10-20-2009

Improving Retention for Principles of Accounting and Elementary Statistics Students: Ultra-Short Tutorials Designed to Motivate Effort and Improve Performance

Carol Springer Sargent

doi: https://doi.org/10.57709/1061144

ACCEPTANCE

This dissertation, IMPROVING RETENTION FOR PRINCIPLES OF ACCOUNTING AND ELEMENTARY STATISTICS STUDENTS: ULTRA-SHORT TUTORIALS DESIGNED TO MOTIVATE EFFORT AND IMPROVE PERFORMANCE, by CAROL SPRINGER SARGENT, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chair, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

____
Amy R. Lederberg, Ph.D.
Committee Chair

____
A. Faye Borthick, Ph.D.
Committee Member

____
Daphne Greenberg, Ph.D.
Committee Member

____
Dennis N. Thompson, Ph.D.
Committee Member

____
Date

____
Peggy A. Gallagher, Ph.D.
Chair, Department of Educational Psychology and Special Education

____
R. W. Kamphaus, Ph.D.
Dean and Distinguished Research Professor
College of Education

AUTHOR'S STATEMENT

By presenting this dissertation as a partial fulfillment of the requirements for the advanced degree from Georgia State University, I agree that the library of Georgia State University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote, to copy from, or to publish this dissertation may be granted by the professor under whose direction it was written, by the College of Education's direction of graduate studies and research, or by me. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential financial gain will not be allowed without my written permission.

____

Carol Springer Sargent

NOTICE TO BORROWERS

All dissertations deposited in the Georgia State University library must be used in accordance with the stipulation prescribed by the author in the preceding statement. The author of this dissertation is:

Carol Springer Sargent
1263 Clairmont Place
Macon, Georgia 31204

The director of this dissertation is:

Amy R. Lederberg
Department of Educational Psychology and Special Education
College of Education
Georgia State University
Atlanta, Georgia 30302-3979

VITA

Carol Springer Sargent

ADDRESS: 1263 Clairmont Place
Macon, Georgia 31204

EDUCATION:

Ph.D.	2009	Georgia State University Educational Psychology
M.S.	1982	University of Virginia Accounting
B.S.	1981	University of Virginia Commerce

PROFESSIONAL EXPERIENCE:

1989–Present	Instructor, School of Accountancy Georgia State University, Atlanta, GA
1985-1989	Vice President and Corporate Controller National Linen Service, Atlanta, GA
1992-1995	Accounting Manager Larson-Juhl, Inc., Norcross, GA

PROFESSIONAL SOCIETIES AND ORGANIZATIONS:

1990-Present American Accounting Association

PRESENTATIONS AND PUBLICATIONS

Sargent, C. W. & Borthick, A. F. (2009). *Just Three Minutes: A Learning Innovation for Struggling Students*. American Accounting Association National Meeting, New York, NY (August 3-5).

Springer, C. W., & Borthick, A. F. (2007). Improving performance in accounting: Evidence for insisting on cognitive conflicts tasks. *Issues in Accounting Education, 22*(1), 1-19.

Springer, C. W., & Borthick, A. F. (2004). Business simulation to stage critical thinking in introductory accounting: Rationale, design and implementation. *Issues in Accounting Education, 19*(3), 277-303.

Springer, C. W., & Borthick, A. F. (2004). *The Locator Business Simulation: Learning Experiences for Critical Thinking in Accounting*. Mason, OH: South-Western.

Springer, C. W. (2004). *Critical Thinking Curriculum.* American Accounting Association National Meeting, Orlando, Florida (August 9-11).

Borthick, A. F. & Springer C. W. (2004). *Developing a business simulation*. Effective learning strategies forum, American Accounting Association National Meeting, Orlando, Florida (August 9-11).

Springer, C. W. (2004). *Critical Thinking Curriculum.* American Educational Research Association National Meeting, San Diego, California (April 12-16).

Springer, C. W. & Borthick A. F. (2003). *Cultivating critical thinking in accounting principles while increasing mastery of traditional accounting knowledge: Tradeoff not required.* American Accounting Association National Meeting, Honolulu, Hawaii (August 3-6).

Borthick, A. F., Springer C. W. & Barden R. (2003). *Learning to develop student capability for critical thinking*. Effective learning strategies forum. American Accounting Association National Meeting. Honolulu, Hawaii (August 3-6).

Borthick, A. F., H. L. Dangel, and C. W. Springer. (2003). *Pedagogy and assessment that support critical thinking*. Community of Practice, American Association for Higher Education Learning to Change Conference, Washington DC (March 14-17).

Borthick, A. F., H. L. Dangel, and C. W. Springer. (2003*). Overcoming barriers to critical thinking*. Colloquium on the Scholarship of Teaching and Learning Collaborating for Change. Carnegie Foundation for the Advancement of Teaching and the American Association for Higher Education, Washington DC (March 13-14).

Springer, C. W., and A. F. Borthick. (2003). *Critical thinking cases in principles of accounting: Results*. Georgia Association of Accounting Educators Annual Meeting, Rome, GA (February 7-8).

Springer, C., and A. F. Borthick. (2002). *Safe Night Out: Critical thinking for solving ill-structured business problems in an introductory accounting course*. American Accounting Association National Meeting. San Antonio, Texas (August 15-17).

ABSTRACT

IMPROVING RETENTION FOR PRINCIPLES OF ACCOUNTING AND ELEMENTARY STATISTICS STUDENTS: ULTRA-SHORT TUTORIALS DESIGNED TO MOTIVATE EFFORT AND IMPROVE PERFORMANCE
by
Carol Springer Sargent

This dissertation reports on two supplemental instruction implementations in courses with high failure rates. In study one, 27 ultra-short on-line tutorials were created for Principles of Accounting II students (N = 426). In study two, 21 tutorials with a similar design were created for Elementary Statistics students (N = 1,411). Accounting students were encouraged by their instructor to use the resource, but statistics students only saw a brief demonstration by the researcher. Neither course gave students credit for using the tutorials.

In study one, 71.4% of the accounting students used the tutorials. Students who used the tutorials had dramatically lower drop rates and better pass rates. Tutorial use was correlated with exam scores, although the effect was moderate. Tutorial use remained at high levels two years after implementation without instructors promoting use of the resource. Course grades were higher for the two-year period after implementation compared to the two years prior to implementation.

In study two, statistics sections were randomly assigned to intervention (tutorials; 695 students) or control (716 students). There were no significant differences in drop rates or average grades between intervention and control sections. On average, 46.0% of the intervention students used the tutorials. Users were less likely to drop and more likely

to pass compared to non-users and control students; these differences were especially pronounced among low-achieving students. Tutorial use was correlated with slightly higher exam scores, but only for low achievers. The lack of differences between intervention and control sections may have been due to the drop off of usage after the first exam and the small learning effect only accruing to the relatively small number of low achievers. Participants reported the tutorials as “important to their course achievement” more often than other course resources. The important features of the tutorials were convenience (24/7 Internet access), efficiency of learning, and clear instruction.

These studies suggest that the magnitude of the learning effect of the ultra-short tutorials depends on the tutorial topics, instructor promotion of the resource, and whether or not they are implemented in a course in which students feel the need to seek extra instruction.

IMPROVING RETENTION FOR PRINCIPLES OF ACCOUNTING AND
ELEMENTARY STATISTICS STUDENTS: ULTRA-SHORT
TUTORIALS DESIGNED TO MOTIVATE EFFORT
AND IMPROVE PERFORMANCE

by

Carol Springer Sargent

A Dissertation

Presented in Partial Fulfillment of Requirements for the
Degree of
Doctor of Philosophy
in
Educational Psychology
in
the Department of Educational Psychology and Special Education
in
the College of Education
Georgia State University

Atlanta, GA
2009

ACKNOWLEDGMENTS

I am indebted to Amy Lederberg and A. Faye Borthick for their endless hours of mentoring, their patience as I rearranged my personal life in the middle of this degree, and for their generosity at fixing, rather than criticizing, my glaring shortcomings as I evolved from business achiever to aspiring scholar. I am grateful to Dennis Thompson, for teaching me to marvel at the creative ways in which scientists isolate variables, for sharing stories and wisdom at every turn, and for treating me as a colleague long before I had earned it. I am grateful to Daphne Greenberg who jumped into an already half-baked project, and helped to push it forward. This project would not have been possible without the encouragement and funding from the GSU Provost, Ron Henry, and the backing of Bill Nelson, who arranged for statistics instructor cooperation on the math project. I appreciate the helpful comments, cooperation, and enthusiasm of countless colleagues in the College of Education, the Math Department, and the Robinson College of Business, as well as participants at annual meetings of the American Accounting Association. I am especially grateful for the patience and loving support of Dr. Robert A. Sargent, Jr., who met me after I had given up on this degree, encouraged me to continue, endured many lonely evenings while his fiancé and then new wife pounded the keyboard late into the night, and professionally edited this entire work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

IMPROVING RETENTION FOR PRINCIPLES OF ACCOUNTING STUDENTS: ULTRA-SHORT TUTORIALS DESIGNED TO MOTIVATE EFFORT AND IMPROVE PERFORMANCE

INTRODUCTION

As retention and progress toward completion of undergraduate degrees receive more attention in higher education, failure rates in principles of accounting courses, the gate-keeper courses for business majors, are coming under scrutiny. Typical explanations for poor performance in the principles courses include the demands of family, work, and extracurricular activities, intimidating classroom environments, low aptitude, and low motivation (Wooten, 1996). This study analyzes the impact of a learning innovation, ultra-short videos called “Digital Tutors,” designed to target the latter three factors and thus improve student effort and retention. In addition, unlike typical instructional innovations, these materials, once created, require little continuing faculty effort.

HYPOTHESIS DEVELOPMENT

Lack of Confidence With Intimidating Subject Matter

Many students are intimidated by math-related subjects because they believe math is complex and hard to learn (Ashcraft & Krause, 2007; Eccles & Midgley, 1990; Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007; Hembree, 1990; Miller & Mercer, 1997; Multon, Brown, & Lent, 1991). This difficulty translates into poor marks, which lowers self-confidence in math-related tasks (math self-efficacy) (Pajares &

Miller, 1994), creates math anxiety (Hembree, 1990), and results in the not-so-good students avoiding math tasks (Boekaerts, 1997; Hackett, 1985; Meece, Wigfield, & Eccles, 1990). In college, approximately 22 percent of freshman take remedial math courses and about half of all college algebra students fail (Thiel, Peterman, & Brown, 2008). Students who fear failure in math-related courses bring this crisis of confidence to their introductory accounting course.

The accounting literature acknowledges the influence of confidence as a driver of effort (Gracia & Jenkins, 2002; Stone, 1994; Stone, Arunachalam, & Chandler, 1996), and estimates that about 25 percent of accounting students feel unsure or not confident in their ability to succeed (Byrn & Flood, 2005). With college students, beliefs about math ability account for more variance in math scores than any other motivational or background variable because low beliefs about ability suppress adaptive academic activity (Gist, Schwoerer, & Rosen, 1989; Pajares & Miller, 1994; Siegel, Galassi, & Ware, 1985). Students who think they cannot do math do not try hard, avoid tasks, and hesitate to ask for help (Kim, Baylor, & Group, 2006; Middleton & Midgley, 2002; Zimmerman & Martinez-Pons, 1990).

Increasing subject matter mastery dominates other interventions in reducing math anxiety (Benson, 1989; Hembree, 1990; Meece, et al., 1990). Principles instructors, however, must cover a prescribed set of topics for entire classes, sometimes in large lecture formats. They necessarily move on to the next topic, even if some students have not yet mastered the current topic. As a course routine, building in a process for remediation, re-teaching topics, and tailoring instruction to individual students should help less confident and less able students (Yates, 2005).

Fortunately, digital media provide convenient platforms to provide remediation, individualization, and re-teaching. Modern textbooks often include a range of supplemental learning aids. So far these resources have not reduced the failure rates of students in principles classes.

Low Aptitude

Accounting is complex, potentially taxing short-term memory for novices or low ability students who have not yet linked ideas systematically together, or who know a large body of facts (Smith, diSessa, & Roschelle, 1993; Sweller & Chandler, 1994). Weak math students cannot hold as much numerical information in working memory as stronger math students (Siegler, 2003). The cognitive literature suggests helping these students learn incrementally by breaking down complex ideas into smaller parts, and later integrating the learned parts into a cohesive interrelated model (Ayres, 2006; Mayer, Mathias, & Wetzell, 2002; Smith, et al., 1993; Sweller & Chandler, 1994).

One study in introductory accounting supported the breakdown-integrate strategy. The students learned the accounting cycle better by first learning the model “assets = revenues,” before moving to the full six-element accounting equation (Edmonds & Alford, 1989). Another study relying on this theory broke down two topics (earnings per share and asset dispositions) into smaller tasks, and found that this approach was associated with improved learning (Byrd & Byrd, 1987). Another way to make complicated material more understandable is to walk students through example problems before asking them to work problems on their own (Ayres, 2006; Sweller & Chandler, 1994); this has been effective in accounting studies (Halabi, Tuovinen, & Farley, 2005; Kachelmeier, Jones, & Keller, 1992).

Students with limited knowledge are particularly vulnerable to flawed ideas and partial understandings (Smith, et al., 1993). Accounting has a conceptual aspect and a procedural aspect. Weak learners can understand the process, but not the concept, or understand the concept, but not the process. Lapses in either lead to systematic errors that can be detected, diagnosed, and corrected (Siegler, 2003). Several studies have shown that targeting misconceptions works better than providing more instruction (Huang, Liu, & Shiu, 2008; Korner, 2005; Muller, Bewer, Sharma, & Reimann, 2007).

Prior success with incremental approaches suggests that course designers might assist weaker students by using a "knowledge in pieces" approach, so they can succeed with smaller bits and build up a base of knowledge to be used for more complex assignments. Given the need to cover the full set of course topics on schedule, weak students could benefit from supplemental instruction that enables mastery learning of small pieces, and offers guidance on misconceptions to help them build up to the same level of knowledge as their classmates.

Inadequate Motivation

Empirical work confirms what most accounting instructors already know from experience—motivation carries more predictive value than ability for students in introductory business classes (Kruck & Lending, 2003), and principles of accounting students can overcome low aptitude by increasing their effort (Wooten, 1996).

Motivating effort may be one of the key issues in the required principles of accounting courses, especially for non-majors whose level of interest may be low. It is an even greater problem for weak or less confident students, who may need extra support to achieve, but do not want the stigma attached to remedial work, and are therefore hesitant

to ask for help (Fayowski & MacMillan, 2008; Karabenick & Knapp, 1988, 1991; Moore & LeDee, 2006). Techniques for motivating introductory accounting students include offering novel ways to learn and giving immediate feedback (De Lange, Suwardy, & Mavondo, 2003; Greer, 2001; Marriott & Lau, 2008), although one study claimed that without significant course credit, students will not complete extra work voluntarily (Elikai & Baker, 1988). To be successful, extra instruction should require little additional effort from students, be distinctly different from traditional course activities (Bueschel, 2008), and be open to all achievement levels to avoid any stigma associated with use.

To attenuate poor motivation, learning activities can be made readily accessible through digital media that respond to students' expectations for anytime, anywhere learning activities with immediate impact. This approach is consistent with Gee's (2003) principles for maximizing learning in interactive video settings:

1. The learner must be enticed to *try*, even if he or she already has good grounds to be afraid to try.
2. The learner must be enticed to *put in lots of effort* even if he or she begins with little motivation to do so.
3. The learner must *achieve some meaningful success* when he or she has expended this effort (Gee, 2003, 61-62).

Supplemental Instruction

Extra instruction, in all its various forms, has improved mastery to some degree for all students, although effect sizes vary depending on the match of the resource to the learner's needs (Congo & Schoeps, 1993; Simpson, Hynd, Nist, & Burrell, 1997). Unfortunately for introductory accounting students, the effect sizes from supplemental

instruction have been low (Etter, Burmeister, & Elder, 2000; Jones & Fields, 2001; Potter & Johnston, 2006) or not significant (McInnes, Pyper, Van Der Meer, & Wilson, 1995). On the brighter side, studies in the accounting literature find increased learning with virtual learning tools (Daroca & Nourayi, 1994; Jones & Fields, 2001; Lane & Porch, 2002; Parker & Cunningham, 1998; Potter & Johnston, 2006). Most accounting students openly embrace virtual learning (E. Martin, Evans, & Foster, 1995; Wells, de Lange, & Fieger, 2008), and the more accounting students used on-line supplements, the better their learning outcomes were (Dowling, Godfrey, & Byles, 2003; Jones & Fields, 2001; Turner, Lesseig, & Fulmer, 2006).

While the literature describes a vast array of supplemental instruction available to assist weak or tentative students, voluntary participation has been very low (R. A. Blanc, L. E. DeBuhr, & D. C. Martin, 1983; Simpson, et al., 1997; Topping, 1996), and those self-selecting into the extra instruction were more motivated students than those that did not (Etter, et al., 2000; Simpson, et al., 1997). In an analysis of 132 introductory accounting classes from 21 four-year colleges, the average participation rate for supplemental instruction was 26.79 percent (Etter, et al., 2000). At one university where supplemental instruction was added to the first accounting course, 18 percent of the students tried it, but only 28 out of 1,359 students attended more than half of the sessions, making it hard to justify the implementation effort (Jones & Fields, 2001). For it to work to support intimidated, low aptitude, or poorly motivated students, supplemental instruction will need to elicit higher participation rates.

Hypotheses for Prompting Effort to Improve Retention

Supplemental instruction that improves mastery may be an antidote to lack of confidence, i.e., when one learns something in a subject, that subject becomes less intimidating to the learner (Benson, 1989; Hembree, 1990; Meece, et al., 1990). Low aptitude might be overcome by breaking down complex ideas into smaller units (Ayres, 2006; Mayer, et al., 2002; Smith, et al., 1993; Sweller & Chandler, 1994), explaining worked examples, and pointing out common misunderstandings to students (Huang, et al., 2008; Korner, 2005; Muller, et al., 2007). To address low motivation, learners can be offered readily accessible activities that give learning results quickly with minimal effort (Gee, 2003). We propose testing the effects of supplemental instruction designed to ameliorate lack of confidence, low aptitude, and inadequate motivation by offering students a set of three-minute video Digital Tutors affording access to concise direct instruction on essential concepts, worked examples, and coaching on misconceptions. The hypotheses we propose are:

H1: Participation rates of Digital Tutors by low achievers will be significant, even without course credit.

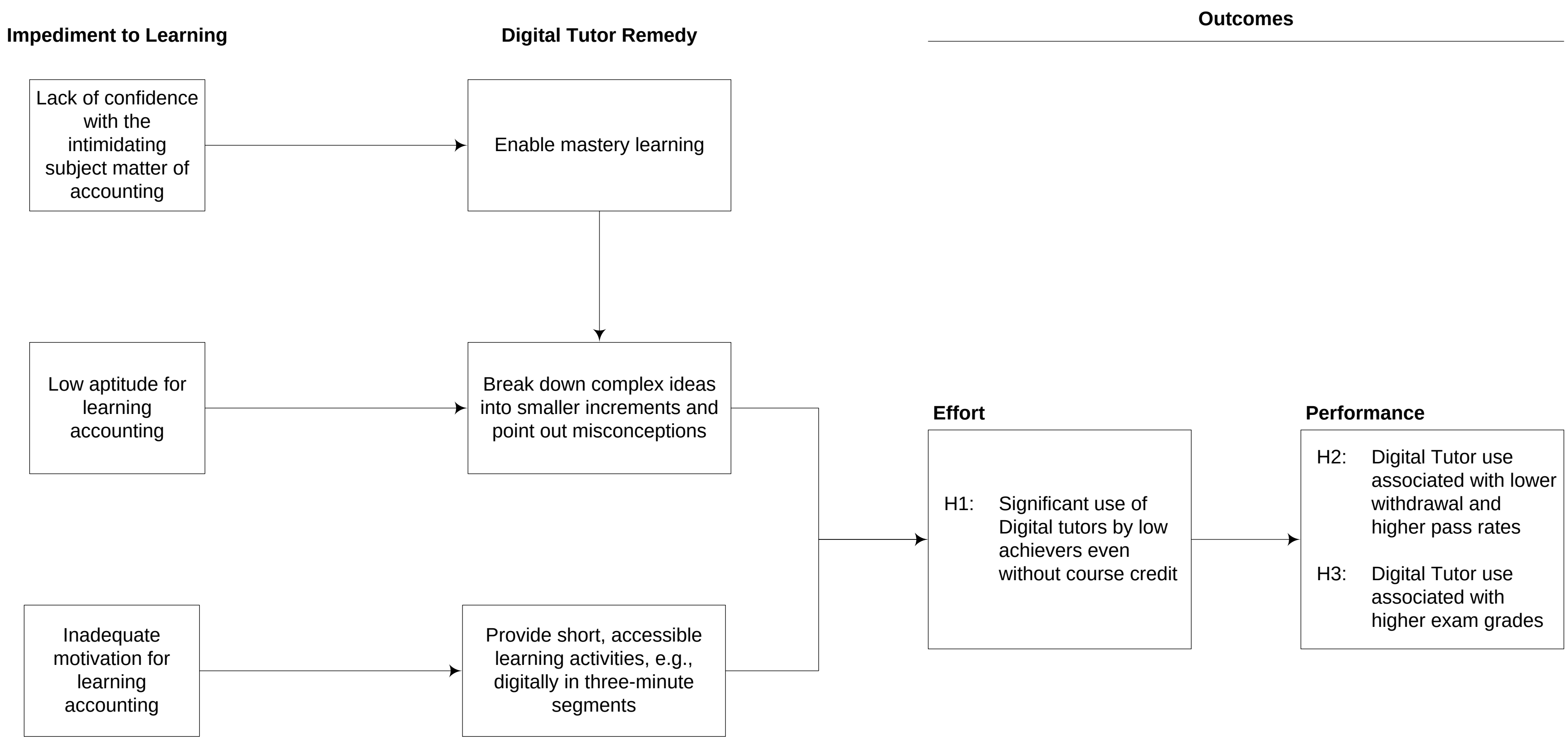
H2: Students using Digital Tutors will be less likely to drop the course and more likely to pass the course than non-users.

H3: Students using Digital Tutors will improve their exam grades more than non-users.

The problems, remedies, and hypotheses concerning student effort and retention are modeled in Figure 1.

The hypotheses are tested in two studies spanning different time periods with different levels of data detail. Study 1 is based on Digital Tutorial use by students in two large sections (320 seat auditorium) of Principles of Accounting II in Spring 2007,

FIGURE 1
Digital Tutor Model for Overcoming Impediments to Learning in Principles of Accounting



analyzed at the student level. In study 2, the tutorials created and implemented in Spring 2007 were used in every section of the course for the two years after the implementation term (six consecutive terms including the implementation term). To assess the long-term effects of tutorial use, student performance in the two years before and in the two years after implementation are compared, analyzed at the term level.

METHOD: STUDY 1

Participants

Participants were students enrolled in two large lecture classes of Principles of Accounting II in spring 2007 (n = 426) taught by the author at a large urban public university with a diverse study body.

Design of the Learning Experience: Digital Tutors

The attention-getting promise of the tutorials for appealing to students with low motivation was the claim that "*you will improve in just three minutes.*" Easy access (i.e., available anywhere on the internet, 24/7) minimized the effort needed to test this promise. The intent of the tutorial design was to prompt poorly motivated students to investigate this claim.

While accounting topics typically build on each other, tutorial topics were as discrete as possible so that students could start at any point in the semester. When this was not possible, a tutorial would direct the learner to view a prior tutorial and then return to the current one. As an additional motivational aspect, the tutors were kept to three central concepts per chapter (27 skills in total, Appendix A) to avoid overwhelming the learner with the volume of material to be learned.

The second major aspect of the design was to create tutors that would meet the cognitive needs of weak or intimidated learners so that their first engagement with the innovation would "*achieve some meaningful success*" (Gee 2003, 62). Cognitive load theory suggests that instruction for inexperienced learners should not only simplify complex ideas, but also avoid seductive details and busy screens (Sweller & Chandler, 1994). Therefore, each three-minute video pertained to one foundational idea with a simple voice-over PowerPoint look and feel, and no animation and minimal artwork. To provide practice, feedback, and reinforcement immediately after the three-minute instruction, two or three worked problems were offered, starting with an easy one, and then one or two harder ones. For the benefit of math anxious students (Hembree, 1990), the voice was warm, relaxed, and unhurried, and the tone conveyed confidence that this was doable in short order with a few new learning experiences.

Twenty-seven ultra-short videos were created for the course, three for each of nine chapters covered on the departmental syllabus. The two principles of accounting courses used an integrated text, which organizes topics by financing, operating, and investing activities (Ainsworth, Deines, Plumlee, & Larson, 2003). Consequently, the Principles of Accounting II course has managerial and financial accounting topics and includes some cumulative materials from the first introductory course (e.g., journal entries and financial statements).

Tutorial topics for each chapter were chosen based on their importance to understanding later topics (e.g., present value of money is critical to learning net present value and bond valuation), or because they were difficult for weak learners (e.g., annuities, disposing of assets, and indirect operating cash flow presentation), or prone to

misconceptions (e.g., salvage value use in depreciation, present versus future value, bond payments versus bond expense, and cash versus accrual accounting). Appendix A contains a list of tutorial topics by chapter.

The video for each tutorial was created from 15-20 slides, starting with explaining the main concept concisely, using lay terms rather than technical jargon to convey the terminology (an obstacle for weak learners), moving to how the main idea can be used to solve accounting problems, revealing the strategy or process steps needed, and finally inviting learners to try to solve a problem. Interspersed throughout each tutorial were informal comments highlighting typical misconceptions or errors. The instruction deliberately avoided repeating the associated lecture, giving students who might not understand the lecture a fresh explanation of the concepts, and hopefully discouraging them from skipping lectures.

Procedure

The Digital Tutors were loaded into the course management software, WebCT, which recorded the date, time, and duration of each use by student. Students had no knowledge of the tracking and received no course credit for tutorial use. Due to obstacles in creating the first tutorials, the first nine tutorials were loaded the week before the first exam, but the rest of the tutorials were loaded approximately the same week as the lecture that introduced the topic. The week before the first exam (when the first nine tutorials were loaded), the instructor demonstrated how to find the tutorials and encouraged students to use them as a review for the exam. After the first exam, the instructor routinely mentioned which tutorial pertained to that week's topic.

At the end of the course, the instructor distributed a survey asking students if they tried various course resources, including the tutorials, and asking for qualitative feedback about which resources were most useful in helping them learn. After submitting all grades to the registrar, the instructor requested an activity report from the technology group on campus showing student viewing of Digital Tutors.

Measures

Digital Tutor Use. Reviewing tutorial activity showed that some students only viewed one or two files within 10-20 seconds of each other, indicating that they previewed the tutorials, but decided not to use them after the preview. Therefore, a "user" was defined as a student who viewed three or more tutorials. The length of time a file was left open on the computer was not captured by the software so the study defined "use" as "the number of file launches" (number of uses).

Math Aptitude. Math aptitude was measured with Math SAT score. Math SAT scores were available for students entering the university as first-term freshmen (n = 317, 74.4%) but not for students transferring from other institutions (n = 109, 25.6%).

Achievement. Cumulative grade point average (GPA) measured academic achievement. The GPA cutoffs to separate the participants into low, middle, and high achievers were selected as an amount above and below the mean, which placed approximately 25 percent of the participants in the low group and 25 percent in the high group. The cutoffs used were low = GPA of 2.5 or less (28.9% of the students) and high = GPA above 3.2 (24.6% of the students). The correlation between GPA and Math SAT was low enough to permit including both variables in the same model (Pearson correlation = 0.287).

Exams. Students took three departmental exams, one at week five, another at week 10, and a cumulative final exam at the end of the 15-week term. Exams contained only multiple-choice questions from departmental exams used in prior terms. Approximately 25 percent of the questions were changed either slightly (e.g., dollar amounts and company name) so repeating students would not have exams identical to those in prior terms, or replaced due to minor changes in course content.

RESULTS: STUDY 1

The data met the assumptions of normality except for two outliers for cumulative GPA (one was 7.9 standard deviations lower than the mean and the other was a GPA of 0.0), and both were retained as valid data.[1]

TABLE 1
Participant Attributes Spring 2007: Mean (Std. Dev.)

Attribute	Non-Users[a]	Users
Number of participants	122	304
Percent female	40.2%	46.7%
Age	22.59 (3.19)	23.21 (5.25)
SAT verbal[b]	530.31 (71.96)	517.84 (70.02)
SAT math[b] ($p < 0.05$)	554.02(75.71)	533.58 (69.91)
Cumulative GPA ($p < 0.001$)	2.61 (0.71)	2.87 (0.56)
Accounting GPA ($p < 0.05$)	2.14 (1.02)	2.40 (0.92)
Credit hour load ($p < 0.001$)	10.37 (5.38)	12.30 (3.55)
Exam 1 score	73.95 (14.47)	75.22 (13.68)
Exam 2 score	74.74 (16.10)	76.22 (14.87)
Final exam score	71.51 (13.24)	73.16 (14.34)

[a] Opened tutorials two or fewer times during term.
[b] Excludes transfer students, for which SAT scores are not required (n = 109, 23 non-users and 86 users).

Attributes of tutorial users compared to non-users are summarized in Table 1. Compared to students not using the tutorials, students who used the tutorials had lower Math SAT scores ($F = 5.4$, $p < 0.02$), higher cumulative GPA ($F = 17.4$, $p < 0.001$), higher accounting GPAs ($F = 6.07$ $p < 0.01$), and higher credit hour loads ($F = 18.7$. $p <$

[1] Excluding the outliers did not change the results of any analysis.

0.001). The pattern of lower aptitude but higher grades signals a higher level of motivation, indicating that users and non-users likely differed on this aspect.

H1: Participation

Tutorial use and grades are summarized in Table 2 by achievement level. Participation was high among all three groups, 61.0 percent for low achievers, 74.7 percent for middle achievers, and 77.1 percent for high achievers. Excluding students that dropped the course, participation was 68.7 percent for low achievers, 80.1 percent for middle achievers and 80.2 percent for high achievers. Examining the average number of views per user further supports the hypothesis that the tutorials stimulated effort. Even though there were only 27 tutorials, the mean number of views averaged over 31 for all achievement levels (Table 2).

TABLE 2
Tutorial Use and Grades by Achievement Level Spring 2007: Mean (Std. Dev.)

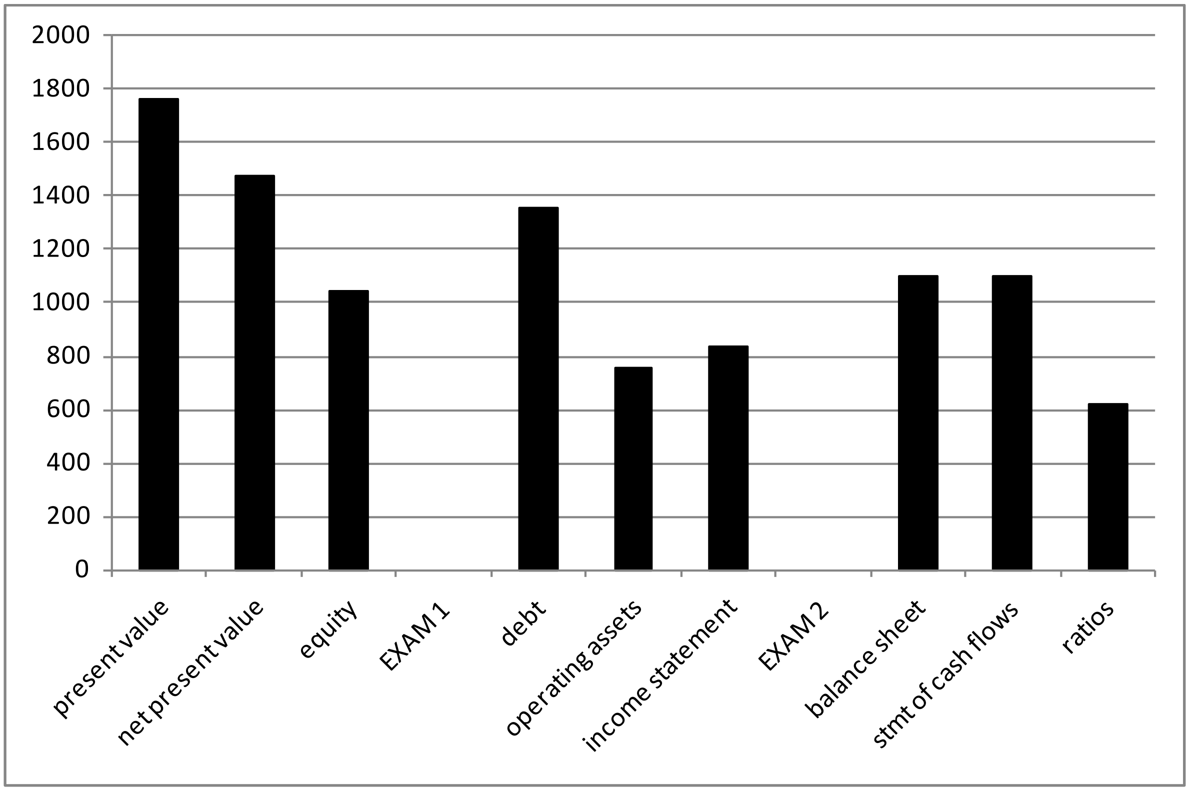
	Cumulative GPAs by Achievement Level		
	Low: < 2.5	**Middle:**	**High: > 3.2**
Number of participants	123	198	105
Participants using tutorials [a]	75	148	81
Percent using tutorials	61.0%	74.7%	77.1%
Average number of views for users [a]	31.30 (29.9)	32.02 (27.1)	31.05 (22.3)
Exam 1 score	65.6 (13.9)	74.7 (11.2)	84.9 (10.9)
Exam 2 score	66.1 (16.4)	75.8 (12.4)	85.7 (11.3)
Final exam score	61.4 (15.0)	72.2 (12.0)	83.5 (9.6)
Percent passing course	48.7%	82.3%	92.4%

[a] Users opened tutorials four or more times during term.

Tutorial use by topic showed high use for the first chapter of the term (Figure 2) due to a flurry of “previewers”--students who opened up one or two tutorials, but viewed less than 20 seconds of the presentation. Views by student do not distinguish between those that viewed the full set and those that might have repeated certain topics strategically. Views by topics in order of presentation over the term (Figure 2) indicate

that after the initial flurry of previewers, use over the terms was generally consistent with spikes for certain topics.

FIGURE 2
Number of Tutorial Views in the Sequence of Topics Over the Term



H2: Retention

A χ^2 test of withdrawal rates between users (10.83 percent) and non-users (35.25 percent) showed that users were significantly less likely to withdraw from the course (χ^2[1, n = 426] = 35.34, $p < 0.001$). The χ^2 test of pass rates (grade of C- or better, Table 3) between users (81.9 percent) and non-users (59.2 percent) showed that users were significantly more likely to pass the course (χ^2[1, n = 426] = 26.12, $p < 0.001$).

Repeating these tests on only the high-risk students revealed that significantly more low-achieving non-users dropped the course (45.8 percent) than low-achieving users (24.0 percent) (χ^2[1, n = 123] = 6.56, $p < 0.01$). Significantly more low-achieving

users passed the course (56.0 percent) than low-achieving non-users (37.5 percent; (χ^2[1, n = 123] = 4.01, p < 0.05).

TABLE 3

Retention Rates Spring 2007: Mean (Std. Dev.)

Attribute	Non-Users[a]	Users
Number of participants	122	304
Number of withdrawals	43	33
Percent of students withdrawing	35.25%	10.85%
Number of participants passing (Grade A, B or C)	71	249
Percent of participants passing (Grade A, B or C)	59.2%	81.9%

[a] Opened tutorials two or fewer times during term.

Tutorial use was significantly associated with passing (t = 3.68, p < 0.001) in a regression analysis with passing (yes/no) as the outcome variable, GPA as a control for motivation and achievement, Math SAT as a control for aptitude, and tutorial use as the predictor. Dropping Math SAT from the model to include transfer students gave similar results (t = 3.85, p < 0.001).

H3: Exam Grades

With hierarchical linear modeling (HLM), exam score growth over the term was analyzed longitudinally as a function of tutorial use (Hox, 2002; Raudenbush & Bryk, 2002; Singer & Willett, 2003). HLM is a multi-level regression analysis that analyzes two aspects of the data: the intercept or starting point, in this case exam one, and the slope, the change in exam scores over the term. The intercept reveals initial differences between students, while the slope shows changes over time within each student, and between students. The slopes can be divided into several components to model different influences on growth. In this study, the final models included a time component to model growth from non-tutorial influences and an intervention component to model growth from tutorial views.

The HLM analysis included three models (Table 4). Model 1, the unconditional model, shows that the intercept, i.e., average exam one score of 74.43, differed significantly between students. Model 2 added a variable for time (weeks), and shows that exam scores decreased significantly, on average 0.34 points per week during the term. Model 3 added GPA and Math SAT to explain differences in starting exam scores (intercept), and tutorial use to explain changes in exam scores over the term (slope). All three variables were significant in Model 3--tutorial use and Math SAT at the $p < 0.05$ level, and GPA at the $p < 0.001$ level.[2]

Model formulas were:

Level 1: $\text{ExamScore}_{ti} = \pi_{0i} + \pi_{1i}\,(\text{Week})_{ti} + \pi_{2i}\,(\text{TutorialUse}) + e_{ti}$

Level 2: $\pi_{0i} = \beta_{00} + \beta_{00}\,(\text{GPA}) + \beta_{00}\,(\text{MathSAT}) + r_{0i}$

$\pi_{1i} = \beta_{10}$

$\pi_{2i} = \beta_{20}$

Substituting the level 2 equations into the level 1 equation yields the combined model:

$$\text{ExamScore}_{ti} = \beta_{00} + \beta_{00}\,(\text{GPA}) + \beta_{00}\,(\text{MathSAT}) + \beta_{10}\,(\text{Week})_{ti} + \beta_{20}\,(\text{TutorialUse}) + r_{0i} + e_{ti}$$

While regression analysis includes only one error term, indicating that some unexplained variance exists, HLM offers several error terms which allow for locating unexplained variances. For instance, there could be unexplained differences in the initial scores as well as unexplained differences in growth rates. The level 1 error term indicates that other time-varying variables might contribute to change over time. A statistically

---

[2] Model 3 excluded transfer students, who are not required to submit SAT scores. Because the integrated curriculum at the implementation school contains a high proportion of financial topics in the second principles course (typically a managerial course), transfer students who already had Principles of Accounting I at a feeder school would have exam scores biased because of prior learning. Tutorial use is not significant with transfer students included and Math SAT left out of the model ($t = 1.27$, $p < 0.21$). Tutorial use is marginally significant without Math SAT and without transfer students ($t = 1.78$, $p < 0.075$).

significant level 2 error term indicates unexplained differences between participants. All models in this study showed statistically significant unexplained level 2 error terms (Table 4), indicating that other predictors (such as time on task, level of outside demands, interest in the topic and so forth) could improve the model even further.

TABLE 4
Longitudinal Analysis of Change in Exam Scores with Tutorial Use Spring 2007

	Model 1: Intercept only		**Model 2: + week**		**Model 3: + week, tutorial use, GPA, & Math SAT**	
Fixed Effects:	**coeff.**	**SE**	**coeff.**	**SE**	**coeff.**	**SE**
Intercept	74.430***	0.665	77.758***	0.997	76.203***	1.170
Week			-0.336***	0.071	-0.251**	0.097
Tutorial use					0.096*	0.049
GPA					12.526***	1.198
Math SAT					0.022*	0.009
Variance:						
Level 1						
Within person	96.284		91.755		96.796	
Level 2						
In initial status	98.438***		103.530***		39.931***	
Deviance	6742		6727		4356	

[a] Includes transfer students, for which Math SAT scores were not available.
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Tutorial use, even though statistically significant, has low to moderate practical significance: each tutorial use improved test scores on average 0.096 points (Table 4, Model 3). Students viewed the tutorials on average 30 or more times (Table 2), and thus could expect an average 2.88 exam point advantage over non-users. In the plus/minus grading environment, this may move tutorial users to the next grade level.

METHOD: STUDY 2

Given the benefits found in Study 1, the tutorials were made available to all sections of Principles of Accounting II in subsequent terms. In study 2, we analyze whether tutorials were associated with continuing benefits without the involvement of the

designer, weekly promotion during lectures, and experimental effects of students knowing they were trying a new resource. We investigated these questions in study 2, which compared grades in the six terms before and the six terms after implementation for all instructors.

Participants

Participants were all students enrolled in Principles of Accounting II from Spring 2005 through Fall 2008 (six terms prior to implementation and six terms after the implementation, n = 5,787) at a large urban public university with a diverse study body.

Procedure

Data for six terms (two spring, two summer, and two fall terms) before and six terms after implementation were considered a matched set. Spring terms included more of the traditional full-time sophomores who took Principles of Accounting I in the fall term, and continued to the second course in the spring term. Fall terms included more of the part-time students who took the course when it fit their schedule, rather than in the traditional pattern. Summer students typically included a greater proportion of transient students from other schools who wanted to complete the prerequisite course while home for the summer, and students who did not pass during the spring and fall terms.

Instructor practices also vary by term. Summer terms included more non-traditional instructors and graduate students, and are all taught in small sections without the requirement to use departmental exams. Approximately three-fourths of the students in fall and spring terms completed the course in a large lecture format with full-time faculty. Adjunct faculty members are more likely to teach small evening sections in all terms. In any one term, there are about 10 different instructors.

The campus technology group loaded the Digital Tutors into the WebCT template for the course so that students in every section could see the resource listed on the homepage. Instructors were unaware of the tutorial contents or learning effects.

Measures

***Tutorial Use*.** Because Study 2 is a retrospective study, detailed use by student was not available in the terms after the implementation term. Total views for the last term in Study 2 were available, which indicated overall use level.

***Course Grade*.** The implementation school used a plus/minus grading system with "pluses" adding 0.3 points, and "minuses" removing 0.3 points. Thus, an A- = 3.7, a B+ = 3.3, and so forth.

***Math Aptitude and Achievement*.** As in Study 1, achievement was measured by cumulative GPA and math aptitude was measured with Math SAT. Correlation between these two variables was low enough to permit use in the same model (Pearson correlation = 0.246).

RESULTS: STUDY 2

The data met the assumptions of normality with no outliers noted. The enrollments by term, average SAT scores, average cumulative GPAs, and course grades in Table 5 show that math aptitude as measured by Math SAT was gradually increasing over the 12-term period; this was consistent with the gradual improvement in admission requirements at this university, as well as with a state-wide emphasis on improving high school math preparation ($F = 13.307$, $p = 0.01$). Differences in cumulative GPA and SAT Verbal score over the 12 terms were not significant (GPA: $F = 0.224$, $p = 0.65$; SAT Verbal: $F = 1.935$, $p = 0.21$).

TABLE 5
Participant Attributes Before and After Implementation: Mean (Std. Dev.)

Term	N	Percent Passing [a]	Cumu-lative GPA	Course Grade GPA	SAT Verbal	SAT Math
Before Implementation						
Spring 2005	534	48.31	2.75 (.62)	1.77 (1.2)	507.57 (78.0)	525.23 (77.1)
Summer 2005	287	77.00	2.48 (.96)	2.48[b] (.96)	495.30 (84.8)	529.50 (85.0)
Fall 2005	489	53.17	2.74 (.61)	1.94 (1.2)	504.76 (73.6)	522.96 (72.0)
Spring 2006	526	52.85	2.78 (.55)	1.76 (1.1)	509.74 (71.6)	538.37 (78.8)
Summer 2006	358	74.30	2.77 (.65)	2.28[b] (1.1)	511.93 (77.7)	535.46 (78.2)
Fall 2006	493	54.36	2.66 (.65)	1.97 (.98)	509.07 (73.3)	536.16 (75.9)
After Implementation						
Spring 20007	620	71.77	2.80 (.62)	2.32 (1.1)	522.67 (75.2)	541.08 (71.5)
Summer 2007	360	81.39	2.82 (.60)	2.49[b] (1.0)	513.39 (76.3)	535.60 (73.8)
Fall 2007	557	70.74	2.71 (.63)	2.18 (1.1)	524.16 (79.9)	545.01 (72.4)
Spring 2008	648	62.19	2.78 (.67)	2.14 (1.2)	519.20 (73.6)	541.75 (77.2)
Summer 2008	347	83.57	2.86 (.61)	2.50[b] (1.0)	515.55 (81.1)	545.08 (75.4)
Fall 2008	568	65.14	2.77 (.62)	2.11 (1.2)	515.84 (70.6)	537.18 (77.4)

[a] Received grade of C- or higher for the course. The university uses a plus and minus grading system.
[b] During summer term, instructors are not required to use the departmental exams, and students are in small classes rather than large lectures.

H1: Participation

For Fall 2008, the last of the six-term sequence, there were 9,545 tutorial views with enrollment of 568 students (average of 16.8 per student), which was down from the 9,726 views in Spring 2007 for 426 students (average 22.8 per student).

H2: Retention

The withdrawal rate of 18.4 percent prior to implementation was significantly higher than the withdrawal rate of 11.3 percent after implementation (Table 6) (χ^2[1, n = 5,787] = 58.71, $p < 0.001$). The pass rate of 57.2 percent prior to implementation was significantly lower than the pass rate of 70.1 percent after implementation (Table 6) (χ^2[1, n = 5,787] = 104.57, $p < 0.001$). The grade distribution before and after tutorial implementation are shown in Figure 3 and the number of students receiving D, W or F grades before and after tutorial availability are shown in Figure 4.

FIGURE 3
Grade Distribution Before and After Tutorial Implementation

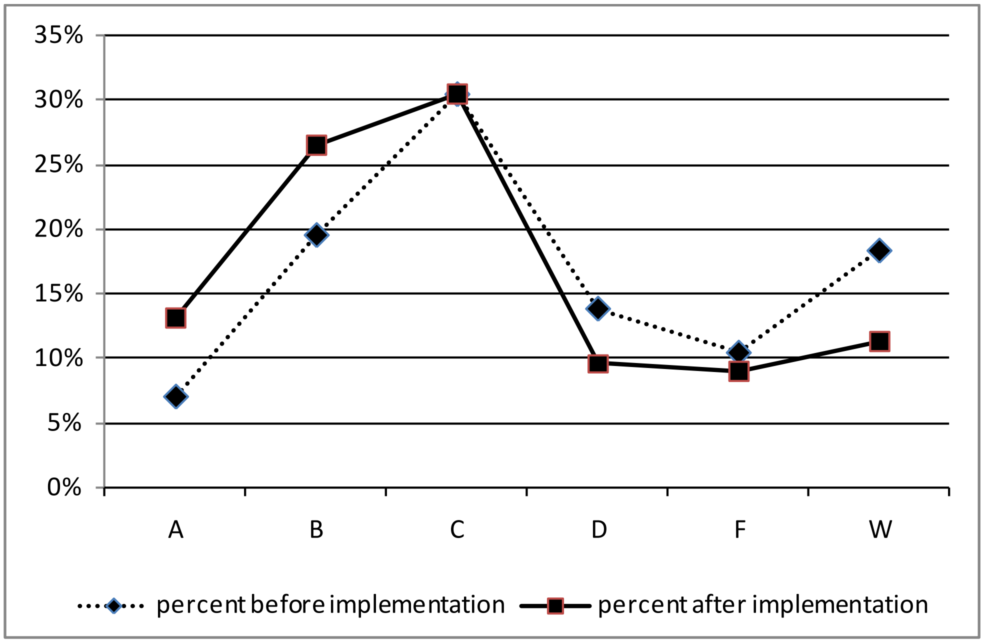
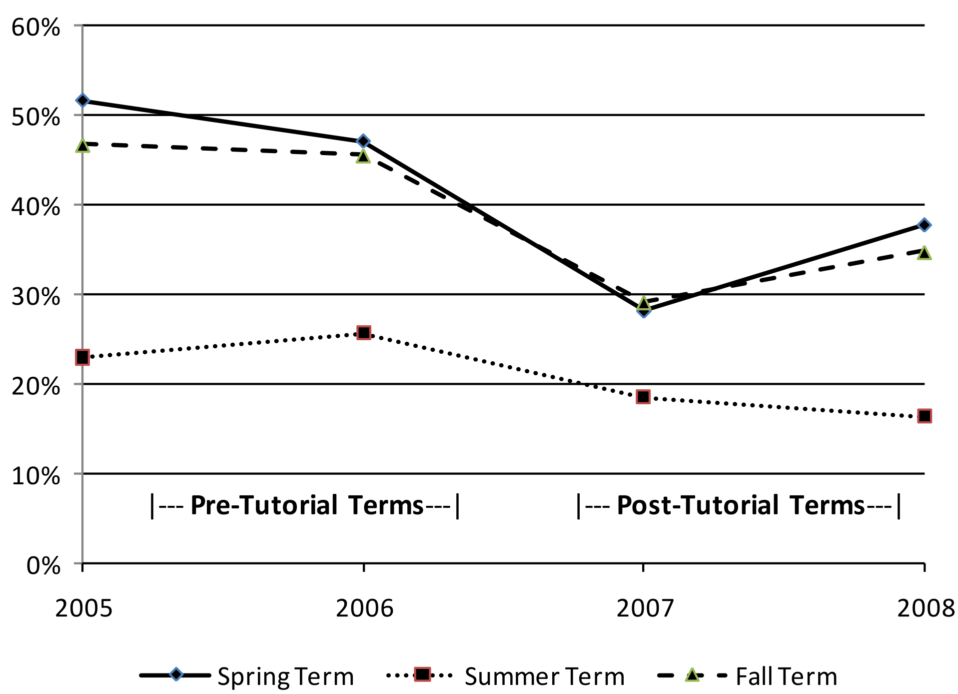


FIGURE 4
Students Receiving D, W, or F Grades Before and After Tutorial Availability



Tutorial availability was significantly associated with passing ($t = 8.53$, $p < 0.001$) in a regression with pass (yes/no) as the outcome variable, GPA as a variable to control for motivation, Math SAT to control for aptitude, and tutorial availability as the predictor. Excluding Math SAT scores in order to include transfer students in the analysis gave similar results ($t = 10.39$, $p < 0.001$).

TABLE 6
Grade Distribution Six Terms Before and Six Terms After Implementation

	Before Implementation		**After Implementation**	
	#	**%**	**#**	**%**
A	192	7.1	267	8.6
A- [a]			140	4.5
B+	11	0.4	170	5.5
B	515	19.2	413	13.3
B- [a]			238	7.7
C+	16	0.6	251	8.1
C	757	28.2	449	14.5
C-	46	1.7	246	7.9
D	373	13.9	298	9.6
F	282	10.5	278	9.0
W	495	18.4	350	11.3
Total	2687	100.0	3100	100.0
Pass Rate (C- or better)	**57.20%**		**79.81%**	

[a] A- and B- grades were not assigned prior to Spring 2007.

Repeating these tests on only the high-risk students (GPA below 2.5), revealed that significantly more low-achieving pre-implementation students dropped the course (27.1 percent) than low-achieving post-implementation students (16.3 percent) (χ^2[1, n = 1,871] = 31.81, $p < 0.001$). Significantly more low-achieving post-implementation students passed the course (43.8 percent) than low-achieving pre-implementation students (30.0%) (χ^2[1, n = 1,871] = 38.24, $p < 0.001$). Tutorial use was significantly associated with passing ($\underline{t} = 5.60$, $p < 0.001$) in a regression on the low achievers with pass (yes/no) as the outcome variable, GPA to control for motivation and achievement, Math SAT to

control for aptitude, and tutorial availability as the predictor. Leaving Math SAT out to include transfer students gave similar results ($t = 6.77$, $p < 0.001$).

H3: Exam Grades

Tutorial availability was significant in explaining variance in course grades in a regression with course grades as the dependent variable, tutorial availability as the independent variable, GPA as a control for motivation and achievement, and Math SAT as a control for aptitude (Table 7, Panel A). Leaving Math SAT out to include transfer students gave similar results (Table 7, Panel B). The low correlation between Math SAT and GPA allowed both covariates to be included in the analysis (Pearson correlation = 0.246).

TABLE 7
Course Grade as a Function of Tutorial Availability

Panel A: Cumulative GPA and Math SAT as covariates (entering freshmen only)

Variable	*B*	*SE*	*β*	*t*	*Sig.*
Constant	-1.754	0.118		-14.873	0.000
Tutorial availability	.277	0.029	0.124	9.399	0.000
Cumulative GPA	1.242	0.028	0.609	45.004	0.000
Math SAT	.000	0.000	0.027	1.985	0.047

Model $R^2 = .401$

Panel B: Cumulative GPA as covariate (entering freshmen and transfer students)

Variable	*B*	*SE*	*β*	*t*	*Sig.*
Constant	-1.427	0.060		-23.850	0.000
Tutorial availability	0.257	0.025	0.112	10.380	0.000
Cumulative GPA	1.219	0.020	0.644	59.956	0.000

Model $R^2 = .430$

DISCUSSION

Participation Rates

The tutorials elicited remarkable participation rates during Spring 2007, the initial implementation. In Spring 2007, 71.4 percent of Principles of Accounting II students

used the tutorials three or more times, which is comparable to mandatory supplemental instruction of 70 percent (Jones & Fields, 2001), and higher than the average of 27 percent for voluntary participation in supplemental instruction with Principles of Accounting (Etter, et al., 2000). While some studies suggests that stronger students self select into voluntary supplemental instruction (Moore, 2008; Moore & LeDee, 2006; Simpson, et al., 1997; Xu, Hartman, & Guillermo, 2001), 61.0 percent of low achievers in this study used the tutorials. Furthermore, the low achievers, who viewed the tutorials on average 31.30 times, were just as active as higher achievers, who averaged 31.05 tutorial views. The use on par with high achievers confirms that low achievers are willing to exert effort with novel resources (De Lange, et al., 2003; Greer, 2001; Marriott & Lau, 2008).

A relatively small effort, three minutes of instruction, may have triggered students to recognize that a series of small actions can accumulate to success (Gee, 2003; Maurer, 2004); a message that may have improved weaker students studying habits enough to get them up to passing. Or, the discrete nature of working this tutorial in private as many times as needed may have preserved self-esteem and made this resource comfortable to use for all, especially low achievers (Karabenick & Knapp, 1988, 1991). This study refutes the notion that students will not complete extra work voluntarily (Elikai & Baker, 1988), and supports findings that accounting students embrace virtual learning (E. Martin, et al., 1995; Wells, et al., 2008).

Total tutorial use by topic (Figure 2) suggests that users were somewhat strategic, viewing certain topics more than others. It is unclear if consistent users (looking at the full set) have different outcomes than users who are more strategic (select only certain

chapters to view), or whether low achievers use the tutorials differently than high achievers.

Although total use is down five terms after implementation, the use rates are still remarkable compared to published rates for other supplemental instruction (Etter, et al., 2000). It is even more remarkable that this level of use continued without instructors encouraging use during each class session.

Retention Rates

Tutorial users, including those at most risk of failing, were more likely to persist with the course (not drop it), thereby exerting enough effort to pass it. In the implementation term, users withdrew one-third less often than non-users (Table 3) and had a pass rate of 81.9 percent versus 59.2 percent for non-users. Low achieving users were less likely to withdraw and more likely to pass than low achieving non-users.

Over 12 terms (Table 5) with many instructors, student types, and course formats, terms without tutorials available had higher drop rates and lower pass rates compared to terms with tutorials. The pattern over 12 terms of higher grades and better pass rates after implementation suggests that the tutorial availability affords benefits across class sizes (large lecture in Spring and Fall terms, small classes in Summer term), a wide range of instructor types (graduate student, adjunct, and full time faculty), student types (traditional full-time, part-time, repeaters, and transient), and exam content. This result confirms the increasing body of literature showing that supplemental instruction can improve retention, especially for students in high risk courses or who are underprepared or poorly motivated (Congo & Schoeps, 1993; Moore, 2008; Moore & LeDee, 2006; Ramirez, 1997; Xu, et al., 2001).

The improved grades and pass rates for the six terms after implementation may have included factors other than the tutorials. The faculty course coordinator changed in the second year of implementation, and grades and pass rates did worsen slightly following this change (Figure 4). The departmental exams were intentionally changed in minor ways each term so repeating students would not have the same exams in the next term. The only other known change after the tutorial implementation was the addition of class activities by the large lecture instructors, which impacted about 75 percent of the spring and fall students.

Exam Scores

Tutorial use was associated with exam scores in only minor ways. The model (Table 4) indicates that the tutorials were associated with on average an improvement of 0.096 points per view. This finding is consistent with low effect sizes reported for supplemental instruction in accounting (Etter, et al., 2000; Jones & Fields, 2001; Potter & Johnston, 2006).

A low learning effect may be attributable to the emphasis on just core concepts. While affording a solid foundation, the low level of difficulty of the basic ideas in the tutorials, while enough to dramatically alter pass rates, may not have brought students up to the high competency required to perform at a levels above passing.

Tutorial quality would affect learning. Students indicated on the end-of-course survey, as well as by their high level of use, that they believed the tutorials were effective at teaching the material. On end-of-course surveys, over 95 percent of the students cited Digital Tutors as more useful in achievement than any other course resource. Further, the

high use level (Table 2) suggests that the students found the tutorials helpful enough to spend time viewing them, even without course credit for the effort.

The low to moderate size exam score increase from using tutorials may be due to a ceiling effect based on student goals. Students may not have used the tutorials to maximize their grade, but instead ceased work when they reached their typical grade goal or did not start using tutorials until after they failed an exam. This *satisficing effect* (stopping when the grade was sufficient rather than maximized) has been referred to in the problem-solving literature as a typical adaptation given limits on time, knowledge, and resources (Simon, 1956; Starbuck, 1963). According to Simon's theory, students would resolve competing goals of varying importance, recognizing that all outcomes need not be maximized. The student's personal level of aspiration would constitute a ceiling effect based on the learner's grade objective, rather than the maximum possible score. Because this study used cumulative GPA in the model, the effect of the learning innovation would disappear if the learner ceased learning once the grade approached the learner's historical grade objective. To my knowledge, a satisficing effect for grades has not been investigated in the literature, although studies have reported that supplemental instruction seems to help students get a "C" and avoid "D" or "F," more than it propels them to earn higher grades (Moore & LeDee, 2006).

Another possible reason for the small learning effect is the pattern of practice in the tutorials. While blocked practice, where similar problems are presented together, reduces errors during learning, random practice leads to better retention and transfer (Carlson & Yaure, 1990). Although the tutorials were intended to make initial learning faster for weak or tentative students, the learning effect might be stronger if the tutorials

included some mixed practice sets and cumulative problems. This would increase the level of difficulty and help students learn to switch among course topics on a cumulative final exam.

The tutorial set contained three tutorials per chapter, a total of 27, or approximately 81 minutes of instruction and about 100 minutes of worked examples. The length of the entire tutorial set was comparable to about two lectures. If the students froze the video while they worked the problems (as they were encouraged to do), and then viewed the worked-out solutions, it likely extended their time on task. It is not clear whether more tutorials would have yielded stronger learning effects. Given the high use rates (more than 30 views), students may well have benefitted from more tutorials.

WEAKNESSES AND FUTURE WORK

Future studies could improve on Study 1 by using a randomized experimental design. The principal investigator served as course instructor in Study 1 had no control group. Tutorial users were likely more motivated than non-users, resulting in learning effects potentially being confounded with motivation level. Although prior research suggests that GPA controls for the self-selection bias (Fayowski & MacMillan, 2008), users may differ from non-users in ways other than prior achievement.

While the 71 percent participation rate was remarkable, especially without course credit for tutorial use, students were not asked which aspects of the tutorials were most appealing or most useful. Teasing out the motivating aspects from the instructionally effective aspects would inform the design of future tutorials. Another tutorial design objective was to help math anxious students. A study testing whether students that used the tutorials became more confident and less anxious may indicate whether tutorial use

reduces the intimidation associated with accounting topics, and whether tutorial use prompts other academically adaptive behaviors.

Another design objective for the tutors was to break down complex ideas into smaller pieces, making learning easier for lower aptitude students. The tutorials may have been too easy to affect exam grades appreciably. A future study could improve on this design by offering tutorials at two different levels of difficultly. This would give novices a chance to build skill at the easy level, but also develop skills for responding to more complex exam questions.

Future tutorials may be able to increase the learning effect by changing the practice pattern. The basic-level tutorials could retain the blocked practice to make initial learning easy, and a second set of tutorials could afford practice on more advanced cumulative problems over randomized topics. This would not only respond to the finding that novices need to transition to more difficult work after initial learning but might also shed light on the satisficing effect. If students only study to their grade objective (satisficing effect), perhaps the challenge set would not achieve the level of activity of the basic set.

Prior work suggests that failing students are caught in a paradox–they need the structure of lectures and deadlines to stay motivated, yet they resist instructor control (Gracia & Jenkins, 2002). Future work might reveal whether learner control and structured content in the tutorials helps meet these contrasting needs.

Many studies of supplemental instruction find that students who participate have higher re-enrollment rates than non-participants (Congo & Schoeps, 1993). Tracking participants to future terms to see if momentum gained from practicing self-regulated

learning (voluntarily working through a series of learning steps in the tutorials) improves future habits and academic success would be insightful.

CONCLUSION

This study presents great news for students, instructors, and administrators. Students, especially the poorly motivated ones, can appreciate that with 24/7 convenience and relatively modest effort (viewing 30 or so three-minute tutorials and working out problems at the end of them), they can improve their probability of passing significantly. Furthermore, for weak students who often do not seek help, the tutorials offer as many repeated views as needed without stigma and without having to first ask for them (Yates, 2005). This study confirms that student effort in principles of accounting courses can improve pass rates even with low ability (Wooten, 1996) and that a modest set of on-line tutorials can contribute to achieving that objective.

Instructors will be encouraged that principles of accounting students are willing to work harder, even without course credit, and that once tutorials are in place, they do not add to instructor workload each term. Furthermore, the innovation works across student type (full-time, part-time, and transient) and student ability (low, middle, and high achievers), relieving them from having to customize the set.

For administrators, once created, tutorials can be a perennial resource used year after year to improve retention in large enrollment courses regardless of class format, instructor types, or student achievement levels, and without adding to the workload of faculty. Creating the initial set of tutorials requires faculty labor, but compared to other tutoring options, involving hiring, training, and compensating human tutors, the securing of meeting space, and the coordination of tutoring sessions, investing in the creation of a

set of basic tutorials looks reasonable. This work brings into question the notion that supplemental instruction that improves student retention needs to be a full-featured program with term-long schedules, two-way communication, and individualized scaffolding (Congo & Schoeps, 1993; Fayowski & MacMillan, 2008; D. C. Martin & Blanc, 2001).

The innovation's success across many instructors each term and persisting for six terms without coordinated promotion sends a strong message that these tutorials make a difference to all stakeholders: those who need to pass and those who wish they would.

REFERENCES

Ainsworth, P., D. Deines, D. R. Plumlee, and C. X. Larson. 2003. *Introduction to accounting: An integrated approach*. 3rd ed. New York, NY: McGraw-Hill.

Ashcraft, M. H., and J. A. Krause. 2007. Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review* 14 (2): 243-248.

Ayres, P. 2006. Impact of reducing intrinsic cognitive load on learning in a mathematical domain. *Applied Cognitive Psychology* 20: 298-298.

Benson, J. 1989. Structural components of statistical test anxiety in adults: An exploratory model. *Journal of Experimental Education* 57 (3): 247-261.

Blanc, R. A., L. E. DeBuhr, and D. C. Martin. 1983. Breaking the attrition cycle: The effects of supplemental instruction on undergraduate performance and attrition. *The Journal of Higher Education* 54 (1): 80-90.

Boekaerts, M. 1997. Capacity, inclination, and sensitivity for mathematics. *Anxiety, Stress and Coping* 10: 5-33.

Bueschel, A. C. 2008. Listening to students about learning: The Carnegie Foundation for the Advancement of Teaching.

Byrd, S. D., and D. B. Byrd. 1987. Utilizing task analysis and sequencing in order to more efficiently teach financial accounting. *Issues in Accounting Education* 2 (2): 349-360.

Byrn, M., and B. Flood. 2005. A study of accounting students' motives, expectations and preparedness for higher education. *Journal of Further and Higher Education* 29 (2): 111-124.

Carlson, R. A., and R. G. Yaure. 1990. Practice schedules and the use of component skills in problem solving. *Journal of Experimental Psychology* 16 (3): 484-496.

Congo, D. H., and N. Schoeps. 1993. Does Supplemental Instruction Really Work and What is It Anyway? *Studies in Higher Education* 18 (2).

Daroca, F. P., and M. M. Nourayi. 1994. Some performance and attitude effects on students in managerial accounting: Lecture vs. self-study courses. *Issues in Accounting Education* 9 (2): 319-329.

De Lange, P., T. Suwardy, and F. Mavondo. 2003. Integrating a virtual learning environment into an introductory accounting course: determinants of student motivation. *Accounting Education* 12 (1): 1-14.

Dowling, C., J. M. Godfrey, and N. Byles. 2003. Do hybrid flexible delivery teaching methods improve accounting students' learning outcomes? *Accounting Education* 12 (4): 373-391.

Eccles, J. S., and C. Midgley. 1990. Changes in academic motivation and self-perception during early adolescence. In *From childhood to adolescence*, edited by R. Montemayor, G. R. Adams and T. P. Gullotta. Thousand Oaks, CA: Sage Publications, Inc.

Edmonds, T. P., and R. M. Alford. 1989. Environmental complexity and the level of information processing by introductory accounting students. *Issues in Accounting Education* 4 (2): 345-358.

Elikai, F., and J. Baker. 1988. Empirical evidence on the effectiveness of quizzes as a motivational technique. *Issues in Accounting Education* 3 (2): 248-254.

Etter, E. R., S. L. Burmeister, and R. J. Elder. 2000. Improving student performance and retention via supplemental instruction. *Journal of Accounting Education* 18: 355-368.

Fayowski, V., and P. D. MacMillan. 2008. An Evaluation of the Supplemental Instruction Programme in a First Year Calculus Course. *International Journal of Mathematics Education in Science and Technology* 39 (7): 843-855.

Gee, J. P. 2003. *What Video Games Have to Teach Us About Learning and Literacy*. New York: Palgrave Macmillan.

Gist, M. E., C. Schwoerer, and B. Rosen. 1989. Effects of alternative training methods on self-efficacy and performance in computer software training. *Journal of Applied Psychology* 74 (6): 884-891.

Gottfried, A. E., G. A. Marcoulides, A. W. Gottfried, P. H. Oliver, and D. W. Guerin. 2007. Multivariate latent change modeling of developmental decline in academic intrinsic math motivation and achievement: Childhood through adolescence. *International Journal of Behavioral Development* 31 (4): 317-327.

Gracia, L., and E. Jenkins. 2002. An exploration of student failure on an undergraduate accounting programme of study. *Accounting Education* 11 (1): 93-107.

Greer, L. 2001. Does changing the method of assessment of a module improve the performance of a student? *Assessment & Evaluation in Higher Education* 26 (2): 127-138.

Hackett, G. 1985. Role of mathematics self-efficacy in the choice of math-related majors of college woman and men: A path analysis. *Journal of Counseling Psychology* 32 (1): 47-56.

Halabi, A. K., J. E. Tuovinen, and A. A. Farley. 2005. Empirical evidence on the relative efficiency of worked examples versus problem-solving exercises in accounting principles instruction. *Issues in Accounting Education* 20 (1): 21-32.

Hembree, R. 1990. The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education* 21 (1): 33-46.

Hox, J. 2002. *Multilevel Analysis*. Mahwah, New Jersey: Erlbaum.

Huang, T.-H., Y.-C. Liu, and C.-Y. Shiu. 2008. Construction of an online learning system for decimal numbers through the use of cognitive conflict strategy. *Computers & Education* 50: 61-76.

Jones, J. P., and K. T. Fields. 2001. The role of supplemental instruction in the first accounting course. *Issues in Accounting Education* 16 (4): 531-547.

Kachelmeier, S. J., J. D. Jones, and J. A. Keller. 1992. Evaluating the effectiveness of a computer-intensive learning aid for teaching pension accounting. *Issues in Accounting Education* 7 (3): 164-178.

Karabenick, S. A., and J. R. Knapp. 1988. Help Seeking and the Need for Academic Assistance. *Journal of Educational Psychology* 80 (3): 406-408.

———. 1991. Relationship of Academic Help Seeking to the Use of Learning Strategies and Other Instructional Achievement Behavior in College Students. *Journal of Educational Psychology* 83 (2): 221-230.

Kim, Y., A. L. Baylor, and P. Group. 2006. Pedagogical agents as learning companions: The role of agent competency and type of interaction. *Journal of Computer Assisted Learning* 54 (3): 223-243.

Korner, C. 2005. Concepts and misconceptions in comprehension of hierarchical graphs. *Learning and Instruction* 15: 281-296.

Kruck, S. E., and D. Lending. 2003. Predicting academic performance in an introductory college-level IS course. *Information Technology, Learning and Performance Journal* 21 (2): 9-15.

Lane, A., and M. Porch. 2002. Computer aided learning (CAL) and its impact on the performance of non-specialist accounting undergraduates. *Accounting Education* 11 (3): 217-233.

Marriott, P., and A. Lau. 2008. The use of on-line summative assessment in an undergraduate financial accounting course. *Journal of Accounting Education* 26: 73-90.

Martin, D. C., and R. Blanc. 2001. Video-Based Supplemental Instruction. *Journal of Developmental Education* 24 (3).

Martin, E., P. Evans, and E. Foster. 1995. The use of videos in the teaching of accounting. *Accounting Education* 4 (1): 77-86.

Maurer, R. 2004. *One Small Step Can Change Your Life: The Kaisen Way*. New York: Workman Publishing.

Mayer, R. E., A. Mathias, and K. Wetzell. 2002. Fostering understanding of multimedia messages through pre-training: Evidence for a two-stage theory of mental model construction. *Journal of Experimental Psychology: Applied* 8 (3): 147-154.

McInnes, W. M., D. Pyper, R. Van Der Meer, and R. A. Wilson. 1995. Computer-aided learning in accounting: educational and managerial perspectives. *Accounting Education* 4 (4): 319-334.

Meece, J. L., A. Wigfield, and J. S. Eccles. 1990. Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology* 82 (1): 60-70.

Middleton, M. J., and C. Midgley. 2002. Beyond motivation: Middle school students' perceptions of press for understanding in math. *Contemporary Educational Psychology* 27: 373-391.

Miller, S. P., and C. D. Mercer. 1997. Educational aspects of mathematics disabilities. *Journal of Learning Disabilities* 30 (1): 47-56.

Moore, R. 2008. Who's Helped by Help-Sessions in Introductory Science Courses? *The American Biology Teacher* 70 (5): 269-273.

Moore, R., and O. LeDee. 2006. Supplemental Instruction and the Performance of Developmental Education Students in an Introductory Biology Course. *Journal of College Reading and Learning* 36 (2): 9-20.

Muller, D. A., J. Bewer, M. D. Sharma, and P. Reimann. 2007. Saying the wrong thing: Improving learning with multimedia by including misconceptions. *Journal of Computer Assisted Learning* 24: 144-155.

Multon, K. D., S. D. Brown, and R. W. Lent. 1991. Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology* 38 (1): 30-38.

Pajares, F., and D. Miller. 1994. Role of Self-Efficacy and Self-Concept Beliefs in Mathematical Problem Solving: A Path Analysis. *Journal of Educational Psychology* 86 (2): 193-203.

Parker, J. E., and B. M. Cunningham. 1998. Using an electronic tutorial to enhance students' knowledge of advanced tax accounting. *Issues in Accounting Education* 13 (2): 395-407.

Potter, B. N., and C. G. Johnston. 2006. The effect of interactive on-line learning systems on student learning outcomes in accounting. *Journal of Accounting Education* 24: 16-34.

Ramirez, G. M. 1997. Supplemental Instruction: The Longterm Impact. *Journal of Developmental Education* 21 (1).

Raudenbush, S. W., and A. S. Bryk. 2002. *Hierarchical Linear Models: Applications and Data Analysis Methods*. Thousand Oaks, CA: Sage.

Siegel, R. G., J. P. Galassi, and W. B. Ware. 1985. A comparison of two models for predicting mathematics performance: Social learning versus math aptitude-anxiety. *Journal of Counseling Psychology* 32 (4): 531-538.

Siegler, R. S. 2003. Implications of cognitive science research for mathematics education. In *A research companion to principles and standards for school mathematics*, edited by J. Kilpatrick, W. B. Martin and D. E. Schifter. Reston, VA: National Council of Teachers of Mathematics.

Simon, H. A. 1956. Rational choice and the structure of the environment. *Psychological Review* 63 (2): 129-138.

Simpson, M. L., C. R. Hynd, s. L. Nist, and K. I. Burrell. 1997. College Academic Assistance Programs and Practices. *Educational Psychology Review* 9 (1): 39-87.

Singer, J. D., and J. B. Willett. 2003. *Applied Longitudinal Data Analysis*. New York: Oxford University Press.

Smith, J. P. I., A. A. diSessa, and J. Roschelle. 1993. Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The journal of the learning sciences* 3 (2): 115-163.

Starbuck, W. H. 1963. Level of Aspiration. *Psychological Review* 70 (1): 51-60.

Stone, D. N. 1994. Overconfidence in initial self-efficacy judgments: Effects on decision processes and performance. *Organizational Behavior and Human Decision Processes* 59: 452-474.

Stone, D. N., V. Arunachalam, and J. S. Chandler. 1996. An empirical investigation of knowledge, skill, self-efficacy and computer anxiety in accounting education. *Issues in Accounting Education* 11 (2): 345-376.

Sweller, J., and P. Chandler. 1994. Why some material is difficult to learn. *Cognition and Instruction* 12 (3): 185-233.

Thiel, T., S. Peterman, and M. Brown. 2008. Addressing the crisis in college mathematics: Designing courses for student success. *Change* July/August 2008: 44-49.

Topping, A. J. 1996. The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education* 32: 321-345.

Turner, K. G., V. P. Lesseig, and J. G. J. Fulmer. 2006. Motivation in the first accounting course. *CPA Journal*: 66-69.

Wells, P., P. de Lange, and P. Fieger. 2008. Integrating a virtual learning environment into a second-year accounting course: determinants of overall student perception. *Accounting & Finance* 48: 503-518.

Wooten, T. C. 1996. Factors influencing student learning in introductory accounting classes: A comparison of traditional and nontraditional students. *Issues in Accounting Education* 13 (2): 357-373.

Xu, Y., S. Hartman, and M. Guillermo. 2001. The Effects of Peer Tutoring on Undergraduate Students' Final Examination Scores in Mathematics. *Journal of College Reading and Learning* 32 (1): 22-31.

Yates, G. C. R. 2005. "How obvious": Personal reflections on the database of educational psychology and effective teaching research. *Educational Psychology* 25 (6): 681-700.

Zimmerman, B. J., and M. Martinez-Pons. 1990. Student differences in self-regulated learning: Relating grade, sex and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology* 82 (1): 51-59.

APPENDIXES

APPENDIX A

Digital Tutor Topics by Chapter (Ainsworth, et al., 2003)[3]

Time Value of Money

1. How to solve a lump-sum present or future-value problem
2. How to distinguish between lump sum and annuity problems
3. How to solve an annuity prevent or future value problem

Planning for Investing

4. Cost of Capital
5. Rate of return, internal rate of return, and net present value
6. Using net present value to compute the value of a long-term asset

Planning for Equity Financing

7. Partnership accounting
8. Accounting for issuing stock
9. Accounting for cash and stock dividends

Planning for Debt Financing

10. Lump sum notes (interest and principal paid at end)
11. Periodic notes (mortgages or installment notes)
12. Interest only notes

Recording and Communicating Operational Investing Activity

13. Computing asset costs (basket purchases, items excluded from cost)
14. Depreciation methods
15. Asset disposals

Firm Performance: Profitability

16. Operating earnings
17. Extraordinary items
18. Earnings per share

---

[3] A sample Digital Tutor:
http://hollywood.gsu.edu/video/acc/acccws/Ch_18_Balance_Sheet/index.html

Firm Performance: Financial Position

19. Classified balance sheet basics
20. Using adjunct and contra accounts
21. How to diagnose and solve when you are out of balance

Firm Performance: Cash Flows

22. Classifying by operating, investing and financing
23. Distinguishing between cash and accrual basis items
24. Indirect method of presenting operating cash flows

Firm Performance: A comprehensive Evaluation

25. Profitability ratios
26. Liquidity and solvency ratios
27. Productivity ratios

CHAPTER 2

A LOW MAINTENANCE SOLUTION FOR IMPROVING RETENTION: SHORT TUTORIALS AIMED AT ENGAGING THE BOTTOM OF THE GRADE CURVE IN ELEMENTARY STATISTICS

Introduction

Many students find math-related material complex and hard to learn, generally starting with middle school and continuing through college level (Ashcraft & Krause, 2007; Eccles & Midgley, 1990; Gottfried, et al., 2007; Hembree, 1990; Miller & Mercer, 1997; Multon, et al., 1991). This difficulty often translates into poor grades which lowers self-confidence in math-related tasks (Pajares & Miller, 1994), creates math anxiety (Hembree, 1990) and causes struggling students to avoid math (Boekaerts, 1997; Meece, et al., 1990). By college, less confident and anxious students shun math-related classes and majors (Hackett, 1985). When forced by degree requirements to enroll in a math-related course, students often exhibit the classic avoidance behaviors: they do not attend class, do not complete the homework, and do not seek help (Kim, et al., 2006; Middleton & Midgley, 2002; Zimmerman & Martinez-Pons, 1990). These dysfunctional academic responses result in poor grades, confirming their self beliefs that they are terrible at math.

While the digital age has made a vast array of supplemental instruction available to assist low-achieving math students, voluntary participation is low (R. Blanc, L. E. DeBuhr, & D. C. Martin, 1983; Simpson, et al., 1997). This study examined a low-maintenance supplemental instructional innovation designed to turn around this self-

defeating cycle by motivating effort, increasing course learning, and improving student confidence in their ability. Unlike most full-featured supplemental instruction, this innovation, once developed, requires no administration or faculty effort.

Math Self-Efficacy Impacts Math Performance

Student beliefs about their math ability, or math self-efficacy, impact their math performance in surprisingly strong ways. While motivation, abilities, and strategies are likely inextricably bound together in predicting math performance, math self-efficacy wields particular power because students who believe they are not good in math avoid the learning task, give up more easily, experience more stress under demanding circumstances, and set fewer academic goals (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996; Bates & Khasawneh, 2007; Linnenbrink & Pintrich, 2003). When lack of confidence suppresses academic activity, ability does not get employed as it might in a more confident student (Wigfield, Eccles, Schiefele, Roeser, & Deavis-Kean, 2006).

The link between math self-efficacy and math achievement shows up in middle school (Boekaerts, 1997; Frenzel, Pekrun, & Goetz, 2007; Pajares, 1996; Whang & Hancock, 1994), persists through high school (Beal, Qu, & Lee, 2008; Greene, DeBacker, Ravindran, & Krows, 1999; Koutsoulis & Campbell, 2001; Pajares & Miller, 1995; Randhawa, Beamer, & Lundberg, 1993; Steinmayr & Spinath, 2008) and continues in college (Gist, et al., 1989; Pajares & Miller, 1994; Siegel, et al., 1985). While confidence in one's ability naturally rises and falls with success and failure, task confidence is informed only partially by actual skills and accomplishments (Bandura, 1986; Cooper & Robinson, 1991; Finney & Schraw, 2003; Gutman, 2006; Matsui, Matsui, & Ohnishi, 1990; Meece, et al., 1990; Pajares, 1996; Pajares & Kranzler, 1995;

Pajares & Miller, 1994, 1995; Pintrich & Schunk, 1996). In a recent longitudinal study of 5,649 seventh graders in Germany, math self-efficacy had a strong impact on math grades and test scores, even after controlling for interest, prior math grades, and prior math scores (Marsh, Trautwein, Ludtke, Koller, & Baumert, 2005). In a path analysis of high school students, math self-efficacy accounted for 35% or more of the variance in math problem-solving, much higher than cognitive ability and prior math grades (Pajares, 1996).

Math Anxiety Tied to Math Self-Efficacy

Some studies assert that math anxiety is related to math self-efficacy and has a separate impact on math performance. While general test anxiety depresses performance in all domains, general test anxiety and math anxiety are different but correlated constructs (Benson, 1989). In a meta-analysis, math anxiety was related to enjoyment of math and self-confidence in math ability (math self-efficacy), rather than directly to math achievement (Hembree, 1990). Other authors suggest that math anxiety is a global response to a mix of variables such as prior achievement, beliefs about ability, general test anxiety, and importance of the task rather than a separate unrelated construct (Benson, 1989; Meece, et al., 1990; Randhawa, Beamer, & Lundberg, 1993)

Improving Competence for Students with Low Math Achievement

Clearly, math self-confidence cannot improve in any stable way until competence improves (Meece, et al., 1990). Higher achievement consistently accompanies a reduction in math anxiety (Benson, 1989; Hembree, 1990). While the motivational literature documents how learning helps improve math self-efficacy and math anxiety, it offers few instructional choices associated with these shifts.

Increasing competence for the entire class is the instructor's goal, but classroom studies tracking improvements in confidence or math anxiety are few and not encouraging. In an introductory astronomy course, adding hand-on exercises to lectures improved learning but lowered self-efficacy (Hemenway, Straits, Wilke, & Hufnagel, 2002). Of course, the shift in self-efficacy in this instance could reflect a closer calibration of ability, since the students may have been new to astronomy. In Hembree's (1990) meta-analysis on math anxiety studies, whole class treatments designed to increase confidence or reduce nervousness were not effective. Only individual assistance with managing emotionality or with completing math tasks reduced math anxiety.

Math teachers who provide instruction for entire classes are held accountable for covering prescribed curricula, so individual attention may not be feasible, especially when the classes are large. When instructors decide to "go on" to the next topic, students who fail to understand earlier ideas are further disadvantaged, because math is a hierarchical domain with later ideas built on earlier concepts (Miller & Mercer, 1997). As a course routine, building in a process for remediation, re-teaching, and individualization should help less confident math students (Yates, 2005). Fortunately, remedial math students respond to a variety of media used to convey supplemental instruction. In a study of 164 remedial college algebra students, half taking the course fully on-line and half attending a traditional classroom, class setting was not a significant variable in the model (Spence & Usher, 2007). So, instructional tutorials designed to teach basic concepts may help students build a collection of critical facts, procedures, and concepts, and may help them feel more competent.

Mathematical knowledge is a complex system of related elements, potentially taxing short-term memory for novices who have not yet systematically linked ideas together, or know a large body of facts (Smith, et al., 1993; Sweller & Chandler, 1994). Grain size of concepts in math and science has typically been too few and too large, especially for those with less experience in the concepts being taught. Learning math incrementally, i.e., breaking down complex ideas into smaller parts, maximizes mastery (Ayres, 2006; Smith, et al., 1993). That is, students may better build expertise one nugget at a time and later assemble the parts into a cohesive interrelated model (Ayres, 2006; Mayer, et al., 2002; Sweller & Chandler, 1994). Weak math students cannot hold as much numerical information in working memory as stronger math students (Siegler, 2003). So, course designers may help beginners, weaker, or less confident students by using a "knowledge in pieces" approach, so they can succeed with smaller bits and build up a base of knowledge to be used for more complex assignments. Smaller pieces would give uneasy students a lighter processing load, more opportunities to feel competent, and potentially more chances to calibrate their ability realistically.

Math understanding has procedural and conceptual aspects. Students might understand the process, but not the concept, or the concept, but not the process. Lapses in either lead to systematic errors that can be detected, diagnosed, and corrected (Siegler, 2003). Novices are particularly vulnerable to flawed ideas and partial understandings (Smith, et al., 1993). Work targeting misconceptions is promising. University students interpreting graphs did better with "more instruction" versus "less," but the biggest performance gains came from information about possible misconceptions (Korner, 2005). College students with low prior knowledge gained more from explicit instruction of

misconceptions than from additional lectures (Muller, et al., 2007). In a study of middle school math students, computer instruction on misconceptions led to significant improvement in initial learning, and the students retained the learning better four weeks later (Huang, et al., 2008).

Refinement and organization of previously introduced ideas can be better than adding a new layer of information to unstable existing knowledge, especially for novices. Coaching students on actual or typical misconceptions, however, is not the norm. A study of 90 teachers working with low ability math students showed that only half of them could identify misconceptions, even fewer could identify the most common errors and only about 30% of them changed instruction to address the errors (Smith, et al., 1993). The majority of the teachers chose to re-teach basic facts, even after learning about misconceptions. Cognitive scientists have suggested having students explain why some answers are wrong in addition to why answers are right, in order to flush out misconceptions more thoroughly (Siegler, 2003).

Low math achievers need special guidance to reduce anxiety and improve math performance, thereby increasing successful trials (Matsui, et al., 1990). However, the weaker students are less likely to ask for the needed help (Zimmerman & Martinez-Pons, 1990) and are more likely to have adopted performance-avoidance behaviors (Hsieh, Sullican, & Guerra, 2007). Proactive help can offset low prior knowledge and give confidence to low self-efficacy learners, who might not otherwise request assistance. In a college computer literacy class, students receiving coaching at the onset of a new topic outperformed those that received guidance only when they requested it (Kim, et al.,

2006). Thus, providing supplemental assistance without waiting for requests may help low-achieving students.

Supplemental Instruction

Decades of work consistently shows that extra instruction, in all its various forms, works to some degree, with effect sizes varying depending on the match of the resource to the learner (Congo & Schoeps, 1993; Simpson, et al., 1997). Help with study strategies, special lectures, peer discussions, study sessions or tutoring all increase time on task and thereby enhance learning compared to students who do not receive the extra assistance (Simpson, et al., 1997). While quality instruction has traditionally been labor intensive, computer access has made it possible to build a vast array of ready-built on-line resources to supplement classrooms. A review of 254 studies shows that computer instruction helps (Kulik & Kulik, 1991).

The issue with supplemental instruction is not whether it works, but how to get students to use it (Simpson, et al., 1997). Students that self-select into extra instruction are more motivated (R. Blanc, et al., 1983). Low achievers may not only be poorly motivated, but may also shun the stigma attached to remedial work, adding to the problem of getting them to self-select into extra instruction (Karabenick & Knapp, 1988; Moore & LeDee, 2006). While disengaged and underperforming students often do not volunteer for supplemental instruction, what does seem promising is that low-achieving students whose typical mode is passive, once exposed to useful teaching innovations, are often quick to adopt them, learn, and feel more confident as a result (Bueschel, 2008). So the main hurdle with supplemental instruction is to get the passive, weak, or unsure students to *engage*—to sample the supplemental resources and be successful using them.

The purpose of this study was to test supplemental instruction designed to solve the biggest hurdle—passivity—and then to deliver quality instruction targeted at the needs of lower achieving students.

Design of Innovative Supplemental Instruction

This study assessed supplemental instruction consisting of a set of on-line tutorials called "Digital Tutors." The key design features of the tutorials came from suggestions in both the motivational and cognitive literatures. For instance, motivational literature predicts that traditional supplemental instruction such as extra lectures, online course textbook supplements, learning communities, peer tutoring, and extra practice opportunities will not interest discouraged and poorly motivated students, as these all require considerable extra effort (Linnenbrink & Pintrich, 2002; Simpson, et al., 1997). To attract the tentative or passive math students, the instruction should require a small effort, but also be distinctly different from traditional course supplements (Bueschel, 2008). The unique attention-getting promise that was designed to attract less confident and less able students was the ultra-short length of the Digital Tutors: just three minutes. In addition, easy access (available anywhere there is an Internet connection, 24/7) minimized the effort needed to participate.

The second major aspect of the design was to create instruction that would meet the cognitive needs of weak learners, so that their first engagement with the innovation would be successful. Cognitive load theory suggests that instruction for inexperienced learners should break down complex concepts and processes into small pieces to avoid overloading short-term memory, and that the instruction should avoid seductive details and busy screens (Sweller & Chandler, 1994). Therefore, each three-minute segment

emphasized one foundational idea using basic voice-over PowerPoint with no animation and minimal artwork. The instruction coached learners on the use of strategies that have been shown to help students achieve success and improve their confidence for future tasks (Linnenbrink & Pintrich, 2003). Where possible, the instruction included tips on how to avoid common misconceptions and errors (Korner, 2005; Muller, et al., 2007). To provide practice, feedback, and reinforcement immediately after the three-minute instruction, the student could view two or three worked-out problems, an easy one and then one or two harder ones. At the end of the practice, the learner was told "you now know __(concept/skill)__" and was encouraged to try another one or to go to the next logical topic.

In keeping with the motivational literature, the content of the tutorials focused on core ideas, skills, or processes immediately recognized by the student as something appearing on major exams (i.e., high-task value), and conveyed a sense of control (Pintrich & Schunk, 1996) by permitting them to watch, listen, or both, and start and stop anytime. To keeping with the literature on math-anxious students, the voice in the tutorials was warm, relaxed, and unhurried, and the tone conveyed confidence that this was do-able in short order with the use of a few strategies (Hembree, 1990).

While math topics typically build on each other, the instruction kept each topic as discrete as possible so the students could start anywhere in the course without needing to "start over." This was done in order to motivate participation as needed at any point in the semester. When this was not possible, the instruction indicated that the video built on an earlier one, and the learner needed to run through a prior tutorial first. As an

additional motivational aspect, the supplemental instruction included 15 critical skills for the entire course in order to avoid overwhelming students with the volume of material.

First Study

The first tutorial implementation in a Principles of Accounting II class (Spring 2007) was motivated by an extremely low course pass rate, ranging from 45-55% over several years. Tutorial participation during the first semester of use averaged 71.4%, and pass rates improved 20%, but the study found only a small improvement in exam scores for tutorial users, about three exam points (Sargent, 2009).

The small effect on exam scores in this study raised a number of questions. Did the basic tutorials only provide enough extra instruction to enable students to pass? Would additional tutorials with more challenging content lead to a larger learning effect? Did students use the tutorials to pass or reach only a modest grade goal, and then quit the extra instruction, making more advanced tutorials of little interest? In order to increase exam scores and test whether students were working only until their grade goal was met (satisficing effect), rather than using all resources possible to maximize their course grade, a more advanced set of tutorials was created for the current study.

The high participation rates in the first implementation raised questions about what features of the tutorials appealed most to students, especially the low achievers. Although the previous tutorials were designed to improve student confidence in math-related tasks, the prior study did not track changes in confidence. Thus, this study was designed to collect beginning and ending confidence measures and to survey users about tutorial features.

Since the accounting study was a campus project to increase pass rates, it lacked an experimental design. This study replicated the first implementation with random assignment and a control group.

The Current Investigation

This paper reports an implementation of "Digital Tutors" created for freshman elementary statistics, a course where there was already a vast array of extra instructional resources available to students. Students in the course had access to the Math Assistance Center (i.e., the Math Lab) on Monday-Thursdays, 9:00 a.m. – 7:00 p.m., which offered one-on-one tutoring and computer stations loaded with practice software. Students could also use on-line publisher resources such as quizzes, on-line lectures, on-line diagnostic study managers, slides, outlines, and extra practice problems with worked-out solutions. Further, twice a week during the lunch hour (when no classes are in session) the course coordinator provided homework help sessions open to students in any section. However, in spite of the impressive array of extra help, the course failure rate still averaged 20-30%.

The current study loaded tutorials onto WebCT, the campus learning management system, for randomly selected sections of elementary statistics (intervention sections), but not for others (control sections). This created three groups: (a) control students without access to tutorials; (b) users, students enrolled in the intervention sections who chose to view the tutorials; and (c) non-users, students enrolled in intervention sections with access to the tutorials, but chose not to use them.

This study analyzed a series of questions. First, would the high risk students (low achievers) use the tutorials?

H1: Participation rates for low achievers will be significant even without course credit.

Second, would the users be less likely to drop and more likely to pass than non-users and control students?

H2: Students using tutorials will be less likely to drop and more likely to pass than non-users and control students.

Third, would the exam scores, drop rates and course grades in the intervention sections (users and non-users combined) be better than the control sections?

H3: Intervention sections will outperform control sections on drop rates, exam averages and course grades.

Fourth, would the users see improved exam scores versus non-users and control students?

H4: Students using tutorials will have better exam grades than non-users and control students.

Finally, would users increase their math self-efficacy more than non-users and control students?

H5: Students using Digital Tutors will increase their math self-efficacy more than non-users and control students.

Methods

Participants

Participants were 1,411 students enrolled in 31 sections of freshmen elementary statistics, a math core elective and requirement for business and science majors at a large urban university with freshman SAT scores averaging 1050. Attributes of participants

are summarized by users, non-users, and control students in Table 8. Users had significantly more college level credit hours than nonusers and control students ($F = 3.79$, $p = .03$), but the three groups did not significantly differ on any other of the attributes reported in Table 8.

Table 8

Participant Attributes: Mean (SD)

Attribute	Users[a]	Non-Users	Intervention	Control
Number of participants	320	375	695	716
Percent female	58.4%	59.7%	59.1%	58.4%
SAT verbal[b]	517.46 (70.40)	521.77 (77.03)	518.98 (74.30)	521.09 (74.84)
SAT math[b]	525.17 (73.09)	527.30 (72.73)	526.41 (72.81)	527.06 (76.00)
Cumulative GPA[c]	2.93 (0.65)	2.85 (0.81)	2.88 (0.74)	2.83 (0.78)
College credit hours ($p < .05$)	69.40 (35.12)	62.11 (35.64)	65.47 (35.56)	65.74 (34.33)

[a] Opened two or more tutorials during term.

[b] Excludes transfer students, for which SAT scores are not required ($n = 430$, 54 non-users, 138 users and 238 control).

[c] Includes 11 transferred students who withdrew from all their classes leaving no GPA so their transfer GPA was used.

Procedure

The 31 sections of elementary statistics offered in Spring 2009 were randomly assigned to intervention and control sections by first stratifying sections into groups taught by the same instructor and then randomly assigning control and intervention by instructor. Instructors teaching only one section were randomly assigned to either control or intervention. After random assignment, the 21 instructors were notified about which of their sections, if any, would have tutorials loaded. Six full-time faculty, six visiting

instructors, and three graduate teaching assistants taught intervention sections. Four full-time faculty, seven visiting instructors, and five graduate teaching assistants taught control sections.

The departmental course coordinator distributed a common syllabus, exam requirements, course materials, teaching notes, learning objectives and minimum chapter coverage requirements to all instructors. Per departmental policy, instructors had to give a minimum of three exams and a cumulative final, although they could add additional exams and quizzes. Only one instructor gave a fourth exam, but most instructors added a series of small quizzes between exams. The department required every instructor to include one of the two departmental provided problems on the final exam.

During the first week of the semester, the author visited all intervention and control sections of elementary statistics, asking students to complete a survey of their math self-concept (a general impression of their confidence for math related tasks) and statistical self-efficacy (the confidence to complete a specific statistical course task) and introduced either the tutorials or the Math Lab. She told students in the intervention sections that they could try a new learning tool, “Digital Tutors,” and launched a tutorial to demonstrate how to use them. She asked students in the control sections to try the Math Lab, explaining the lab’s hours and services offered, and giving them directions to find the lab.

A set of 21 tutorial files were loaded into each intervention section’s learning management sytem (WebCT)--15 basic level tutorials (see Appendix B for a list of topics), and six advanced level tutorials. Students could open but not download the files, thereby permitting the capture of each view by student. The participants had no

knowledge of this tracking, and received no credit for using the tutorials or completing the practice problems offered after the instruction. The software captured the number of file launches but not length of time the file was open, so "tutorial use" was measured in number of launches or "views."

During the last week of the semester, the author again visited all sections and asked students to complete an end-of-semester measure of math self-concept and statistical self-efficacy and a survey on course resources used. At the end of the course, the technology team on campus summarized WebCT activity showing the number of views (launches) for each tutorial by student. At the end of the semester, all but one instructor of a control section submitted the course grades. The missing section exam scores were only partially recovered from a damaged file, so the hypothesis on exam grades was tested with only 30 sections of data.

Measures

Math Self-Concept

Math self-efficacy and math self-concept differ in their level of specificity. Math self-efficacy is the confidence for a particular task, that can vary considerably as tasks change, and was measured as statistical self-efficacy in this study. Math self-concept is the student's general impression of his/her ability in math, a more general measure across a wide variety of math-related tasks, and was measured in this study using a five-item survey from a study linking math self-concept to academic achievement that showed good reliability (αs>.8) (Marsh, et al., 2005). This survey asked students to rate themselves on a four-point Likert scale from strongly agree to strongly disagree on statements such as "I'm just not good at math" and "math topics are hard to understand."

In the current sample, beginning and ending math self-concept were significantly correlated, Pearson correlation = .723, p = < .001.

Statistical Self-Efficacy

Confidence for the specific course-related tasks in this study, statistical self-efficacy, was measured using 12 of 14 items on a survey from a prior study of elementary college statistics (Finney & Schraw, 2003). The factor analysis for the 14 item survey showed that the items in the prior study loaded primarily on one factor explaining 73.71% of the total variance, with no other factor having an eigenvalue of less than one. The two items that were removed were not learning goals of the course in this experiment. These items asked students to rate themselves on a six-point Likert scale on their "confidence to learn" (beginning of course) or "confidence to complete" (end of course) specific tasks such as explaining what standard deviation means, identify a skewed population distribution and selecting the correct statistical procedure to be used to test a research question. In this study's sample, beginning and ending statistical self-efficacy were significantly correlated, Pearson correlation = .367, p = < .001.

Grade Goal

One of the questions from the author's first study pertained to whether student goals created a low ceiling effect on exam grades. In order to examine how a grade goal impacts exam scores or tutorial use, students were asked via a survey if they "worked only until they achieved a sufficient grade goal and then moved to other priorities," "were just trying to pass," or they "worked to get the maximum possible grade." Students checking "yes" to "sufficient grade" or "just passing" were coded as "satisficers"; students checking "maximum possible" were coded as "maximizers."

Tutorial Use

This work defines a "user" as a student who viewed two or more tutorials. A review of tutorial launches showed that 82 students previewed the tutorials, viewing only one. Previewers were not included as users. The length of time the file was open was not captured, so the study defined "use" as "the number of file launches" (i.e., number of views) rather than minutes viewed.

Math Aptitude

Math aptitude was measured with Math SAT scores, which were available for students entering the university as first-term freshmen (N = 981, 69.5%), but not for students transferring from other institutions, N = 430, 30.5%.

Achievement

Cumulative grade point average (GPA) measured academic achievement. The GPA cutoffs for separating students into low and high achiever groups were selected as an amount above and below the mean GPA, which grouped approximately 25% of the participants in the low group and 25% in the high group. The cutoff used for the low GPAs was 2.4 or less (25.3% of the students) and a high GPA was 3.4 or higher (26.3% of the students). The correlation between GPA and Math SAT was low enough to permit including both variables in the same model, Pearson correlation = .174.

Exams

Students took either three or four exams during the semester, along with a cumulative final. All instructors wrote their own exams, but the department specified that all exams include at least 50% worked-out problems. All but one instructor indicated that they took some or all of their exam questions from the textbook publisher's test bank.

Tutorial Contents

The author selected the tutorial topics based on interviews of seasoned statistics faculty, the supervisor of the math lab on campus, and a review of the course syllabus. In the interviews, she probed the content experts for central topics that impacted cumulative understanding, common misconceptions, traditionally difficult areas, and helpful strategies. All interviewees mentioned eight of the 15 final topics, suggesting that there was general agreement on central topics and areas of difficulty. She selected the remaining topics based on a review of several popular elementary statistics textbooks, course learning goals published by the math department, and advice from the elementary statistics course coordinator. Appendix A shows five of the tutorial topics, along with a sample problem worked out in the slides. Appendix B lists all the tutorial topics.

The six advanced tutorials contained brief reviews of the major concepts and an assortment of challenge problems. The script helped the students identify the topic in each problem, discussed the appropriate strategy to solve it, and then worked through the steps towards a solution. The first three advanced tutorials included the typical chapters before each of the three exams (Note: There were slight variations by instructor in the chapters mapping to each exam.) Then the last three advanced tutorials included an assortment of all course topics intended to prepare students for the cumulative final exam.

The author created the slides and supporting scripts, but had no particular expertise in statistics (except a few courses during doctoral work). She occasionally consulted a few elementary statistics textbooks provided by major publishing houses, though not necessarily the required course text, to get a variety of problem types and explanations. The slides were not a repetition or summary of class lectures since she did

not attend any of the lectures. A graduate student recommended by the Math Lab supervisor reviewed each tutorial for errors, technical correctness, and instructional clarity.

Results

The data met the basic assumptions of normality with no range restrictions or outliers noted. Since users had significantly more college level credit hours than non-users and control students (see Table 8) ($F = 3.79$, $p = .03$), the analysis of exam scores and confidence measures included cumulative credit hours earned as a control variable.

Participation

Within the intervention section, 39.3% of the low achievers used the tutorials (Table 9). A greater proportion of middle achievers used tutorials (51.0%) compared to both low achievers (39.3%) and high achievers (43.1%), $\chi^2(2, N = 695) = 7.15$, $p = .03$. Of the low achievers who finished the course, 45.8% used the tutorials.

Table 9

Participation and Student Goals by Achievement Level for Students in Intervention Sections: Mean (SD)

	Cumulative GPA		
Attribute	Low: < 2.4	Middle	High: > 3.4
Participants in intervention sections	168	339	188
Participants using tutorials [a]	66	173	81
Percent using tutorials [a] ($p < .05$)	39.3%	51.0%	43.1%
Percent of users who opened advanced tutorials	31.3%	29.2%	26.1%
Average number of views per user	13.03 (12.5)	10.15 (9.2)	9.16 (8.9)

[a] Opened two or more tutorials during term.

The average user viewed 10.49 tutorials, about half of the tutorial set if each view was of a different file. Use of tutorials by topic in semester sequence (Figure 5) shows an initial surge of interest, and then strategic use by topic rather than consistent use across the full semester. Students viewed advanced files less often than basic topics, with the typical user viewing 2.49 advanced tutorials. The average number of advanced views did not differ among achievement levels, $F = 1.06$, $p = .37$.

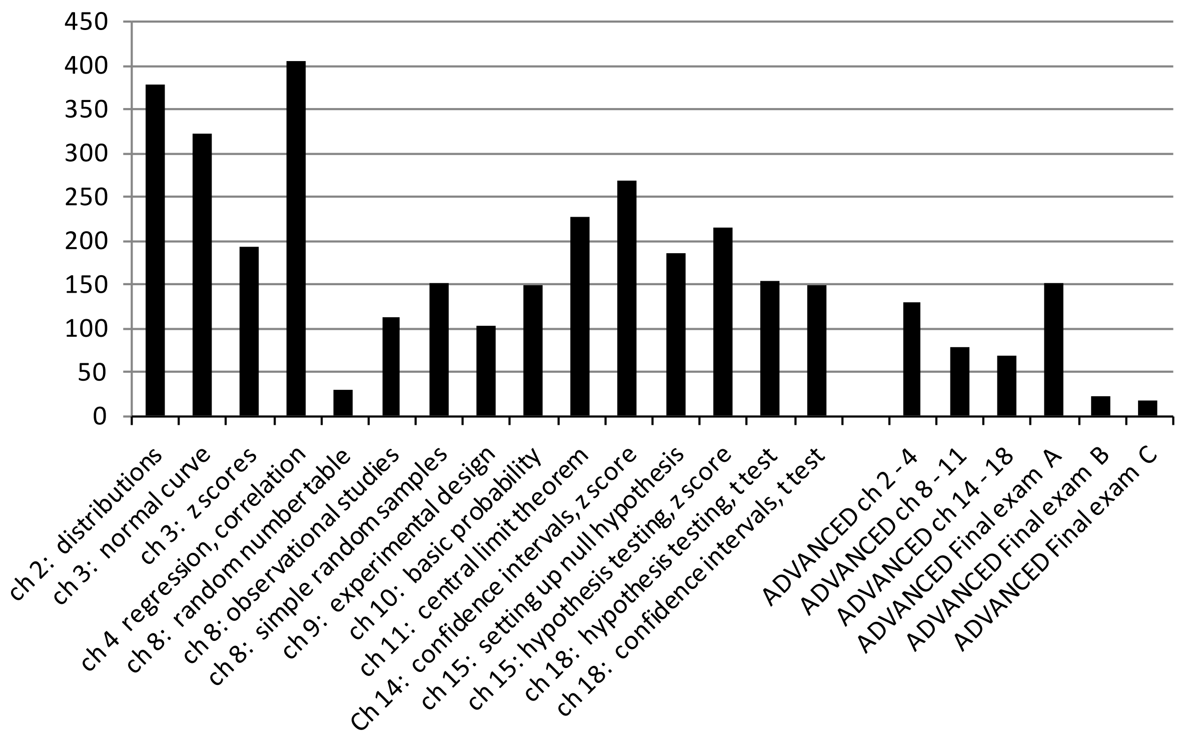


Figure 5. Number of tutorial views by topic in order of course syllabus

Impact of Tutorial Use on Drop Rate and Pass Rate

Figure 6 shows the grade distribution for users, non-users, and control students. The drop rate for users (9.1%) was significantly lower than both non-users (18.4%) and control students (16.2%), $\chi^2(2, N = 1{,}411) = 12.91$, $p = .002$. The pass rate of users

(83.1%) was significantly higher than non-users (72.8%) and students without access to tutorials (75.7%), $\chi^2(2, N = 1{,}411) = 103.51$, $p = .004$.

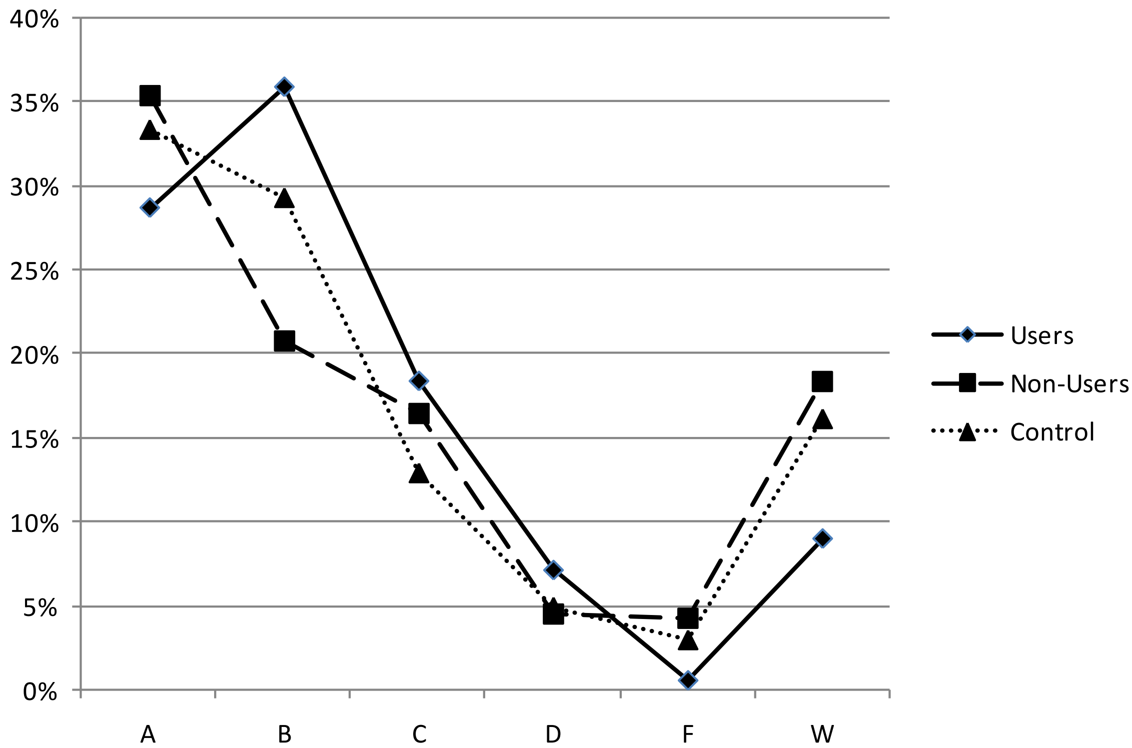


Figure 6. Grade distribution percents by group – all achievement levels

Users who dropped the course were more likely to have stayed long enough to take the first exam than non-users or control students who dropped the course, $\chi^2(2, N = 1{,}411) = 15.07$, $p < .001$. In a regression with passing (yes/no) as the dependent variable, group (user, non-user, control) as the explanatory variable, and GPA, Math SAT, and total credit hours accumulated as control variables, group was significant in predicting pass rates t = 2.65, p = .008.

For low achievers--those most at risk for dropping or not passing--the drop rate for users (18.2%) was significantly lower than the drop rate for both non-users (37.3%) and control students (33.3%), $\chi^2(2, N = 357) = 7.26$, $p = .03$. The low achieving users

had a significantly higher pass rate (63.7%) compared to both non-users (36.3%) and control students (44.4%), $\chi^2(2, N = 357) = 12.33$, $p = .002$. Low achieving users who dropped the course were more likely to take the first exam than low-achieving non-users or control students who dropped the course, $\chi^2(2, N = 357) = 9.75$, $p = .008$. The grade distribution for low achieving users, non-users, and control students (Figure 7) shows that fewer users dropped or failed compared to the other groups and users received more "C" grades than both the non-users and control students.

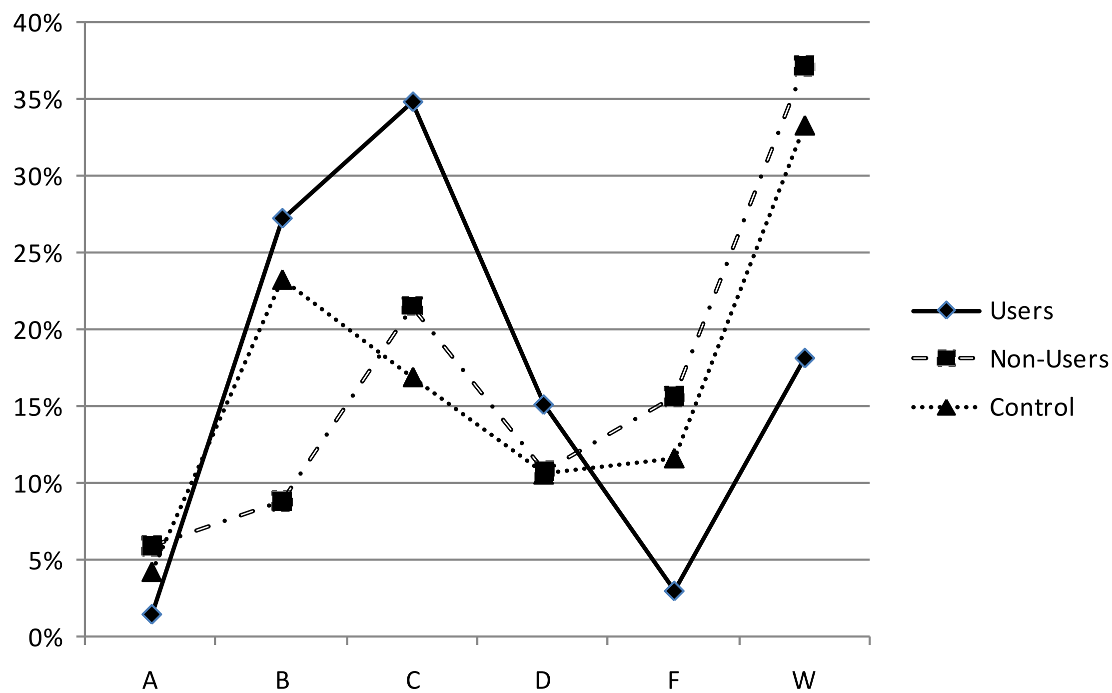


Figure 7. Grade distribution percents by group – low achievers only

Intervention versus Control Sections

The drop rate between intervention (14.1%) and control sections (16.2%) was not significantly different, $\chi^2(1, N = 1{,}411) = 1.21$, $p = .271$. A regression with exam average for students completing the course as the outcome variable, section (intervention or

control) as the predictor, and Math SAT, GPA, and credit hours accumulated as control variables shows that exam scores were slightly lower (*B* = -0.008 per tutorial view) for intervention sections, t = -2.74, $p = .006$. There is no practical effect of an exam score grade being less than one point lower. The grades assigned to students who completed the course were not significantly different between intervention and control students, $\chi^2(10, N = 1{,}196) = 11.18$, $p = .344$.

Impact of Tutorial Use on Exam Scores

Because control section instructor did not report exam grades due to a corrupt computer file, the analyses omits the 47 students in that section. The letter grades assigned in the omitted section did not differ significantly from the other sections ($\chi^2[10, N = 1{,}336] = 13.19$, $p = .21$) so there is no reason to believe this omission introduces bias.

Using hierarchical linear modeling (HLM), exam score growth over the semester was analyzed longitudinally as a function of tutorial use and instructor (Hox, 2002; Raudenbush & Bryk, 2002; Singer & Willett, 2003). Like traditional regression, HLM analyzes two aspects of the data, the intercept or starting point, in this case exam one, and the slope, the change in exam scores over the semester. HLM, however, permits nesting of exam scores and tutorial use within students and students within sections, something traditional regression does not permit.

The intercept revealed initial differences between students' exam scores, and the slopes showed changes in exam scores over time within each student and between students. The slopes can be divided into several components to model different influences on growth. The hypothesized model included an instructor component (to model different starting points due to different exams by instructor and growth unique to each student's

instructor), an intervention component (to model growth from tutorial views), and cumulative GPA, Math SAT, and cumulative credit hours (to model differential starting points in exam scores). The change over time and the impact of tutorial use were also predicted to be different for students using advanced tutorials. The formulas by level were:

Level 1:
$\text{ExamScore}_{tij} = \pi_{0ij} + \pi_{1ij}\,(\text{Time}_{tij}) + \pi_{2ij}\,(\text{TutUse}_{tij}) + e_{tij}$

Level 2:
$\pi_{0ij} = \beta_{00j} + \beta_{01j}\,(\text{GSUGPA}_{ij}) + \beta_{02j}\,(\text{Total Credit Hours}_{ij}) + \beta_{03j}\,(\text{SATMath}_{ij}) + r_{oij}$
$\pi_{1ij} = \beta_{10j} + \beta_{11j}\,(\text{AdvancedUse}_{ij}) + r_{1ij}$
$\pi_{2ij} = \beta_{20j} + \beta_{21j}\,(\text{AdvancedUse}_{ij}) + r_{2ij}$

Level 3:
$\beta_{00j} = \gamma_{000} + u_{00j}$
$\beta_{01j} = \gamma_{010}$
$\beta_{02j} = \gamma_{020}$
$\beta_{03j} = \gamma_{030}$

$\beta_{10j} = \gamma_{100} + u_{10j}$
$\beta_{11j} = \gamma_{110}$

$\beta_{20j} = \gamma_{200} + u_{20j}$
$\beta_{21j} = \gamma_{210}$

ExamScore_{tij}
$= \gamma_{000} + \gamma_{010}\,(\text{GSUGPA}_{ij}) + \gamma_{020}\,(\text{Total Credit Hours}_{ij}) + \gamma_{030}\,(\text{SATMath}_{ij})$
$+ \gamma_{100}\,(\text{Time}_{tij}) + \gamma_{110}\,(\text{AdvancedUse}_{ij})\,(\text{Time}_{tij})$
$+ \gamma_{200}\,(\text{TutUse}_{tij}) + \gamma_{210}\,(\text{AdvancedUse}_{ij})\,(\text{TutUse}_{tij})$
$+ u_{10j}\,(\text{Time}_{tij}) + u_{20j}\,(\text{TutUse}_{tij}) + r_{oij} + r_{1ij}\,(\text{Time}_{tij}) + r_{2ij}\,(\text{TutUse}_{tij}) + e_{tij}$

The HLM analysis did not proceed past the second model (Table 10). Model 1, the unconditional model, showed that the intercept, i.e., average exam one score of 79.18, $t(19) = 110.79$, differed significantly between students. It also indicated that the variances between students were statistically significant ($\tau_{\pi 00} = 136.86$, $\chi^2[1245] = 5008.19$, $p < .001$), as were the variances between instructors, $\tau_{\beta 00} = 6.83$, $\chi^2(19) = 69.10$, $p < .001$.

Model 2 added a variable for time (weeks). This shifted the predicted intercept upward and indicated that exam scores decreased on average 0.18 points per week during the semester, although time was not significant in the model. The between student variance of the slope was not statistically significant, $\tau_{\pi 11} = 0.02$, $\chi^2(1197) = 5008.19$, $p = .05$. Since the decrease in exam scores did not differ between students, no student-level predictors could explain the differential impact of time on the exam scores. However, the between instructor variance of the slope was statistically significant ($\tau_{\beta 11} = 0.16$, $\chi^2[19] = 183.55$, $p < .001$), indicating that some sections had growth in scores, but not others, likely reflecting unique testing patterns of instructors.

The lack of a significant slope coefficient, however, makes further analysis with the hypothesized model meaningless. The variances in Model 2 indicate that there are additional predictors that can explain the differences in the initial status. These predictors were student-level predictors ($\tau_{\pi 00} = 113.56$ $\chi^2[1197] = 1926.85$, $p < .001$), as well as instructor-level predictors, $\tau_{\beta 00} = 30.81$, $\chi^2(19) = 183.54$, $p < .001$. Differences in starting points were not a focus of this study, so the model was not expanded to investigate this aspect.[4]

Much of the tutorial use occurred before the first exam (Figure 5), removing much of the tutorial impact from the growth component of the HLM model, which uses the first score as the starting point. A regression run with average exam scores as the dependent variable, tutorial use as the predictor, and credit hours, cumulative GPA, and Math SAT as control variables (Table 11, Panel A), showed tutorial use was insignificant in

[4] A third model was run with cumulative GPA to explain different starting points and GPA was significant ($p < .001$) although the slope was still insignificant. This means that no additional predictors added to the slope of the model would improve the model. Further analysis for explaining the intercept was not a goal of this study.

Table 10
Longitudinal Analysis of Change in Exam Scores with Tutorial Use

	Model 1: Intercept		Model 2: + week	
Fixed Effects:	Coeff.	SE	Coeff.	SE
Intercept	79.18***	0.714	81.15***	1.369
Week			-0.18	0.099
Tutorial use[a]				
GPA[a]				
Math SAT[a]				
Total credit hours [a]				
Variance:				
Level 1				
Within person[#]	143.46		136.75	
Level 2				
Between persons in initial status	136.86***		103.56***	
Between persons in growth			0.02	
Level 3				
Between instructors in initial status	6.83***		30.81***	
Between instructors in growth			0.16***	

*** $p < .001$

There is no significance test in HLM for the within person variance.

[a] Because the slope for week was insignificant, adding variables to explain the slope would not improve the model

Table 11

Exam Average as a Function of Tutorial Use

Panel A: Low, middle and high achievers

Variable	*B*	*SE*	*β*	*t*	*p*
Constant	23.133	3.762		6.150	.000
Tutorial views	0.103	0.073	0.038	1.411	.159
Total credit hours	0.044	0.016	0.075	2.775	.006
Cumulative GPA	13.611	0.682	0.551	19.961	.000
Math SAT	0.023	0.006	0.098	3.547	.000

Model $R^2 = .340$

Panel B: Only low achievers

Variable	*B*	*SE*	*β*	*t*	*p*
Constant	20.393	10.198		2.000	.047
Tutorial views	0.379	0.158	0.161	2.407	.017
Total credit hours	0.039	0.047	0.059	0.835	.405
Cumulative GPA	12.051	3.090	0.270	3.901	.000
Math SAT	0.033	0.016	0.138	2.026	.044

Model $R^2 = .141$

explaining exam scores. Running this same regression for only low achievers showed tutorial use was significant as a predictor of average exam scores (Table 11, Panel B). The practical significance of this finding for low achievers was low to moderate; the *B* of

0.379 on tutorial use predicts exam scores will be 0.379 points higher per tutorial view. Since the average number of views was approximately 10, this translates into about four points per exam, enough to bump a student up to the next level in a plus/minus grading system.

Impact of Tutorial Use on Math Self-concept and Statistical Self-Efficacy

As seen in Table 12, a significant amount of data on math self-concept and math self-efficacy was missing due to absenteeism on one of the two survey dates and partially completed survey forms. The survey completion rate was significantly higher for users than for non-users and control students, $\chi^2(2, N = 1{,}115) = 14.87$, $p < .001$.

Table 12

Self-Efficacy Measures and Survey Data: Mean (SD)

Attribute	Users[a]	Non-Users	Control
Number of students	320	375	716
Completed beginning-of-course survey	265	281	567
Completed end-of-course survey	196	189	396
Completed both surveys	178	163	348
Beginning math self-concept [b]	1.85 (0.79)	1.91 (0.77)	1.83 (0.81)
Ending math self-concept [b]	1.82 (0.81)	1.99 (0.85)	1.91 (0.81)
Beginning statistical self-efficacy [b]	3.86 (1.29)	3.98 (1.33)	3.89 (1.25)
Ending statistical self-efficacy [b]	4.28 (0.85)	4.39 (0.96)	4.32 (0.94)
Had previous statistics class	37	42	67

[a] Opened two or more tutorials during term.

[b] A higher number equals a higher level of confidence.

As summarized in Table 12, beginning and ending math self-concept did not differ among users, non-users,, and control students, $F = 0.97$, $p = .38$ and $F = 2.08$, $p = .13$. Beginning and ending statistical self-efficacy did not differ among users, non-users, and control students, $F = 0.63$, $p = .54$ and $F = 0.90$, $p = .41$. There was a significant correlation between beginning confidence in statistical self-efficacy and having a prior course in statistics, Pearson correlation = .157, $p = < .01$.

A regression with ending math self-concept as the dependent variable, tutorial use and beginning math self-concept as explanatory variables, and cumulative GPA, Math SAT, and credit hours as control variables, found that math self-concept decreased with tutorial use, t = -2.368, $p = .018$. The same regression with ending statistical self-efficacy as the dependent variable, and beginning statistical self-efficacy replacing math self-efficacy in the model, found tutorial use was not significant in predicting ending statistical self-efficacy.

Survey Results

As noted in Table 12, a significant number of students were absent during survey dates both at the beginning and end of the semester. The missing data gave a very rough measure of how attendance and class attendance habits likely influence drop and pass rates. There was a significant difference among users, non-users, and control students in the number of students attending on both survey dates, $\chi^2(2, N = 1{,}115) = 14.87$, $p = .001$. However, the uneven attendance is concentrated in the middle and high achievers. The attendance rates on survey dates were even across all the low achievers, $\chi^2(2, N = 315) = 5.56$, $p = .06$.

Of the students completing end-of-the-course surveys, 297 (37.9%) were "satisficers" based on their self report that they "worked only until they achieved a sufficient grade goal" or "worked to just pass." For the low achievers, 63.0% reported themselves as "satisficers," a much higher rate than the middle (43.4%) or high achievers (24.6%), $\chi^2(4, N = 385) = 33.67$, $p < .001$. The percentage of satisficers among users (39.0%), non-users (39.5%), and control students (36.6%) did not differ significantly, $\chi^2(2, N = 781) = 0.586$, $p = .746$. The correlation between those who used advanced tutorials and those self reporting as maximizers (working towards the best grade possible) was not significant, Pearson correlation = .007, $p = .836$.

Table 13

Course Resources Reported As Important to Achievement: Count (Percent)

Attribute	Users[a]	Non-Users	Control
Completed end-of-course survey	196	189	396
Lecture	89 (45.5%)	127 (67.2%)	274 (69.2%)
Course notes provided by instructor	42 (21.4%)	48 (25.4%)	118 (29.8%)
Digital Tutors	111 (56.6%)		
Math Assistance Center (Math Lab)	10 (5.1%)	22 (11.6%)	28 (7.1%)
Office Hours	16 (8.2%)	17 (9.0%)	50 (12.6%)
Course textbook	95 (48.5%)	98 (51.9%)	205 (51.8%)
Course website resources	14 (7.1%)	10 (5.3%)	18 (4.5%)

[a] Opened two or more tutorials during term.

Student survey responses indicating what resources were important to their achievement are shown in Table 13 and the percent of students reporting each tutorial

feature as important are shown in Figure 8. Users were less likely to rate their lecture as important compared to non-users or control students (χ^2[4, N = 781] = 32.48, $p < .001$) and non-users were more likely to use the Math Lab, $\chi^2(4, N = 781) = 6.02$, $p = .049$. Users rated tutorials as "important to their achievement" more often than any other resources. Low achieving users were even more likely than their middle and high achieving counterparts to cite tutorials as important to their achievement when compared to other resources (Table 14).

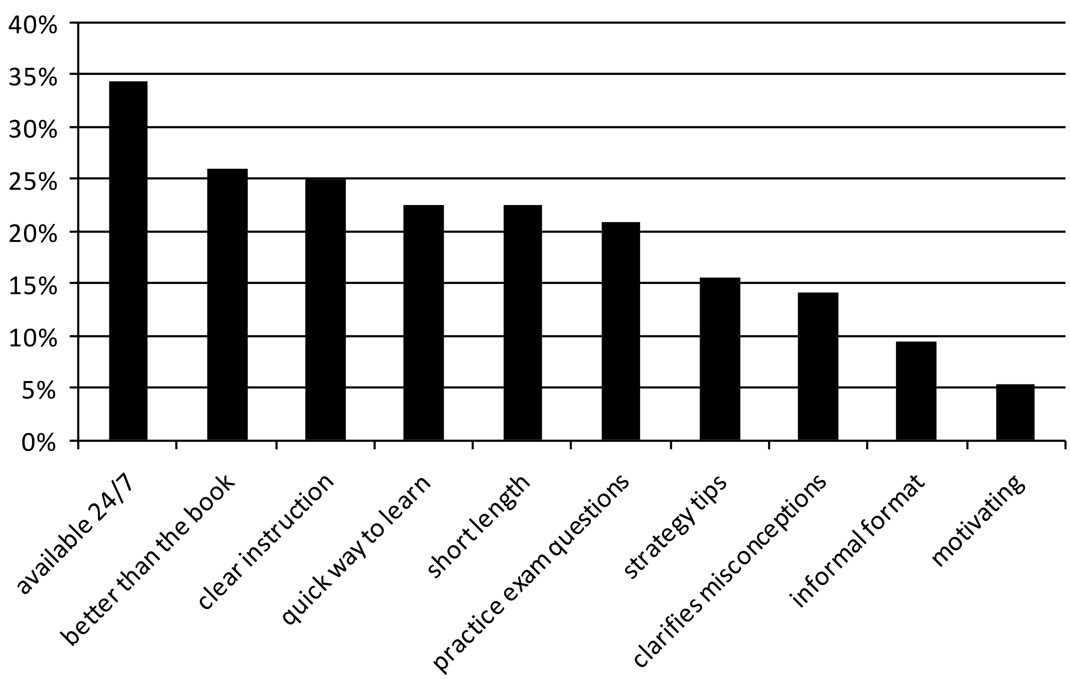


Figure 8. Percent reporting feature as important to their course achievement.

Table 14

Low Achievers Only: Course Resources Reported As Important to Achievement: Count (Percent)

Attribute	Users[a]	Non-Users	Control
Completed end-of-course survey	31	23	70
Lecture	14 (45.2%)	14 (60.1%)	46 (65.7%)
Course notes provided by instructor	0	0	0
Digital Tutors	19 (61.3%)		
Math Assistance Center (Math Lab)	3 (9.7%)	3 (13.0%)	6 (8.6%)
Office Hours	4 (12.9%)	3 (13.0%)	12 (26.1%)
Course textbook	15 (48.4%)	14 (60.9%)	33 (47.1%)
Course website resources	1 (3.2%)	1 (4.3%)	3 (4.3%)

[a] Opened two or more tutorials during term.

Only 90 (22.7%) of the 396 control students and 32 (8.3%) of the 385 intervention students who completed the end-of-the-course survey reported using the Math Lab. Of the students completing the end-of-the-course survey, 111 (56.6%) reported using Digital Tutors. Of those who reported visiting the Math Lab, 49.2% reported it was important to their course achievement. Of those who reported using the tutorials, 56.5% indicated that they were important to their achievement. Among the low achieving students present during the end-of-the-course survey, 17 reported attending the Math Lab and 12 (70.6%) reported it as important to their achievement. Among the low achieving students present during the end-of-the-course survey, 24 reported using the tutorials and 21 (87.5%) reported them as important to their achievement. Total Math Lab visits in Spring 2009

were 702 (data on number of visits per student were not available), down from an average of 887 in the four prior spring terms, even though course enrollment was up 8%.

Discussion

Drop rates and grades did not differ between intervention sections and control sections, and average exam scores were slightly (0.008 points per view) lower for intervention sections (users and non-users) compared to control sections, a difference which is too small to have any practical significance. If tutorial use led to a clear learning advantage, the users in the intervention sections should have increased the average exam scores enough to outperform the control sections. While tutorial use was correlated with higher exam scores for low achievers, the average four-point advantage was too small and the low achievers too few to pull up the overall average of intervention students when compared to control sections. There are several potential reasons for the weak results.

The non-detectable difference between drop rates and grades for intervention and control sections could be due to the low level of awareness of the resource. A large portion of the intervention sections (42.5%) did not view a single tutorial file. In the prior study, only 18.3% of the students did not view any tutorials. Attendance during the demonstration of the tutorials was only 79% of the enrolled intervention students. Unlike the prior study where the instructor regularly demonstrated how each tutorial connected to course materials, only two of the statistics instructors opened a tutorial (both previewed a single topic), so they had little or no knowledge of how the tutorials connected with class lectures and exams.

The intervention classes may not have outperformed the control sections because students used too little extra instruction. Users on average opened 10.49 tutorials, equivalent to about 30 minutes of extra lecture. In the prior study, where there was a low learning effect for all users, not just low achievers, the average user viewed 31.58 files. The low average number of views may also have been a function of the smaller set of tutorials. The prior study contained 27 basic topics, while this study contained 15 basic topics. The extra instruction was important to students according to the survey responses but it may have been just too little to boost overall exam scores with the exception of a small group of failing students.

Another possible reason for the low usage was the relatively high first exam grades. Participation was higher at the start of the semester and then dropped significantly after the first exam, following the fourth chapter. The drop off could have resulted from students reaching their grade goals early in the semester, which diminished students' motivation to learn more (Hsieh, et al., 2007). The average exam grades in this study were a full letter grade higher than in the prior study. It is unlikely that the drop off was due to low usefulness, because tutorials were cited on student surveys as "important to course achievement" more often than any other course resource.

The low use of tutorials may have resulted from topics that were too easy and from advanced tutorials that were not appealing. Several of the basic tutorials were only visited a few times, perhaps indicating that students did not need help with those topics. Use of the advanced files, a series of challenge problems on the topics in the basic tutorials, was very low. It is not clear whether students would have preferred, and therefore used, additional lectures on different topics rather than harder problems on the

existing set of topics. The low use of advanced tutorials may have been caused by lack of interest in working challenge problems versus the listen-to-lecture style of the basic tutorials.

Participation rates were likely just too low to obtain a measurable effect for the intervention students. The participation rate in the prior study (71%) was much higher than this study (46%). The higher participation rate in the prior implementation could have been due to instructor encouragement of tutorial use but also student maturity. In the current study, users had earned more college credit hours than both non-users and control students, indicating that experienced students may be more likely to use supplemental resources. Because elementary statistics is a pre-requisite course for sophomore courses, the accounting students in the prior study were more experienced than the current sample. Lower participation in this study versus the prior one may also have been a function of the topics available. A seasoned faculty member created the accounting tutorials, but the statistics tutorials were created by a designer with no experience teaching the course. The selection of topics in the prior study likely benefitted from the author's career wisdom in accounting.

Data showing no difference between intervention and control, while at the same time showing users outperforming both non-users and control students, illustrates a common methodological flaw. Studies comparing participants to non-participants and claiming the comparison demonstrates the effectiveness of a program on retention and other academic outcomes (Congo & Schoeps, 1993; D. C. Martin & Blanc, 2001), or studies comparing participants to control students and making similar claims (Commander & Stratton, 1996; Peled & Kim, 1996; Topping, 1996), are not sophisticated

enough to make those claims (McCarthy & Smuts, 1997). Participation in supplemental instruction may be a function of level of academic persistence (Robbins, Allen, Casillias, & Peterson, 2006) or other tendencies that lead to positive course results. These tendencies, such as propensity to attend class, ability to recognize the potential value of extra instruction, interest in the topic, self-regulated habits, motivation to succeed, and so forth, make participants looks stronger than non-participants and control students, but not as a function of the resource provided to participants (McCarthy & Smuts, 1997). The current study illustrates the classic error that McCarthy and Smuts described.

While the drop rates and exam averages for intervention students were on par with control sections, the study did reveal that this resource could be important for low achievers. Even though at-risk students do not self-select into supplemental instruction at high rates when the commitment required is high (R. Blanc, et al., 1983; Karabenick & Knapp, 1988; Kenney & Kallison, 1994), forty-five percent of low achievers who finished the course used the tutorials, suggesting that low achievers may be amenable to convenient extra instruction. Low-achieving users were more willing to try course exams before dropping than their non-user and control counterparts. Low achievers reported tutorials as important to their achievement more often than their higher-achieving classmates. Therefore, if the participation levels and number of views can be increased for low achievers, course retention may improve.

One question this study addressed was whether students who were trying to maximize their grade would use advanced tutorials. Use of the advanced tutorials was much lower than that of the basic set. Oddly enough, use of the advanced tutorials was even across achievement levels, even though more of the low achievers reported that they

studied only enough to reach a grade goal, including just pass, and then moved to other priorities (satisficers). The lack of correlation between those reporting themselves as a maximizer (working for the best grade possible), and those using advanced tutorials, confirms the literature that reported goal attitudes and actual goal-oriented behavior differ (White, 2002), but also hints that advanced tutorials were not an attractive resource for maximizers.

The survey data at the start of the term showed that students slightly disagreed that they were good at typical math tasks (math self-concept) and were slightly unconfident in their statistics ability (statistics self-efficacy). Higher achievers started and ended with more confidence, in both general math self-concept and topic specific statistical self-efficacy, which confirms the literature that confidence is related to competence (Gist, et al., 1989; Hsieh, et al., 2007; Meece, et al., 1990; Pajares & Miller, 1994; Siegel, et al., 1985). Tutorial use was associated with a practically insignificant decrease in math self-concept, but was not associated with a change in task specific statistical confidence. The literature suggests that low and middle achievers often need help with calibrating their true math ability, and the tutorials may have improved the calibration of comprehension in small ways (Pajares, 1996). The increase in topic specific confidence for users was on par with their classmates (and therefore had no tutorial effect). Given the average exam grade was 77.4%, most students who completed the course likely felt more confident at the end of the semester in course specific tasks, regardless of what resources they used.

Students who used the tutorials ranked them higher than other course resources on the course survey. This confirms prior work showing that college students prefer video

over text-based resources (Choi & Johnson, 2007) as well as research indicating that modern students prefer to interact with computer resources versus face-to-face options (McGuire, 2006). Student enthusiasm for the resource may reflect a benefit to student well-being rather than higher exam scores (Fries, Schmid, Dietz, & Hofer, 2005). That is, perhaps users spend less time studying than their counterparts in the control group, who achieved at the same level.

Users ranked the 24/7 availability of the tutorials most often on a survey of important features confirming that convenience is important to participants (McGuire, 2006). Users also reported that clarity ("clear," "better instruction than the book"), and efficiency ("quick way to learn") were important. The themes of convenience and efficiency confirm that students value resources that reduce the time investment needed to achieve their grade goals (Fries, et al., 2005). The surprise in this ranking of important features was the relatively low rank of "short length" (fifth out of 10 qualities). Isolating just the low achievers, short length was seventh out of 10 features, lower even than middle and high achievers, with only 9 of the 121 (7.4%) who completed the end-of-the-course survey indicating that short length was important to them.

Only 18 (< 1%) of users reported that the tutorials were motivating. Students may have already had a reasonable level of motivation by the time they logged on to view. However, from the student's persepctive, the tutorials' primary value was developing the needed subject mastery quickly and conveniently, not giving them compelling reasons to move to another tutorial or work harder on course materials.

The competing tutoring resource for the control students was the Math Lab, staffed with graduate students 10 hours a day, Monday – Thursday. The reported Math

Lab participation rates for those who completed an end-of-the-semester survey were on par with typical undergraduate supplemental instruction, but still well below the tutorial participation rates. The total visits to the Math Lab during Spring 2009 were 79% of prior spring term levels, even though course enrollment was growing, a sign that on-line tutorials diverted students away from the Math Lab, and further confirmation that students prefer to interact with computers (McGuire, 2006).

Limitations and Areas for Further Work

One flaw in this work was that the surveys were duplicated exactly as found in the prior studies, and that resulted in the math self-concept scale being coded with one as most confident, and the statistical self-efficacy scale with six as the most confident. This was an administrative detail overlooked during design. Since students filled out the surveys on consecutive pages, some students may have assumed the scales were identical. Manual review of surveys indicated that two or three students in each section were extremely confident and extremely unconfident between the two instruments, suggesting that they may not have noticed the reverse coding.

While this work asked students if they had a prior course in statistics, it did not conduct a pre-test of statistics knowledge. In addition, the measures of learning differed across all 21 instructors. Using a pre-test and departmental-wide exams (to use as post-tests) would have strengthened the study.

This work defined use as number of files opened. After the short lesson, the tutorials asked students to freeze the frame and attempt the problems before reviewing the answers. Students who worked the sample problems before viewing the solution

spent much more time working the tutorials than those who just viewed the short lesson. Time spent viewing tutorials might be a better measure in future studies.

Participation was down considerably from the prior accounting study. It is not clear if participation rates were lower due to better exam scores (less need for extra help), differences in instructor coaching, fewer tutorials topics available, or all of these. Lack of information from instructors concerning how the tutorials connected with course topics or how they might help students prepare for exams may have diminished student awareness of, or interest in, the resource. Future work might include more topics and some sections where instructors alerted students about the resource. Other studies might track participation in more difficult courses (with lower grades) where the need for extra instruction is higher.

Although short length was considered an important design feature of the tutorials, even low-achieving students did not cite length as an important feature. Future work might investigate how participation and learning changes with longer tutorials.

The literature suggests that mastery goals lead to better achievement than performance goals (Shim, Ryan, & Anderson, 2008). Separating users with differential goals may reveal if achievement is an interaction of tutorial use with academic goals.

In an attempt to please the researcher, students may have reported using resources they never used. Eleven students reported using the tutorials on the survey when in fact they had not opened a file. There was no way to verify if students reporting visiting the Math Lab actually made those visits. Future work in which the tutorial author is not the principal investigator may reduce this effect.

Studies of supplemental instruction find that students who participate have higher re-enrollment and graduation rates than non-participants (R. Blanc, et al., 1983; Congo & Schoeps, 1993). In addition, students who set their own goals improve their goal-setting ability (Hannafin, 2001). Future work might track users and non-users to see if the experience of self-regulated learning in a freshman course (self-guided completion of a set of tutorials that were not required) could demonstrate for students how many little steps accumulate to success.

Conclusion

Because the tutorial implementation did not improve the performance of intervention sections compared to control sections, it failed to replicate the prior study. While users outperformed non-users within the intervention sections and the average students in control sections, this could have been due to academic habits of those self-selecting to use tutorials, rather than the tutorial content. The drop rates and exam scores in the intervention sections did not outperform control sections, likely because participation and use levels were just too low. Although tutorial use was associated with higher average exam scores for low achievers, the learning effect from tutorial use was small, and impacted too few of the participants to help intervention sections outperform the control sections.

Given that the users only viewed 10 tutorials on average, about 30 minutes of extra instruction, the lack of effect is no surprise. What is not clear is whether a larger inventory of tutorials, instructor encouragement, or lower exam grades would have increased participation and use levels.

In spite of the weak result, the study did reveal that low achievers will use extra resources. Remarkably, low achievers used the tutorials as frequently as the higher achievers, even without course credit for the effort. At-risk students rated tutorials higher in importance than any other course resources and higher than their classmates, likely reflecting the low achievers' heavier reliance on the convenient tutorials.

This work confirmed the most important feature of the tutorials to users: convenience (24/7 Internet access). After convenience, the most important feature of the tutorials was the clear, concise instruction. Short length was not as attractive as was thought during initial design, and users may have spent more time on topics if the tutorials were longer.

A relatively modest resource, 21 ultra-short tutorials, was not enough to improve course outcomes. From the student's point of view, however, the tutorials were important to their achievement, perhaps by permitting them to meet their learning goals quicker (Fries, et al., 2005), rather than boosting their achievement above their counterparts in other sections. In courses with a larger set of tutorials, where instructors can encourage more participation, and where exam scores are lower so the need is greater, an on-line tutorial set designed for the at-risk population may be a great low maintenance investment in the battle to improve campus retention.

References

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*(2), 243-248.

Ayres, P. (2006). Impact of reducing intrinsic cognitive load on learning in a mathematical domain. *Applied Cognitive Psychology, 20*, 298-298.

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

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (1996). Multifaceted impact of self-efficacy beliefs on academic functioning. *Child Development, 67*, 1206-1222.

Bates, R., & Khasawneh, S. (2007). Self-efficacy and college students' perceptions and use of online learning systems. *Computers in human behavior, 23*, 15-191.

Beal, C. R., Qu, L., & Lee, H. (2008). Mathematics motivation and achievement as predictors of high school students' guessing and help-seeking with instructional software. *Journal of Computer Assisted Learning, 24*, 507-514.

Benson, J. (1989). Structural components of statistical test anxiety in adults: An exploratory model. *Journal of Experimental Education, 57*(3), 247-261.

Blanc, R., DeBuhr, L. E., & Martin, D. C. (1983). Breaking the attrition cycle: The effects of supplemental instruction on undergraduate performance and attrition. *Journal of Higher Education, 54*(1), 80-90.

Boekaerts, M. (1997). Capacity, inclination, and sensitivity for mathematics. *Anxiety, Stress and Coping, 10*, 5-33.

Bueschel, A. C. (2008). *Listening to students about learning*: The Carnegie Foundation for the Advancement of Teaching.

Choi, H. J., & Johnson, S. D. (2007). The effect of problem-based video instruction on learning satisfaction, comprehension and retention in college courses. *British Journal of Educational Technology, 38*(5), 885-895.

Commander, N. E., & Stratton, C. B. (1996). A learning assistance model for expanding academic support. *Journal of Developmental Education, 20*(2).

Congo, D. H., & Schoeps, N. (1993). Does supplemental instruction really work and what is it anyway? *Studies in Higher Education, 18*(2).

Cooper, S. E., & Robinson, D. A. (1991). The relationship of mathematics self-efficacy beliefs to mathematics anxiety and performance. *Measurement and evaluation in counseling and development, 24*(1), 4-11.

Eccles, J. S., & Midgley, C. (1990). Changes in academic motivation and self-perception during early adolescence. In R. Montemayor, G. R. Adams & T. P. Gullotta (Eds.), *From childhood to adolescence* (pp. 134-155). Thousand Oaks, CA: Sage Publications, Inc.

Finney, S. J., & Schraw, G. (2003). Self-efficacy beliefs in college statistics course. *Contemporary Educational Psychology, 28*, 161-186.

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics - A "hopeless" issue: A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education, XXII*(4), 497-514.

Fries, S., Schmid, S., Dietz, F., & Hofer, M. (2005). Conflicting values and their impact on learning. *European Journal of Psychology of Education, XX*(3), 259-273.

Gist, M. E., Schwoerer, C., & Rosen, B. (1989). Effects of alternative training methods on self-efficacy and performance in computer software training. *Journal of Applied Psychology, 74*(6), 884-891.

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., Oliver, P. H., & Guerin, D. W. (2007). Multivariate latent change modeling of developmental decline in academic intrinsic math motivation and achievement: Childhood through adolescence. *International Journal of Behavioral Development, 31*(4), 317-327.

Greene, B. A., DeBacker, T. K., Ravindran, B., & Krows, A. J. (1999). Goals, values and beliefs as predictors of achievement and effort in high school mathematics classes. *Sex Roles, 40*(5/6), 421-458.

Gutman, L. M. (2006). How student and parent goal orientations and classroom goal structures influence the math achievement of African Americans during the high school transition. *Contemporary Educational Psychology, 31*, 44-63.

Hackett, G. (1985). Role of mathematics self-efficacy in the choice of math-related majors of college woman and men: A path analysis. *Journal of Counseling Psychology, 32*(1), 47-56.

Hannafin, M. J. (2001). Effects of teacher and student goal setting and evaluations on mathematics achievement and student attitudes. *Journal of Educational Research, 74*(5), 321-326.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46.

Hemenway, M. K., Straits, W. J., Wilke, R. R., & Hufnagel, B. (2002). Educational research in an introductory astronomy course. *Innovative Higher Education, 26*(4), 271-280.

Hox, J. (2002). *Multilevel Analysis.* Mahwah, New Jersey: Erlbaum.

Hsieh, P.-H., Sullican, J. R., & Guerra, N. S. (2007). A closer look at college students: self-efficacy and goal orientation. *Journal of Advanced Academics, 18*, 454-476.

Huang, T.-H., Liu, Y.-C., & Shiu, C.-Y. (2008). Construction of an online learning system for decimal numbers through the use of cognitive conflict strategy. *Computers & Education, 50*, 61-76.

Karabenick, S. A., & Knapp, J. R. (1988). Help Seeking and the Need for Academic Assistance. *Journal of Educational Psychology, 80*(3), 406-408.

Kenney, P. A., & Kallison, J. M. J. (1994). Research studies on the effectiveness of supplemental instruction in mathematics. *New Directions for Teaching & Learning, 60*, 75-82.

Kim, Y., Baylor, A. L., & Group, P. (2006). Pedagogical agents as learning companions: The role of agent competency and type of interaction. *Journal of Computer Assisted Learning, 54*(3), 223-243.

Korner, C. (2005). Concepts and misconceptions in comprehension of hierarchical graphs. *Learning and Instruction, 15*, 281-296.

Koutsoulis, M. K., & Campbell, J. R. (2001). Family processes affect students' motivation, science and math achievement in Cypriot high schools. *Structural Equation Modeling, 8*(1), 108-127.

Kulik, C.-L. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in human behavior, 7*, 75-94.

Linnenbrink, E. A., & Pintrich, P. R. (2002). Motivation as an enabler for academic success. *School Psychology Review, 31*(3), 313-327.

Linnenbrink, E. A., & Pintrich, P. R. (2003). The role of self-efficacy beliefs in student engagement and learning in the classroom. *Reading & Writing Quarterly, 19*, 119-137.

Marsh, H. W., Trautwein, U., Ludtke, O., Koller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76*(2), 397-416.

Martin, D. C., & Blanc, R. (2001). Video-Based Supplemental Instruction. *Journal of Developmental Education, 24*(3).

Matsui, T., Matsui, K., & Ohnishi, R. (1990). Mechanism underlying math self-efficacy learning and college students. *Journal of Vocational Behavior, 37*, 225-238.

Mayer, R. E., Mathias, A., & Wetzell, K. (2002). Fostering understanding of multimedia messages through pre-training: Evidence for a two-stage theory of mental model construction. *Journal of Experimental Psychology: Applied, 8*(3), 147-154.

McCarthy, A., & Smuts, B. (1997). Assessing the effectiveness of supplemental instruction: A critique and a case study. *Studies in Higher Education, 22*(2).

McGuire, S. Y. (2006). The impact of supplemental instruction on teaching students "how" to learn. *New Directions for teaching and learning* (Vol. 106): John Wiley and Sons, Inc.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*(1), 60-70.

Middleton, M. J., & Midgley, C. (2002). Beyond motivation: Middle school students' perceptions of press for understanding in math. *Contemporary Educational Psychology, 27*, 373-391.

Miller, S. P., & Mercer, C. D. (1997). Educational aspects of mathematics disabilities. *Journal of Learning Disabilities, 30*(1), 47-56.

Moore, R., & LeDee, O. (2006). Supplemental instruction and the performance of developmental education students in an introductory biology course. *Journal of College Reading and Learning, 36*(2), 9-20.

Muller, D. A., Bewer, J., Sharma, M. D., & Reimann, P. (2007). Saying the wrong thing: Improving learning with multimedia by including misconceptions. *Journal of Computer Assisted Learning, 24*, 144-155.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 38*(1), 30-38.

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem-solving of gifted students. *Contemporary Educational Psychology*, *21*, 325-344.

Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem-solving. *Contemporary Educational Psychology, 20*, 426-443.

Pajares, F., & Miller, D. M. (1994). Role of Self-Efficacy and Self-Concept Beliefs in Mathematical Problem Solving: A Path Analysis. *Journal of Educational Psychology, 86*(2), 193-203.

Pajares, F., & Miller, D. M. (1995). Mathematics self-efficacy and mathematics performance: The need for specificity of assessment. *Journal of Counseling Psychology, 42*(2), 190-198.

Peled, O. N., & Kim, A. C. (1996). *Evaluation of supplemental instruction at the college level*. Unpublished manuscript.

Pintrich, P. R., & Schunk, D. H. (1996). *Motivation in education: Theory, research and applications*. Englewood Cliffs, NJ: Prentice Hall Merrill.

Randhawa, B. S., Beamer, J. E., & Lundberg, I. (1993). Role of mathematics self-efficacy in the structural model of mathematics achievement. *Journal of Educational Psychology, 83*(1), 41-48.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods*. Thousand Oaks, CA: Sage.

Robbins, S. B., Allen, J., Casillias, A., & Peterson, C. H. (2006). Unraveling the differential effects of motivational and skills, social and self-management

measures from traditional predictors of college outcomes. *Journal of Educational Psychology, 98*(3), 598-616.

Sargent, C. S. (2009). Improving retention for principles of accounting students: Ultra-short digital tutorials designed to motivate effort and improve performance. Georgia State University.

Shim, S. S., Ryan, A. M., & Anderson, C. J. (2008). Achievement goals and achievement during early adolescence: Examining time-varying predictor and outcome variables in growth-curve analysis. *Journal of Educational Psychology, 100*(3), 655-671.

Siegel, R. G., Galassi, J. P., & Ware, W. B. (1985). A comparison of two models for predicting mathematics performance: Social learning versus math aptitude-anxiety. *Journal of Counseling Psychology, 32*(4), 531-538.

Siegler, R. S. (2003). Implications of cognitive science research for mathematics education. In J. Kilpatrick, W. B. Martin & D. E. Schifter (Eds.), *A Research Companion to Principles and Standards for School Mathematics* (pp. 219-233). Reston, VA: National Council of Teachers of Mathematics.

Simpson, M. L., Hynd, C. R., Nist, s. L., & Burrell, K. I. (1997). College academic assistance programs and practices. *Educational Psychology Review, 9*(1), 39-87.

Singer, J. D., & Willett, J. B. (2003). *Applied Longitudinal Data Analysis*. New York: Oxford University Press.

Smith, J. P. I., diSessa, A. A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences, 3*(2), 115-163.

Spence, D. J., & Usher, E. L. (2007). Engagement with mathematics courseware in traditional and online remedial learning environments: Relationship to self-efficacy and achievement. *Journal of Educational Computer Research, 37*(3), 267-288.

Steinmayr, R., & Spinath, B. (2008). Sex differences in school achievement: What are the roles of personality and achievement motivation? *European Journal of Personality, 22*, 185-209.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction*, *12*(3), 185-233.

Topping, A. J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education, 32*, 321-345.

Whang, P. A., & Hancock, G. R. (1994). Motivation and mathematics achievement: Comparisons between Asian-American and non-Asian students. *Contemporary Educational Psychology, 19*, 302-322.

White, F. (2002). A cognitive-behavioural measure of student goal setting in a tertiary educational context. *Educational Psychology, 22*(3), 285-304.

Wigfield, A., Eccles, J. S., Schiefele, U., Roeser, R. W., & Deavis-Kean, P. (2006). Development of achievement motivation. In N. Eisenberg, W. Damon & R. M. Lerner (Eds.), *Handbook of Child Psychology* (pp. 933-1002). Hoboken, NJ: John Wiley & Sons, Inc.

Yates, G. C. R. (2005). "How obvious": Personal reflections on the database of educational psychology and effective teaching research. *Educational Psychology 25*(6), 681-700.

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*(1), 51-59.

APPENDIXES

APPENDIX A

Tutorial Sample Worked Out Problems

Topic	Example of problem worked in the tutorial
Basic probability rules	North Carolina State University posts the grades for their courses online. Students in the management 302 course in Spring 2005 semester received 45% A's, 30% B's, 20% C's and the rest D's. If you selected a student at random from this course, what is the probability they got a B or better?
Using a random number table to select a sample	Every year Fortune Magazine lists America's Largest Corporations (The Fortune 500). You need to select five large firms for a marketing project and have decided to pick those five randomly from the "Fortune 500". Use the random number table to select the firms to study. Use line 111 from the table.
Using standard normal distribution (z-scores) to estimate probabilities	A milling machine needs to shave metal to narrow specifications. A well maintained machine should have a cut width of 0.875 inches and no more than a standard deviation of 0.012 inch. If your machine is well maintained, what is the probability of a cut between 0.82 and 0.89 inches?
Constructing confidence intervals with known population variance	128 customers sampled had an average grocery checkout total of $65. The standard deviation for grocery check outs for all customers is $12. Give a 98% confidence interval for the mean level check out totals for all customers.
Distinguishing between observational and experimental designs	Studies found that different brands of gasoline do not change miles per gallon (MPG) results. A study gathered a sample of Honda Civics all getting 30 MPG and collected data on the gasoline brand preferred by the owner (driver), the typical proportion of city/highway driving, and history of speeding tickets. Is this an observational or experimental study?

APPENDIX B

Tutorial Topics

1. Describing distributions
2. Basics of normal distributions (including using 68-95-99.7 rule)
3. Computing and using z-scores
4. Regression analysis and correlation
5. Using a random number table
6. Observational vs. experimental studies (response and explanatory variables)
7. Selecting simple random samples
8. Attributes of good experimental design
9. Rules of probability
10. Central Limit Theorem
11. Confidence intervals with known population variance – z score
12. Hypothesis testing – setting up the null, one and two-tailed tests
13. Hypothesis testing – z scores
14. Hypothesis testing – t tests
15. Confidence intervals with unknown population variance – t tests