Effectiveness of SMART Board Use in the Teaching and Learning of Statistics

Patricia May
e-mail: maypl@delhi.edu
State University of New York at Delhi
Delhi, NY 13753 USA

Abstract

Many researchers have explored the use of the SMART Board in elementary and secondary mathematics education. There is a lack of SMART Board research at the post-secondary level. The purpose of this study was to measure the effectiveness of an electronic SMART Board in an undergraduate elementary statistics course at a two-year technical college in south-central New York. Students were recruited from two sections of the researcher's statistics course. One section of the course (test group) was taught using a SMART Board, while the other section of the course (control group) did not have a SMART Board available. The control group was taught as it was in previous semesters, with the instructor presenting the lecture on the document camera. For the test group, the SMART Board allowed the instructor to readily post the lecture notes (in video format, including audio) on the college online course management system for students to view. This was not the case for the control group. Other than the differences noted above, the course content and presentation was identical for each section. Final course grades were compared using ANCOVA. Although the test group out-performed the control group, the difference was not statistically significant. The results also included a summary of student responses to questions regarding use of the SMART Board. Students in the test group reported that use of the SMART Board increased their attentiveness and engagement during lecture, and found the video postings beneficial to learning the course material.

1. Introduction

Several researchers have studied the effectiveness of SMART Board use in elementary and secondary mathematics classrooms, e.g., [3],[5],[6], [20]. The studies indicate that use of the SMART Board at these levels has positive effects on student achievement, attentiveness, and motivation. However, there is a lack of research focusing on the implementation of this technology in post-secondary mathematics courses. Analysis of SMART Board technology at the college level has primarily been restricted to areas such as computer science [19], engineering [9], and teacher education [2],[8],[12],[13]. This study aims to fill the research gap by examining the effectiveness of SMART Board use in an undergraduate introductory statistics course.

Some researchers have used experimental study designs to assess the effectiveness of the SMART Board in mathematics education. In a study by Oleksiw, the researcher found that use of the SMART Board in a third grade mathematics class significantly improved state test scores [14]. Similar research at elementary and middle school level mathematics demonstrated positive learning outcomes with SMART Board use [16],[21]. At the college level, researchers made similar comparisons in the areas of science, mathematics, and literature, but found no significant difference in student performance based on use of the SMART Board [4],[7],[18]. In a high school statistics course, Ottman compared a teacher-centered approach to a student-centered delivery method. For the control group, the material was delivered by the instructor using a traditional format. The students in the experimental group were assembled into teams, and each team taught a portion of the material using the SMART Board. Ottman found no significant differences in performance outcomes for the two methods [15].

Specific populations of students that are more likely to reap positive learning benefits from the SMART Board are identified. For example, Savoie demonstrated that SMART Board use increased motivation for elementary school math students with learning disabilities [17].

Blanton and Zirkle found similar results with special needs math students at the secondary level [1],[20]. Leberatore's research results of middle school math students indicated that use of the SMART Board for problem solving was more beneficial for lower level learners [11].

Two studies, one at the elementary level [10] and another at the college level [7], include specific analysis of the recording feature on the SMART Board. In the research involving elementary school students, the investigator used the SMART Board to record audio and video of the children while they worked in small groups to discuss and learn the mathematics. The recordings fostered effective mathematical communication among the students and allowed them to preserve and share important learning experiences. The college level study involved students enrolled in a statistics class. The instructor used the SMART Board recording capabilities to post copies of the class lecture notes on the course website. The postings were a transcript of the completed writings performed by the professor during class. They did not include video or audio enhancements. The researcher found that there was no significant difference in exam performance when students had access to class lecture notes [7].

2. Interactive SMART Board

The SMART Board model 680, an interactive whiteboard (IWB) developed by SMART technologies, was used by the instructor to present the statistics lectures in the experimental group. To prepare the outline of the lectures, the instructor used SMART Notebook (version 11) software. The problems to be covered in lecture were saved as a SMART Notebook file prior to class. During class, the files were displayed on the SMART Board, and the teacher and students were able to write on the board using an electronic pen. Students were encouraged to write problem solutions on the SMART Board for the rest of the class to view. A sample SMART Board screen is shown in Figure 1.

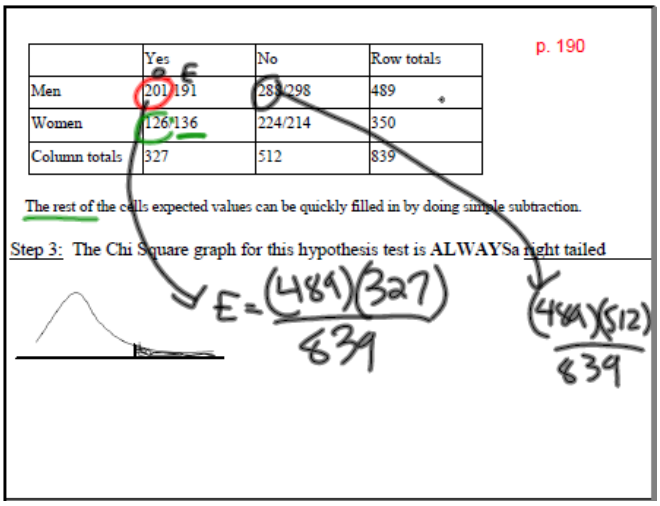

Figure 1: *Sample SMART Board screen*

With a SMART Board, unlike a traditional chalk board, the professor does not erase notes, and can more easily transition from one section of the lecture to another. A variety of pen colors are used to emphasize specific calculations. Where appropriate, the dual page display feature of the SMART Board was used. This allowed two screens to be displayed simultaneously. This feature also enabled the instructor to "pin" an important diagram on one of the pages so that it remained for the entire lecture. For example, when teaching the Empirical Rule, it was helpful to "pin" the diagram showing the 68-95-99.7 percentages. The technology includes the capability to record audio and video, capturing the instructor's voice and writing during the

lecture. At the end of each class, the video was saved as a Windows Media Audio/Video file (.wmv) and uploaded to the college course management system for students to view at their convenience.

3. Method

Forty-one statistics students from a two-year college in New York participated in the study during the Spring 2013 semester. Due to limited availability of classrooms equipped with a SMART Board, one section of the course had access to the technology, while the other did not. The test group (n = 23) was taught at 12:00 PM every Monday, Wednesday, and Friday for 50 minutes, while the control group (n = 18) was taught at 2:00 PM on the same days for the same length of time. Students voluntarily registered for each section of the class, without knowledge of whether or not the SMART Board would be used. According to local and federal Institutional Review Board policies, only students who voluntarily signed an informed consent document participated in the study. Three students from each section chose not to participate in the study. One student from the 12:00 PM section and six students from the 2:00 PM section withdrew from the course before the end of the semester.

The content covered in the control group section was identical to that covered in the experimental group, but the SMART Board was not used for the control group. Lectures were instead presented on a document camera, similar to the old-fashioned overhead projector. Unlike the SMART Board, which allows for a variety of pen colors, the content on the document camera is displayed in black and white only. To transition from one page of notes to another on the document camera, the instructor must physically remove one page and replace it with another. This differs from the SMART Board, on which the instructor simply presses a button to move from one page to another. The dual page display capabilities of the SMART Board were not available using the document camera, because two pages would not simultaneously fit. Students in the control group were encouraged to write problem solutions on the document camera for the class to view, and participation levels were comparable in both groups. The lectures materials for the control group were not recorded and therefore were not accessible after the lecture had commenced. The lecture notes for the control group were not posted online.

In order to attempt to control for any differences in initial mathematical ability, the researcher obtained students' scores on the New York State Integrated Algebra Regents Exam from college records. The exam consists of 39 questions. Thirty of the questions are multiple-choice format and the remaining 9 questions are open ended, yielding a maximum raw score of 87. These are converted to scaled scores using a chart provided by the New York State Education Department (http://www.p12nysed.gov/assessment). The test includes questions covering topics in algebra, probability, and statistics. More information detailing the psychometric properties of the test items can be found at www.p12.nysed.gov/assessment/reports/ia/ia-es-10.pdf.

The instructor covered identical material in each section, and both the experimental group and the control group utilized graphing calculators throughout the course. The same grading criteria were used for each section. The students' cumulitative course grade was the response variable in the ANCOVA. The course grade was based on a total of 620 possible points (5 exams at 100 points each, 10 homeworks at 10 points each, and a 20-point article critique). To determine the course grade, the instructor added up the total points earned by the student, divided by 620 and converted to a percent. The student's Regents score was used as the covariate in the ANCOVA.

A questionnaire (see Appendix) was administered to the test group in order to support the initial quantitative anlaysis (ANCOVA). Students were surveyed about the effectiveness of the SMART Board during class, and how they utilized the SMART Board lecture videos outside of class.

4. Results

1. Regression and ANCOVA

The relationship between Regents scores and course grade was examined using a regression plot as shown in Figure 2. The relationship between course grades and Regents scores is fairly linear, with course grades increasing as Regents scores increase. Regents scores accounted for a significant but small proportion of the variance in course grades, ($R^2 = .268, F(1,39) = 14.29, p = .001$).

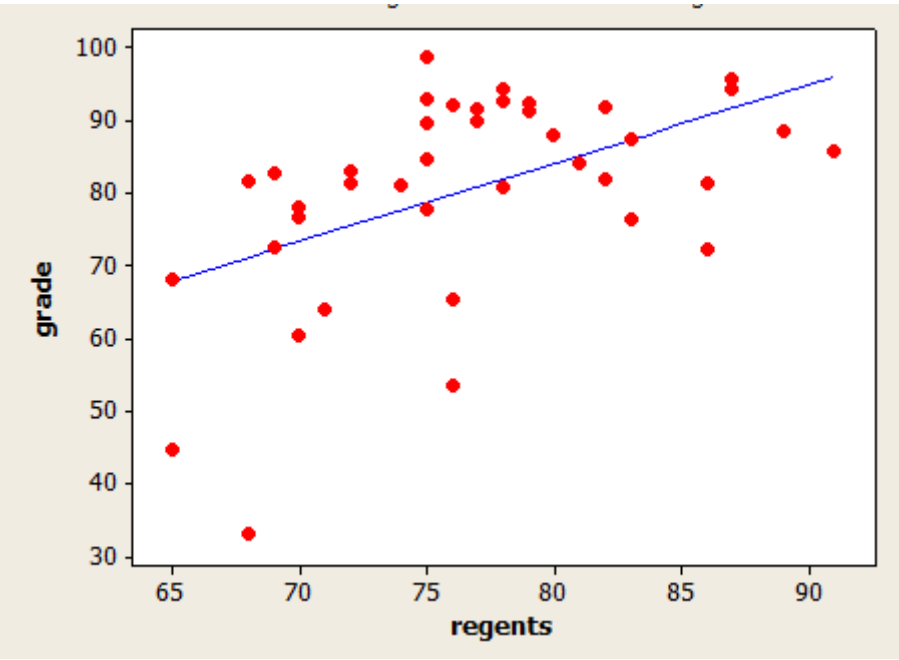

Figure 2: *Grade versus Regents regression plot*

As seen in Table 1, the test group had a higher mean Regents score and a higher average course grade. The difference in Regents scores was not significant, $t = 1.36$, $p = 0.182$.

Table 1: *Summary of subject characteristics*

Group	NYS Regents score $\bar{x}$ (*SD*)	Course grade $\bar{x}$ (*SD*)
Test (SMART Board) n = 23	77.70 (6.17)	83.12 (11.70)
Control (no SMART Board) n = 18	74.83 (7.33)	76.49 (16.26)

Table 2 shows the ANCOVA results for the course grades. Although the test group had a higher mean course grade than the control group, the result was not significant, $F = 0.89, p = 0.352$.

Table 2: *ANCOVA results for course grades*

Source	DF	Seq SS	Adj SS	Adj MS	F	P
regents	1	2131.5	1820.3	1820.3	12.17	0.001
section	1	133.1	133.1	133.1	0.89	0.352
Error	38	5684.1	5684.1	149.6		
Total	40	7948.7				

2. Supplemental questionnaire

Based on student responses to the questionnaire, 70% of students reviewed the lecture videos outside of class, for the reasons noted in Table 3. As seen in Table 3, the most popular reasons for viewing the lecture videos were missing a lecture and reviewing a difficult topic. One student took advantage of the videos for all four reasons listed on the questionnaire.

Table 3: *Students' reported reasons for viewing video lectures*

	Student															
Reason	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Missed lecture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Difficult topic	✓	✓	✓	✓		✓	✓									✓
Lecture too fast	✓															
Review for exam	✓	✓	✓	✓	✓											

The questionnaire included the open-ended question, "If you did view the online lecture videos, were they helpful to you? Please explain." Responses included those listed below, as were written by the students.

- *Yes. Gave me another chance to review the material again.*
- *Very helpful to review and understand.*
- *Yes, they offered explanation along with the notes and excercises which made them faster and easier to understand.*
- *Yes, helped me when I missed a class.*
- *Yes, because it's just as you're there in class.*
- *Yes, they were very helpful when I missed a class or didn't understand a topic.*
- *Yes, I was able to view the whole lecture if I missed it.*
- *Very. It was like I was sitting in class.*
- *Yes, because you talk and explain during.*

- *Yes, easy to follow.*
- *Yes, because I was able to stop and play to work at my own pace.*
- *Yes, it's pretty much a tutorial available for our use.*
- *Yes, it was like being in class and I could stop and go back if I needed to. Allowed for my own pace.*
- *Yes, I was able to review the lecture and use it to help me with homework, step by step.*
- *Yes, for all of the resasons I circled above. And they can be accessed at any time.*

Results of the questions related to the in-class SMART Board experience are shown in Table 4 (1 = strongly agree, 5 = strongly disagree). The students reported that the SMART Board was an effective presentation tool, and prompted them to become more engaged, attentive learners.

Table 4: *Frequency of student responses to questions*

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Mean
The Smartboard allowed for more student participation than traditional teaching tools (i.e. chalkboard, overhead projector, etc.)	0	1	0	12	10	4.35
The SMART Board was a more effective presentation method than traditional teaching tools (i.e. chalkboard, overhead projector, etc.)	0	0	0	11	12	4.52
I feel that I was more attentive to the lecture presented on the SMART Board than I would have been with more traditional teaching tools (i.e. chalkboard, overhead projector, etc.)	0	0	4	8	11	4.30
As compared to more traditional teaching tools (i.e. chalkboard, overhead projector, etc.), the SMART Board made it easier for the instructor to transition between different points in the lecture.	0	1	0	8	14	4.52

5. Conclusions

Although the final course grades from the section using the SMART Board were not significantly higher than those of the non-SMART Board section, the results were still encouraging. In particular, students reported that the ability of the SMART Board technology

to capture audio and video of the class lectures was very beneficial. Based on their responses to the questionnaire, students felt that use of the SMART Board prompted them to become more attentive, engaged learners, and allowed the instructor to more easily transition between different points in the lecture.

There were some logistical limitations to this study, as follows: The study was voluntary, and three students from each section chose not to participate. Furthermore, data from students who did not have New York State Regents scores (three from the test group and two from the control group) were not included in the study. One student from the test group and six students from the control group did not complete the course. If all students were included in the analysis, the statistical results would have been more accurate, and the survey results more comprehensive. The high attrition rate of the control group also may have affected the results. In the technology realm, the instructor continues to struggle with the formatting of the lecture videos. The SMART Board software allows videos to be saved as .wmv and .avi files, neither of which is viewable on a Macintosh computer. While this difficulty was not noted by any students in the researchers' sections, anecdotal evidence indicates this was the case for other instructors using the SMART Board videos.

Results of this research support the existing literature in the post-secondary curricula. Based on an examination of the previous SMART Board studies, it appears that SMART Board use may be more beneficial for learners at the elementary level than the college level. At any academic level, however, student motivation, satisfaction, and engagement seem to increase with use of the SMART Board.

Many ideas for further research emerge upon examining the results of this study in conjunction with the existing literature. Previous research at the elementary and secondary level has demonstrated that use of the SMART Board is more beneficial for lower level learners and for students with learning disabilities [1],[11],[20]. It would be relevant to attempt to replicate these results at the post-secondary level. In the current study, the researcher did not use advanced SMART Board tools, such as the variety of interactive content found at http://exchange.smarttech.com. Employing these activities in a future study would yield interesting, useful results to complement the existing research in this area. For example, the instructor is currently implementing use of the TI-SmartView software which enables a more visual demonstration of the graphing calculator used in the course. In the Fall 2013 semester, this software will be used in conjunction with the SMART Board. Further studies exploring the effectiveness of the combined technology are warranted.

6. References

1. Blanton, Bonnie & Helms-Breazeale, Rebecca (2000). *Gains in Self-Efficacy: Using SMART Board Interactive Whiteboard Technology in Special Education Classrooms.* Retrieved June 19, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/k-12/gains_in_self-efficacy.pdf
2. Canada, D. (2009). Fraction Photo Frenzy: A New Exploration. *Teaching Children Mathematics, 15*(9), 552-557.
3. Clemens, A., Moore, T. & Nelson, B. (2001). *Math Intervention "SMART" Project (Student Mathematical Analysis and Reasoning with Technology).* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/math/math_intervention_smart_project%20_student_mathematical_analysis_and_reasoning_with_technology.pdf

4. Damcott, D. & Landato, D. (2000). *Report on the Use of the SMART Board Interactive Whiteboard in Physical Science.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/report_on_the_use_of_the_smart_board_interactive_whiteboard_in_physical_science.pdf
5. Delaney, M. (2007). *Using the SMART Board Interactive Whiteboard to Create a Hands-on Approach to Learning Mathematics.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/math/using_the_smart_board_interactive_whiteboard_to_create_a_hands-on_approach_to_learning_mathematics.pdf
6. Egeberg, G. & and Wolner, T. (2011). *Board or Bored?* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/k-12/nordic_final_report_norway.pdf
7. Elvers, G. (2000). *The Digital Whiteboard as a Notes-Taking Aid.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/the_digital_whiteboard_as_a_notes-taking_aid.pdf
8. Jacobsen, M. & Davis, B. (2011). *SMART Response™ interactive response systems provide valuable insights in large-group environments.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/u_of_c_research_summary_2011.pdf
9. Jang, J. & Schunn, D. (2012). Physical Design Tools Support and hinder Innovative Engineering Design. *Journal of Mechanical Design, 134*(4), 041001-041001-9.
10. Lapko, B. (2013). Using Voice Recorders to capture their thinking. *Teaching Children Mathematics, 19*(8), 524-526.
11. Liberatore, J. (2008). A Constructivist Approach to Technology-Based Problem Solving. Retrieved June 17, 2013,from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/problem_solving/a_constructivist_approach_to_technology_based_problem_solving.pdf
12. McNeese, M. (2003). *Acquisition and Integration of SMART Board Interactive Whiteboard Skills: Gender Differences Among College Faculty, Staff and Graduate Assistants.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/acquisition_and_integration_of_smart_board.pdf
13. Nonis, A. & O'Bannon, B. (2001). *Technology and Teacher Preparation: Creating Learning Environments for Increasing Student Involvement and Creativity.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/technology_and_teacher_preparation.pdf
14. Oleksiw, T. (2007). *The Effect of the SMART Board Interactive Whiteboard on Raising State Test Scores.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/math/the_effect_of_the_smart_board_interactive_whiteboard_on_raising_state_test_scores.pdf

15. Ottman, L. (2007). *The Effect of Student-directed versus Traditional Teacher-centered Presentations of Content on Student Learning in a High School Statistics Class.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/math/the_effect_of_student-directed_versus_traditional_teacher-centered_presentations_of_content_on_student_learning_in_a_high_school_statistics_class.pdf
16. Preisig, J. (2007). *Report on the Use of SMART Board Interactive Whiteboard as a Tool to Develop an Understanding of Fractions.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/math/report_on_the_use_of_smart_board_interactive_whiteboard_as_a_tool_to_develop_an_understanding_of_fractions.pdf
17. Savoie, M. (2008). Math Motivation with SMART Board Technology. Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/math/math_motivation_with_smart_board_technology.pdf
18. Tate, L. (2002). *Using the Interactive Whiteboard to Increase Student Retention, Attention, Participation, Interest, and Success in a Required General Education College Course.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/using_the_interactive_whiteboard.pdf
19. Vitolo, T. (2003). *The Importance of the Path Not Taken: The Value of Sharing Process as Well as Product.* Retrieved June 18, 2013, from http://downloads01.smarttech.com/media/sitecore/en/pdf/research_library/higher_education/the_importance_of_the_path_not_taken.pdf
20. Zirkle, M. (2005). *The Effects of the SMART Board Interactive Whiteboard on High School Students with Special Needs in a Functional Mathematics Class.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/research/international_research/usa/mennoniteuniversityresearch.pdf
21. Zittle, F. (2004). *Enhancing Native American Mathematics Learning: The Use of SMART Board-generated Virtual Manipulatives for Conceptual Understanding.* Retrieved June 17, 2013, from http://downloads01.smarttech.com/media/research/international_research/usa/ceerzittle.pdf

Appendix

Survey questions for "Effectiveness of Smartboard Use in the Teaching and Learning of Statistics"

1. For what purposes (if any) did you review the online lecture videos? Please circle all that apply.
    a. When I missed a lecture
    b. When a particular topic was difficult to understand
    c. When the lecture was too fast-paced and I missed something in the notes
    d. To review for an upcoming exam
    e. Other (please explain) _____

2. If you did view the online lecture videos, were they helpful to you? Please explain.

The following questions refer to your <u>in-class</u> experience:

3. The Smartboard allowed for more student participation than traditional teaching tools (i.e. chalkboard, overhead projector, etc.)

    1. Strongly disagree 2.Disagree 3.Neither agree nor disagree 4. Agree 5. Strongly agree

4. The Smartboard was a more effective presentation method than traditional teaching tools (i.e. chalkboard, overhead projector, etc.)

    1. Strongly disagree 2.Disagree 3.Neither agree nor disagree 4. Agree 5. Strongly agree

5. I feel that I was more attentive to the lecture presented on the Smartboard than I would have been with more traditional teaching tools (i.e. chalkboard, overhead projector, etc.).

    1. Strongly disagree 2.Disagree 3.Neither agree nor disagree 4. Agree 5. Strongly agree

6. As compared to more traditional teaching tools (i.e. chalkboard, overhead projector, etc.), the Smartboard made it easier for the instructor to transition between different points in the lecture.

    1. Strongly disagree 2.Disagree 3.Neither agree nor disagree 4. Agree 5. Strongly agree

7. If there are any other comments you would like to add regarding use of the Smartboard for this class, please do so in the space provided: