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Using Spreadsheets to Enhance Learning in the Affective Domain for Undergraduate Statistics Students

Howard R. Clayton, Chetan S. Sankar
Department of Management, Auburn University, Auburn, Alabama 36849
{claythr@auburn.edu, sankacs@auburn.edu}

The Association to Advance Collegiate Schools of Business (AACSB) requires that undergraduate and graduate students exhibit proficiency in "statistical data analysis and management science as they support decision-making processes throughout an organization" [AACSB. 2008. Accreditation standards. Accessed October 20, 2008, http://www.aacsb.edu/accreditation/standards.asp]. However, motivating business students to enjoy learning statistics has been a major challenge for decades in many American colleges and universities. This paper reports on the use of spreadsheets to teach an introductory statistics course with an emphasis on business applications. The results suggest that using spreadsheets as a teaching tool can effectively produce learning in the affective domain, which refers to the attitudes, beliefs, feelings, and motivations a student brings to a particular subject. This finding not only encourages business statistics instructors to continue to use spreadsheets in their classes, it also encourages other instructors to consider doing so in the future.

Key words: business statistics; spreadsheets; affective domain
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Introduction

The Association to Advance Collegiate Schools of Business (AACSB) requires that undergraduate and graduate students exhibit proficiency in "statistical data analysis and management science as they support decision-making processes throughout an organization" (AACSB 2008). A less explicitly stated, though no less important, goal is for students to have an emotionally pleasant experience during the learning process. However, motivating students to enjoy learning statistics has been a major challenge for decades in many colleges of business (Bell 2000, Eom et al. 2006, Kvam and Sokol 2004). It is a widely held belief that if students enjoy what they are being taught they will strive to "own" or personalize the material, and the learning of it will be enhanced. Moreover, the students will likely remember key concepts if they are able to associate them with day-to-day events (Bremner and Roberts 2005, Sirias 2002). Some other challenges associated with teaching statistics in business classes are poor class attendance and the inability of students to transfer key concepts to other courses in the curriculum.

In recognition of the challenges facing statistics instructors, researchers have focused on creating new instructional materials to address the statistical needs of business students. At the same time, educational innovators have been emphasizing how critical it is for the business students to be exposed to business applications when learning to master the core material (Mbarika et al. 2003, Bradley et al. 2007). Some textbook writers (e.g., Anderson et al. 2009, Berenson et al. 2006) have begun to address both of these requirements, i.e., to prepare the students on statistics fundamentals and to expose them to business applications. Employing case studies in introductory business statistics classes might also help meet these goals (Köksalan and Batun 2009, Anderson et al. 2008, Cochran 2000). Still, it is difficult for most academic programs to meet the stated AACSB goals of providing learning experiences in statistical data analysis that support business decision-making processes.

Many statistics instructors, for various reasons, are reluctant to try new approaches to teaching statistics. Some of them learned statistics by performing hand computations and, because they regard themselves as successful practitioners, see no compelling reason to leave that methodology for a computer-based system such as spreadsheets. Some lack the confidence to deal with the unfamiliar, whereas others work at institutions that do not offer the facilities necessary to implement new approaches. Statistics anxiety, which is experienced by as many as 80% of graduate students, has been found to debilitate performance in statistics and research methodology courses (Onwuegbuzie 1998, 2004). As such, it is likely that statistics anxiety is, in part, responsible for many students delaying enrollment in these courses for as long as possible. In another study, Liu and Thompson (2007) conducted an eight-day seminar with eight high school statistics teachers. Their analysis of the data revealed that there was a complex mix of conceptions and understandings of probability among the teachers. The teachers' conceptions of statistics were often incoherent and did not help them develop pedagogical strategies regarding probability and statistical inference. It is therefore critical to search for new methods of teaching statistics.

One possible approach is to use spreadsheet software, such as Microsoft Excel, to teach beginning statistics classes. Over the past 20 years, the burden of hand computation in the math and science classrooms has shifted to technology, and in that same period the use of spreadsheets has grown tremendously (Pace and Barchard 2006). Teaching with spreadsheets, a tool that students already recognize as marketable, allows instructors to teach both the subject and the tool itself. But teaching statistics and spreadsheet skills is not easy to achieve. Our prior experience has shown that many students begin the course lacking the foundation knowledge of spreadsheets that we expect them to have. Thus, for these students, the anxiety that accompanies learning to use spreadsheets could trigger a negative attitude toward the class from the onset, despite their regard of spreadsheet skills as marketable.

There are a plethora of texts and research articles (e.g., Warner and Meehan 2001) that extol teaching statistics using spreadsheets, but only recently has research been reported in the literature that recognizes the benefits of teaching with spreadsheets beyond the cognitive realm. Pace and Barchard (2006) documented the effectiveness of using spreadsheets to improve students' learning and comprehension of the underlying principles in statistics. More importantly, these researchers recognized, among other advantages, another major effect of spreadsheet usage in the teaching of statistics, namely, reducing anxiety in students who have difficulties with computation. Pace and Barchard (2006) argued that when, in class demonstrations, an instructor performs hand computations with ease, he or she may unwittingly fluster students who are already apprehensive about learning statistics. By using spreadsheets instead to perform these computations, the instructors will avoid contributing to the students' frustration. In our research, we have discovered an even more rewarding benefit of spreadsheet usage. We have found evidence of its positive effect on students' attitudes.

The Affective Domain

Study of the affective domain of learning is increasing as researchers and educators discover how a positive influence on the affective domain of students increases the students' cognitive abilities both in and out of the classroom (Boyle 2007, Nentl and Miller 2002). The affective domain refers to the attitudes, beliefs, feelings, and motivations a student brings to a particular subject. In contrast, cognitive skills culminate in an individual's ability to identify, integrate, evaluate, and interrelate concepts, and hence make the appropriate decision in a given problem-solving situation (Hingorani et al. 1998). Just as the cognitive domain of learning progresses through a hierarchy of stages that show a more advanced understanding of a subject, from basic knowledge and identification through advanced synthesis and evaluation, the affective domain progresses from basic awareness of a subject through development and analysis of beliefs to acceptance of and adherence to a value system. Boyle (2007) provides a summary of the affective domain taxonomy of Krathwohl et al. (1964), which shows five levels of the affective domain: receiving, responding, valuing, organization, and characterization by value. Examples of the levels, with respect to a statistics concept, are shown in Table 1.

Dressel (1988) pointed out the importance of recognizing the symbiotic relationship between the affective and cognitive means of knowing. Too often, students have only a verbal label for a technical concept. To truly form concepts, one must also learn their meaning and how to apply them to new situations. Every time a teacher helps a student truly learn a concept in this multifaceted way, the learning not only enhances the student's appreciation of

Table 1 Example Learning Outcomes for a Statistics Concept

Affective domain	Learning outcome example
Receiving	Students ask relevant questions about "empirical rule" probability
Responding	A student explains use of "empirical rule" probabilities when questioned
Valuing commitment	A student uses an example to illustrate confidence intervals
Organizing a value system	Students report that they were able to understand several statistical terms, such as standard error, margin of error, and confidence interval, and include them in their discussions of value of statistics
Characterization-philosophy	A student reports that she was able to use the statistical concepts successfully in making an important decision in her life

the subject matter, but also strengthens his/her ability to function successfully as a creative, thoughtful, and communicative member of society (Zeuli and Ben-Avie 2003).

Research on the affective domain in education tends to get pushed aside in favor of continuing work on the cognitive domain. The data a researcher may collect for cognitive research are relatively easy to obtain; exam scores and performance on objective tests offer hard evidence for improvement or decline in the cognitive domain. However, improvement in the affective domain is not so easily seen, mainly because researchers must rely on more subjective forms of data such as student self-reporting and outside observation. The difficulty in obtaining data may be one reason why research on such an important aspect of education and development continues to be ignored. The few articles (Leong 2006, Waters et al. 1989) that do attempt to discuss the impact of integrating technology and spreadsheets into the classroom on the affective domain of students tend to focus more on the students' attitudes toward the tool itself or the usefulness of the tool, rather than on their improved attitudes toward the subject matter. Leong (2006) showed that incorporation of a service-learning project led to the participants' perceiving a positive attitude toward statistics. Cashin and Elmore (2005) found that attitude measures correlated positively with course achievement, showing that students with more positive attitudes performed better in the course. They state that if an instructor has knowledge of students' self-efficacy as well as their attitudes regarding their statistics course, the instructor could facilitate the students' success in the course and their future careers.

Further support for this notion was provided by Gal and Ginsburg (1994), who pointed to the importance of assessing the effect of noncognitive factors on the learning of statistics. Ma and Kishor (1997) showed, in a meta-analysis, that there is a weak relationship between attitude toward mathematics and achievement in mathematics. In 1999, Potthast conjectured that a similar relationship existed for the related subject of statistics. She studied the effect of cooperative learning techniques (involving small groups) on student achievement and found that, not only did the students do better on minitests than the control group, they also demonstrated gains in the affective domain.

In improving the efficacy of a course, the highest levels of the affective domain do not have to be attained—even modest achievements at the lowest two levels (receiving and responding) would be a step forward because few courses even attempt to address these objectives. Austin and Vaughan (1998) show improvements in both the affective and cognitive domains of accounting students in a core accounting course, but only when the class was supplemented by another core course in management information systems. In this paper, we look at how the affective domain was influenced in an introductory statistics course through the use of spreadsheets without having to take a supplementary course.

Method

The discovery that using spreadsheets to teach statistics could positively influence students' attitudes toward the subject was made serendipitously. A required statistics course was taught in a large southeastern university. Typically, multiple sections of this course are taught every semester to business students whose academic status ranges from the sophomore to the senior level, and the method of instruction has been lecture and discussion. For our study, the course was taught during a five-week summer "minimester" by a faculty member in the business college, and Microsoft Excel spreadsheets were the main vehicle of delivery. The main reason for the choice of the summer session was that there were no large computer labs available in the college during the regular semesters when such a course, one that required use of computers by each student in the class, could be offered. Prior to signing up for the class the students were not informed about the teaching method to be used in this section. The academic profile of the 28 students who signed up for this section was quite similar to that of a typical business statistics class. For example, the mean and standard deviation of the grade point average of students in this section were, respectively, 2.78 and 0.56, compared to 2.73 and 0.50 for all business statistics classes taken in the regular semesters two years before and after the summer of the study. Furthermore, although we found the combined percentage of juniors and seniors (90%) in our experimental section to be appreciably higher than the combined percentage of juniors and seniors in the regular business statistics classes (79%), the difference was not statistically significant (p-value of 0.16). Thus, we believe our sample of 28 students is fairly representative of the population of business statistics students at our university.

To obtain more information about the progress of the experimental class, a teaching assistant attended the class to observe the students' behavior. She possessed considerable teaching experience at the middle and high school levels before pursuing her Ph.D. in management and, being a trained teacher, had a good background in the cognitive and affective domains of learning. She was well versed in recording details of classroom activities. Throughout the duration of the five-week course, the teaching assistant wrote down, in a daily journal, her observations of the students' attitudes and actions in class. Examples of some journal entries on the second day of class are as follows: (i) "Students are struggling to keep up in Microsoft Excel," (ii) "Many of the students do not know how to enter functions in Microsoft Excel or how to use the chart wizard," and (iii) "Students are actively participating on the computers but are not verbally engaged." A quantitative measure based on a 5-point scale, ranging from a low of 1 to a high of 5, was developed for each qualitative attribute of overall attitude, verbal participation, and Microsoft Excel participation. Values for each variable were subjectively assigned from the journal entries on observed attitudes and participation levels. To address the issue of observer bias, a second observer attended the final class session and discussed, with the students, their perceptions of the learning achieved in the course and their attitude toward the subject. In addition, students were asked to write open-ended answers to a brief survey of these attitudes and perceptions. The sentiments conveyed in these written comments were consistent with the teaching assistant's logged observations.

The experimental classes were held in a computer lab, and all of the key concepts were taught via class discussions driven by the data. In this hands-on approach, the students had the data on their own computers, and they were able to mimic the instructor's keystrokes, which were projected on the classroom's large screen. Coming into this course, students were unfamiliar with navigating spreadsheets and using formulas in spreadsheets as their only means of problem solving. Their previous classes dealing with quantitative topics were taught using a traditional lecture approach, and as a result students were very apprehensive about being able to work problems by hand and about how the instructor would be assessing their knowledge.

To assess how much material the students had learned by the end of the course, they were given a pre- and posttest at the beginning and the end of the class, respectively. For the sake of efficacy, the same exam served as both the pre- and posttests and contained all the types of questions that were typically asked in a final exam for this course. The mean on the pretest was 22.9% compared to 62.0% on the posttest, representing a mean increase of 39.1%. The standard deviations on the pre- and posttests were, respectively, 8.5% and 11.7%. Thus, regardless of any gains that might have been made in the affective domain, it is clear from the 39.1% mean increase on the post- versus the pretest that substantial gains were made in the cognitive domain as a result of attending this course.

Instructor Observations

In the beginning, verbal class participation was negligible. Students struggled to write down notes on how to execute certain tasks in Excel while attempting to emulate steps demonstrated by the instructor. This slowed down the pace of the class and caused frustration among many students. Most questions posed by the instructor went unanswered as long as the students assumed participation was voluntary. The instructor continued to encourage dialogue, but only when he resorted to posing questions to individual students by name was any attempt made to offer an answer. It took more than five days of classes before students figured out they were better off focusing on mimicking the instructor's keyboard manipulations than attempting to write notes.

The struggle by students to acquire spreadsheet skills and make sense of what was being taught continued at a slow pace for about two weeks. Then a breakthrough finally came two-thirds through the five-week course. Students began to remember the steps necessary to carry out certain tasks without help from the instructor. Class participation dramatically increased. Some students not only answered questions posed by the instructor but also began asking questions and helping their colleagues who were still having difficulties. In this way, students quickly learned how to use software to manipulate and analyze data, and the instructor was able to pass on many "tricks of the trade" and shortcuts to the students. Therefore, the students needed to use help menus and manuals to a lesser extent.

Because of the intensity of the instruction during summer courses in general, students tend to get tired by the final week of class. This tendency was quite noticeable in this class, resulting in a gradual decrease in attendance as the end of the course drew near. However, the excitement generated among the majority of students by their newly acquired spreadsheet skills mitigated the effect of the dwindling attendance and fatigue.

Behaviors Recorded by Observers

Table 2 summarizes some basic statistics for quantified observations of student behavior logged by the teaching assistant, as well as for daily student attendance.

As the semester progressed, a noticeable improvement in the students' overall attitudes became apparent. Figure 1 shows a gradual positive trend over time, but by looking closely we may see that the most significant shift occurred between Days 10 and 15. Amid the day-to-day fluctuations, the average attitude score up to Day 10 was 2.6, compared to 4.2 between Day 15 and the end of the course.

Table 2 **Attitude of Students Toward Course**

	Attendance	Overall attitude/5	Verbal participation/5	Microsoft Excel participation/5
Mean	22	3.5	3.2	4.1
St. dev.	3.6	1.2	1.4	1.1
R-sqr. for regression vs. day	0.538	0.338	0.617	0.43
P-value for regression slope	0.0008	0.014	0.0002	0.0043

Note. Scale: 1, low; 5, high.

We also noticed an overall positive trend in the participation level of students as the semester continued (Figure 2). Again, a distinctive increase took place between Days 10 and 15. The average participation score between Days 1 and 10 was 2.0 compared to 4.2 between Day 15 and the end of the course. The coincidence of this substantial increase in participation and the increase in improvement in overall attitude is noteworthy. The downward slope in the graph for attendance (Figure 3) shows the overall decrease in the number of students attending class as the semester progressed. As shown in Table 2, the overall average attendance was 22 (out of 28 on the official roster). But average attendance between Days 5 and 10 was about 23, and this average fell to about 20 students between Day 15 and the end of the semester.

The noticeable change in attitude, verbal participation, and attendance for the periods preceding Day 10 and following Day 15, as well as the paucity of observations between Days 10 and 15, require some explanation. A key factor is that the midterm exam was given on Day 12. What role did this factor play? First, it is quite normal for students to become more focused as they prepare for an exam. Among undergraduate students, grades are always a powerful motivator to learn the material. Second, the teaching assistant did not log any entries for the two days prior to the exam because the instructor was primarily engaged in review activities. Third, on the day following the exam the students were given a consumer survey assignment requiring them to be outside the classroom. Fourth, anecdotal evidence based on the experience of the instructor teaching undergraduate statistics over many years suggests that students tend to "take a break" from classes immediately after an exam.

Apart from the stimulus of the midterm exam, another reason for the improvement in attitude and verbal participation after Day 15 could be that the "hands-on" approach of teaching statistics with spreadsheets was finally beginning to pay off. It is tempting to explain the coincidence of an uptick in attitude and a falloff in attendance (see Figure 1) by arguing that the sample had changed. That is, one could say the students with poor attitudes simply stopped coming to class, leaving those who were self motivated. This argument can be refuted when we take a closer look at the detailed attendance of each student recorded by the teaching assistant. Of the 28 students on the official roster, only two students, representing 7% of the class, apparently dropped out (unofficially) after Day 5. But the relatively low attitude and participation scores persisted through Day 10. Following the midterm, another two students were consistently among the absentees and therefore could be assumed to also have unofficially dropped the course. Again these students represented less than

Figure 2 **Verbal Participation Scores**

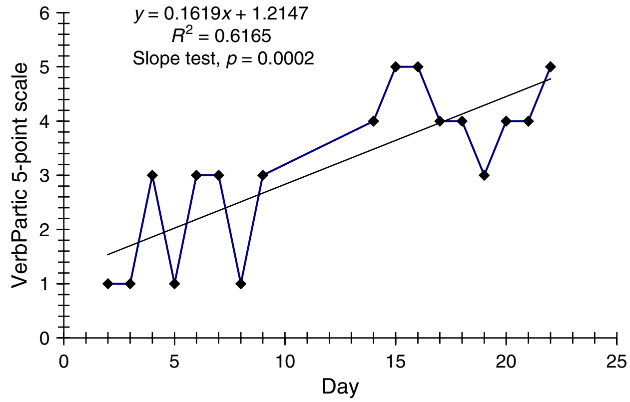


Figure 1 **Overall Attitude Scores**

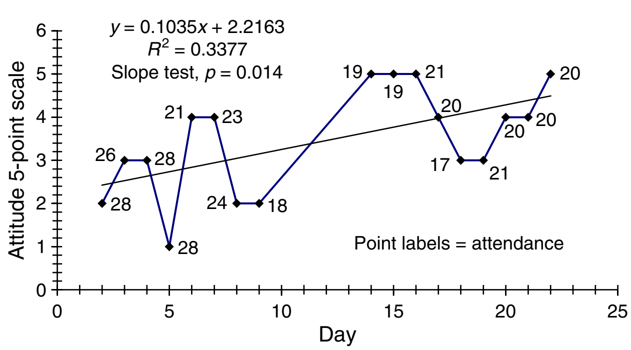
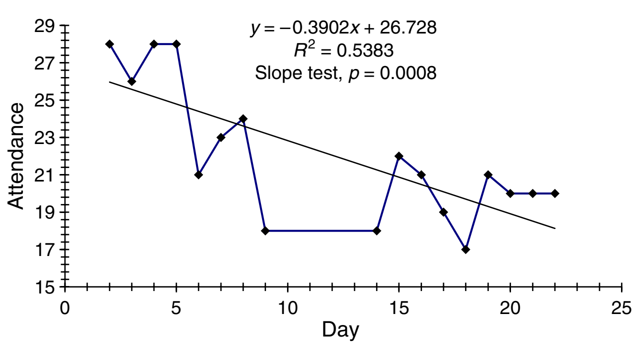


Figure 3 **Class Attendance**



10% of the class. Thus, even if they were among the weaker and unmotivated segment of the class, they cannot, by their exclusion, be solely responsible for the appreciable gains observed in student attitude and participation. Therefore, despite the negative correlation between attendance and attitude scores ($r = -0.52$, $p = 0.03$), there is no evident causal link.

Support for the observations made by the instructor was provided by the details of the teaching assistant's daily logs as well as through feedback from the secondary observer. The teaching assistant recorded noticeable improvement in the students' use of statistical software in data analysis. Students were observed to be much more willing and able to carry out complex manipulations with Microsoft Excel as the course progressed. For example, on Day 18 a log entry read, "Creating a pivot table much better than their first attempts earlier in the term." On Day 20 another entry read, "Students were able to run Excel macro with little or no assistance." The logs also reveal that by the end of the course the students' comfort level with using software was so high that they showed great enthusiasm when analyzing data and were confident in discussions over their findings arising from the analyses. An additional entry on Day 20 read, "I was told by student #22 yesterday that she was much more comfortable using Excel for statistics than a calculator. She described a tutoring session in which the tutor required her to work a 2-sample t-test by hand. She then told him she could work it much faster with Excel and would prefer Excel versus hand calculations. She said she was hesitant about the extensive computer use in the beginning of the term, but now is glad she stayed with the course and really likes using Excel for stats." On Day 24 an entry read, "Many are asking very good questions and volunteering answers during the review."

During his visit to the class at the end of the semester, the second observer noted that the students in the class exhibited an impressive comfort level with statistical terms. They used several technical terms such as confidence interval margin of error, t-test p-value, and regression r-squared. Moreover, they showed enthusiasm in discussing with the observer why statistics is a valuable tool in business.

Limitations and Suggestions for Future Research

Use of this hands-on approach to teach statistics with Microsoft Excel spreadsheets requires that all participants have access to a computer terminal during class. This puts a severe stress on the resources of many business schools. On the other hand, it may create a niche of opportunity for distance education programs with online instruction.

The topic of statistics is typically new for undergraduate business students. The statistical terms like "sampling frame" and "bias," as well as new concepts such as standard deviation and p-value of a significance test, are unusual and challenging. As topics build on each other, however, the students become accustomed to the ideas and their attitudes may change regardless of the teaching method employed. Without a control group comparison, the natural changes that occur in any course and those directly associated with using Microsoft Excel are confounded.

To isolate the effect of this hands-on approach, it would be very instructive to repeat this experiment and include a control group that is taught via traditional methods that do not involve the use of spreadsheets. In this comparative study, it would be crucial to record and track changes in attitudes and participation for both experimental and control groups.

It is possible to give a pretest to the subjects, prior to implementation of the treatment, to measure their skill sets and attitudes, thus providing a benchmark for comparison after the treatment has been administered. Without this benchmarking, it is not possible to determine whether any bias exists from the start. Purely by chance, one group could have a higher skill set or superior attitude going into the course. With benchmarking in place, a good way to gauge any treatment effect would be to compare the *improvement* in attitudes and skills across groups.

Another issue is the number of observers employed to record student behavior. To calibrate the written comments, it may be important to use multiple observers. For consistency, the same observers could be used for both experimental and control groups.

As discussed above, attendance needs to be taken into account when attempting to explain variations observed in attitude or participation. In this study, the attendance for individual students in the experimental group was recorded. However, the attitudes and participation levels of the individuals were not distinguished from the group behavior in general. Our claims about the effects of teaching statistics with spreadsheets on attitudes and participation could have been stronger if more detailed records on the activity of individuals were kept.

The response variables being measured were *attitude* and *participation*, both of which were subjective. One rater was used to assess the values for the two variables. *Was the teaching assistant employed to make the assessments trained in dimensions of attitude*? *What characterized positive behavior—body language*, *posture*, *facial expressions*, *or what they said*? *How can we ascertain whether the measurements are valid*? Although in this study we argue in favor of the professional experience of the observer, these questions need to be more thoroughly addressed in future research.

The experiment was conducted during an intense five-week summer course. A natural extension would be to investigate whether similar changes in attitude are observed over a typical 15-week semester or a 10-week quarter. In doing so, we may be able to generalize the findings. Unfortunately, as mentioned previously, our college cannot provide the laboratory facility during the periods that undergraduate statistics classes are regularly scheduled. Finally, it is also important to examine the relationship between gains in the affective and cognitive domain with the use of new instructional methodologies. There might be connections between the two domains, and future research needs to investigate these.

Educator Implications

1. Students tend to "dwell in fog" for the first two-fifths of a hands-on course, and then a positive shift in attitude and cognition occurs.

2. The participation level of students as the semester progresses might increase when spreadsheets are used in statistics classes.

3. Noticeable improvement in the students' overall attitudes became apparent as the students became comfortable in using spreadsheets. This suggests a need for a hands-on session during most classes so that students can mimic the instructor and learn to use spreadsheets throughout the course.

4. It is important to experiment with other methodologies such as the use of case studies and service-learning projects to improve students' attitudes toward statistics. Additional research is needed to evaluate the value of these pedagogies on gains in student attitudes and cognition.

Summary and Conclusions

We believe that undergraduate statistics can be taught effectively using a hands-on spreadsheet approach. There are documented claims that spreadsheets are useful in teaching cognitive concepts (Bell 2000). However, in this study we argue that the use of spreadsheets can bring about a noticeable change in students' learning in the affective domain as well as the cognitive domain. Using spreadsheets to teach statistics allows students to develop easily transferable spreadsheet skills while also building their confidence in statistical skills such as "data entry and manipulation, writing formulae, using absolute and relative cell references, using array formulae, and gaining access to built-in functions" (Pace and Barchard 2006). We observed that after completing two-thirds of the course, students had learned how to use spreadsheets as a tool for manipulating data. At the same time, the students' overall attitudes improved, and they were more willing to participate in class discussions and help classmates who were experiencing difficulty. It is reasonable to argue that because the ability to use spreadsheets enhances the employability of any job seeker in the current market, students will become more motivated to learn about the core topics when they perceive they have gained some level of spreadsheet proficiency. We acknowledge that our study, with its limitations, provides only a small step in an important but often neglected research area. Nevertheless we believe our results indicate using spreadsheets as a teaching tool can effectively improve the attitudes of students toward learning statistics.

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