Adelphi University) had the opportunity to practice teaching' in this group setting. We hope that future research will more formally encourage cooperative learning as part of the Challenge.

Prof α**:** *So in summary...*

The Post-Course Surveys highlighted several positive aspects of the Study Challenge. Students liked the Study Challenge; they began to study earlier than they might have otherwise (even those who didn't accept the challenge); they used the challenge to better organize their studying; and they found that accepting the challenge repeatedly helped to eliminate some of the stress that comes with studying for an examination.

Students really seemed to like the Study Challenge! In response to the question on the exam asking if he/she accepted the challenge, one student gave the simple reply: "Yes (thanks God I did.)" A different student gave a more detailed response: "Yes, I accepted and completed most of the points and it was definitely better than studying without a plan. You should keep on suggesting it, it undoubtedly benefits the students who decide to follow it." Surprisingly, no student gave a negative comment. Finally, we cannot help but point out that the challenge provided students an opportunity to gleefully discuss mathematics with their friends and family. For instance, once student wrote "while I was in the hospital, before I had surgery and explained to my mom what a derivative was. Therefore I remembered it. She on the other hand looked at me like I had 2 heads."

Students also seemed to begin to study earlier. It is well known that immediate learning and long-term retention are both enhanced by studying throughout the semester rather than 'cramming' right before the exam [9]. Even students who did not accept the challenge were able to use the corresponding handout as a study guide and realized how much material they had to master. One student in this category wrote "No, we studied as a group at my house. We went over the review sheet and explained to each other how to get the solutions. We all feel that examples help us study. We studied as a group on Tuesday and Wednesday for numerous hours." One student who did accept the challenge noted: "Yes, I decided it was best to take off work and avoid hanging out so I can recall everything from the semester for the test today. I think it really helped." Storm noticed this phenomenon repeatedly in discussions with students after examinations.

In the handout that came with the Study Challenge, students had a means of organizing their studying, and many took advantage of the challenge to provide a framework for organizing their preparations. One student noted this directly: "Yes, it helped me effectively organize my study schedule." Another student was able to use the challenge to give herself what looks like an effective study schedule: "I tried to do different topics every night, this way I reviewed everything." These comments indicate that students were able to take the challenge and use it to reduce the (sometimes overwhelming) process of studying for an examination into the more manageable process of mastering specific topics in the curriculum. This was certainly on the mind of one student who commented, "I tried my best but in the end of studying, I just started studying everything, instead of specific things."

One final, unexpected benefit manifested itself in the comments of students who accepted the challenge for several examinations in a row. This benefit is most clearly highlighted by a student who wrote "I found out that after the two midterms and the gateway derivative test that by not actually saying I need to study rather than I need to practice problems and get ready for my exam that it was much easier to work and less stressful too." We leave the words of the student to speak for them.

Not every student who was interested in the Study Challenge was able to complete it. In some instances, students accepted the Challenge but had trouble completing it. In part, this is a natural consequence of being at a university and surrounded by talk of studying. One student summarized the problem this way: "It is very hard not to say study especially during finals week. So I really didn't accept the challenge." Even though this student was unable to accept the surface challenge of avoiding saying the word "study," it's less clear whether or not this student engaged with the true purpose of the challenge, pursuing more active study methods.

5. Recommendations

Recent psychology research points to the underestimated importance of early and distributed (as opposed to late and massed) practicing of problem solving, and implies that it may be critical to learning mathematics deeply. Future research can and will hopefully entail collecting longitudinal data on the effects of this study technique. It is still to be determined which of the suggested strategies and activities are most effective. One way to approach a broader study might include tracking incoming freshmen and the influence of such study habits until the end of their senior year. Indeed, mathematics is largely a vertical' field of knowledge when taught in the undergraduate curriculum, where new knowledge builds directly on old, so the long term implications of students' making use of the ideas of the Study Challenge can be more accurately accessed via a longitudinal study. By means of such a study, researchers might be able to determine if these techniques are statistically significant in the studying and learning of mathematics. In addition, a larger quantitative study across multiple sections of a course taught from a common syllabus at a large university could prove illuminating.

Perhaps other strategies and suggestions could be incorporated as well.

Our experiences are directly applicable in today's classrooms, because instructors need to encourage effective study habits within the minds of mathematics students at all levels. We offer several suggestions for implementing the Study Challenge within the mathematics classroom: The "challenge" can be phrased and introduced as befits each instructor's style. Storm has found that humor and a bit of a challenging tone in combination can be effective. It is very important to have an explicit discussion about active studying versus passive studying as a part of this so that students understand the true purpose of the challenge and see the initial challenge to not say the word "study" as an entertaining sideline to truly effective exam preparation. Depending upon the level of the students and the specific course, some instructors may wish to provide concrete "study tasks" paired with the challenge, while other instructors may wish to leave it to the students to develop their own active studying techniques.

It is important for instructors to experiment with new mechanisms for promoting active study habits to determine their efficacy and ways to tailor it to their teaching styles. The Study Challenge is just one of many techniques that could be developed to promote effective mathematical habits of mind in our students, which is accomplished by encouraging students to be active doers of mathematics when studying for an examination.

Prof β: *Well, this has been very interesting. I think I'm going to try it. Thanks, α.*

Prof α: *My pleasure.*

Prof X: *Well, maybe you have something there... Do you think I could modify it to get the neighborhood kids to stay off my lawn?!*

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Appendix A. A Sample Calculus II Study Challenge

The "Study Challenge" is as follows:

> Do not use the word "study" between now and the midterm.

Instead, phrase your preparation plans in an active way to take charge! Some examples of things you might say are below:

Tonight, I am going to...

- *do all kinds of chain rule problems to solidify my derivatives and pave the way for substitution integrals.*
- *quiz myself with antiderivative flashcards until I can nail all of the elementary functions.*
- *review lecture notes on integration by substitution and then do 20 problems from the book until I know exactly what to substitute and how to make it work out.*
- *compute definite integrals using the area definition.*
- *compute definite integrals using the fundamental theorem of calculus.*
- *get the hang of those weird derivative of the definite integral questions that Professor Storm seems to like.*
- *draw the picture of a Riemann sum and be sure I can write down the area approximation based upon it.*
- *figure out how to convert from a Riemann sum to a definite integral and back.*
- *do 20 integration by parts problems and be sure I know how to select U and dV.*
- *do 20 partial fractions problems.*
- *look over all of the integrals we have done so far and be sure I know how to determine which integration technique to apply.*
- *rework the clicker questions from class and e-mail Professor Storm with any questions that I and my friends cannot puzzle out.*

Appendix B. A Sample Post-Course Survey

1. How many times did you accept the Storm Study Challenge?

   0 1 2 3

2. When studying for exams in this course, did you find that you worked more problems than usual, the same number of problems as usual, or fewer problems than usual as part of your study routine?

   More problems Same number of problems Fewer problems

3. Give an estimate for the percentage of the time that you spent on the given activities while preparing for examinations.

   Reading Class Notes and Clicker Questions:

   Solving new problems:

   Reworking problems from class or homework:

   Working the Sample Exam:

   Discussing the course with classmates:

4. Do you feel that you used your study time in this course more effectively, as effectively, or less effectively than in previous courses?

   More effectively As effectively Less effectively

5. Have you changed the way that you study for other courses as a result of this course?

   Yes / No

6. Please write any general comments below. If you have ideas for improving the Study Challenge, please write those as well.