The Effect of Student-directed Versus Traditional Teacher-centered Presentations of Content on Student Learning in a High School Statistics Class

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Abstract

This study compares the effects of two different instructional delivery methods on student learning in my senior-level statistics classes. A quasi-experimental design Nonequivalent-Groups method was employed. Each of two classes was randomly assigned a treatment of either student-directed presentation, or the traditional teacher-centered presentation for a particular content unit. After administering pre-tests to both groups, the control group was presented with the content in the traditional manner, with the teacher presenting and defining the new concepts for the unit. In the student-directed classroom, students were randomly assigned to working groups. Each working group was given a topic to investigate, using the resources at their disposal (textbooks, student discussion, internet sources, and teacher input), mastered the content knowledge of their assigned topic, and synthesized a presentation of the content material using the SMART Board™ interactive whiteboard and other presentation tools. At the end of the unit, the post-test was administered to both groups. In an attempt to control for differences between the two classes, they switched instructional methods for a second content unit by following the same methods as the first unit.

Analysis of the data revealed that both groups showed significant improvement under both instructional approaches, but showed no significant differences gained by a

particular instructional method. The results seem to indicate that proper and careful instructional design is more important to learning outcomes than the selection of a particular instructional technique or medium.

Introduction

Since the publication of the National Council of Teachers of Mathematics (NCTM) Standards in 1989, a great deal of emphasis in mathematics education has been placed on shifting the classroom environment away from the traditional lecture format to a student-directed, project-oriented learning environment. The explosion of data collection equipment, graphing calculator technology, and presentation software has helped drive this new emphasis. Many teachers have been quick to embrace this new technology and have been witnesses to its positive effects on the classroom environment and student attitudes towards learning mathematics. At the same time, the development and marketing of the SMART Board interactive whiteboard in secondary education has given teachers more flexibility to present materials in more effectively enlightening ways, but leads to a more teacher-centered approach. This study attempts to investigate the effects on student learning of shifting the use of the interactive whiteboard away from the teacher and placing the development and presentation of the mathematics content of a high school statistics course into the hands of the students.

Literature Review

The debate in mathematics education over the different approaches of teaching processes and computation versus teaching concepts and understanding has continued to rage since the 1980s. Because testing results in the United States showed students lacking the ability to apply basic factual knowledge in different contexts, mathematics educators called for a shift in approach to one that emphasizes the students' understanding over an algorithmic process (Schmittau, 2004). This, in turn, led to less of an emphasis on the teacher as the sole source of information and a greater emphasis on the students taking a more active role in their learning. The proliferation of accessible technology has helped fuel this shift and made problem-based, explorative learning more accessible for mathematics students and teachers. These changes went hand-in-hand with the NCTM Standards, which "reflect a cognitive and constructivist approach to teaching and learning mathematics which is a dramatic departure from the rote-learning model that had dominated mathematics instruction until the late 1980s" (Montague, 2003, p.166).

However, the result has been a division in the mathematics education community commonly referred to as "The Math Wars." It is not the intention of this study to engage in the philosophical differences of this debate, and most educators on either "side" would agree that a classroom environment that encourages students to take an active role in their education is a positive one. So what does the existing body of research have to say about the results of students taking the lead role in their instruction? The results are varied.

A three-phase study of college level mathematics was funded by the Center for Academic Transformation at the Rensselaer Polytechnic Institute to redesign entry level, large lecture format college courses. Ten universities participated in the first round, and half of them showed statistically significant improved learning outcomes when "lectures were replaced with a variety of learning resources, all of which involved more active forms of student learning." (Twigg, 2003, p. 2). A study of an undergraduate business course taught in both a traditional and a more constructivist environment, while revealing no statistically significant advantage to the student-directed approach, led the researcher to conclude that there is support that students learning in this manner suffer no disadvantage in standard measures of performance, when compared to their traditionally taught counterparts (Moorhouse, 2001). A study conducted in an educational psychology course concluded that "a constructivist learning environment seems to produce higher-level learning outcomes more efficiently than traditional teaching." (Tynjala, 1998, p.1).

At the high school level, a teacher in Australia used a qualitative, multiple-method research approach of reflective practice through video-taping, interviewing, and journaling to conclude that the optimal form of student participation is characterized by the student contributing to the understanding of the group in a manner in which no one student or teacher dominates the inquiry (Forster, 2002).

A recent study examined the results of a constructivist versus traditionalist approach to learning multiplication with elementary school children (Chung, 2004). While the results of this study showed no statistically significant improvement in multiplication skills for one approach over the other, the researcher did see positive gains in students using the constructivist approach in this limited setting and suggested ideas for extending the research further as well as evidence of its effectiveness that "…was also supported in earlier findings by other researchers." (Chung, 2004, p. 274).

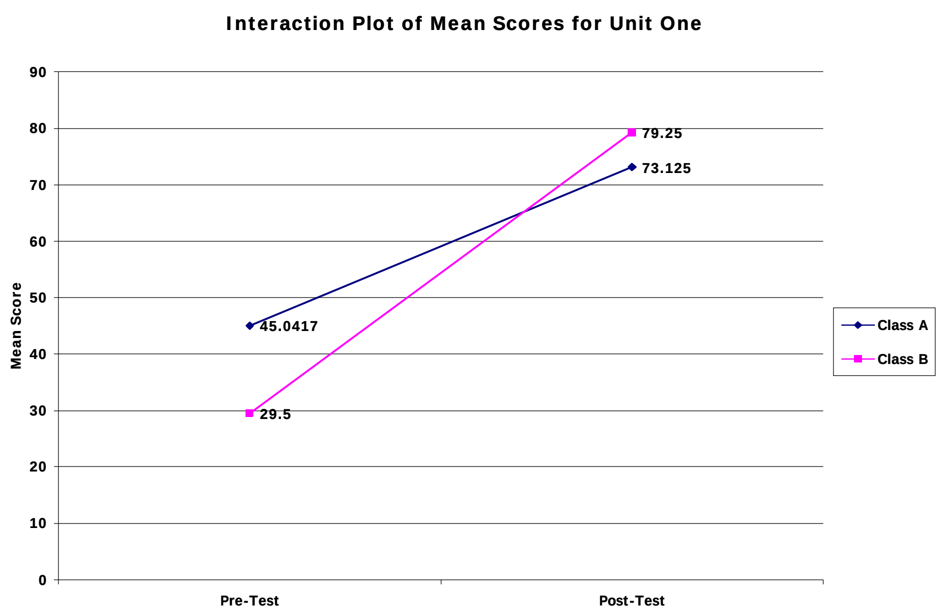
There are also some contradictory opinions about the effect of a constructivist approach with low-achieving students and those with learning disabilities. In an elementary school study undertaken in Finland, the researcher concluded a more traditional approach, termed “explicit instruction,” actually produced significant improvement in student performance when compared to a constructivist approach (Kroesbergen, 2004). Yet, Montague (2003) argues that a constructivist approach is the proper way to teach students with learning disabilities the basic concepts and skill sets of the division process.

Methods

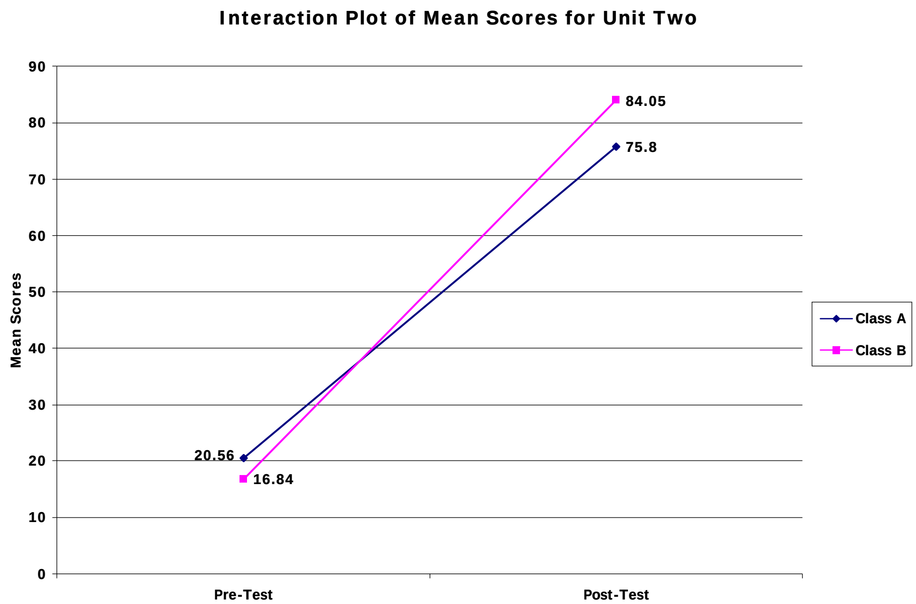
For this study, two senior-level high school statistics classes were used. Students taking this class carried a wide range of mathematical experiences and abilities. Many of these students tend to be typical college preparatory students and may underrepresent low-performing, unmotivated students and have a disproportionately low number of students with identified learning disabilities. Very few special education students have historically taken this course. Students motivated enough to take an optional fourth year of mathematics may perform better in any learning scenario or respond to a unique learning situation differently from the general population. Due to the scheduling limitations of a smaller school, there were also observable differences in the performance and abilities of the two classes, with Class A generally containing more motivated and higher-achieving students. Both instructional units were typical of an introductory statistics class. The first unit was an introduction to correlation and the second unit developed the foundations of confidence intervals. Each pre- and post-test included a mixture of short-answer and multiple-choice questions typical of the College Board Advanced Placement Test, as well as some more process oriented questions involving both extended calculations, forming conclusions, and the use of technology.

Results

For the first unit, Class A was assigned the student-directed approach, with Class B using the teacher-centered model. The mean scores for both the pre- and post-tests were calculated for each class. Analysis showed that Class B's scores on the pre-test were significantly lower ($p = .01$) than Class A. The variance of scores on the pre-test among the students in Class A was also significantly lower ($p = .016$). A 2-factor ANOVA with 1 within factor (pre-test and post-test) and 1 between factor (Class A and Class B) showed a significant interaction ($p < .001$). The interaction plot below shows that the teacher-centered class showed more improvement from pre-test to post-test than the student-directed group.



For the second unit, Class B was now the student-directed group and Class A used the teacher-centered pedagogy. was different, Class B again showed an improvement in Even though the instructional method scores from the pre-test to the post-test that was greater than Class A (p = .02). Class B appeared to be better learners regardless of the instructional method employed.



A flaw in the design of the study exists in the fact that the instructional units contained completely different content and, therefore, there was no method in place to control for possible differences in the students' ability to learn the different material. In spite of this, the scores of the two units were combined to investigate how much students improved under each type of instructional delivery, regardless of which unit they were learning. A 3-factor ANOVA (comparing class, training method, and pre-test/post-test) showed a positive interaction (p = .001) between training method and group, meaning that the improvement in scores shown under a particular method depended on the individual class. An analysis of the interaction between the pre/post-test scores and the type of instructional delivery showed that there was no significant difference. While the traditional-method students showed slightly more improvement, it was not statistically significant ($p = .112$).

Conclusion

The results seem to indicate that the instructional delivery method does not appear to make a significant difference in student learning. This conclusion is in line with findings from other studies. In a study comparing a college introductory programming course taught using computer-based modules with the same course taught using a more traditional test-based approach, there was no significant difference in performance between the two courses, which led the researcher to conclude that "Variance in student performance is explained by their preparation and effort and teacher skill, not the teaching material" (Press, 2006). Richard Clark has long championed the idea that different types of instructional media do not produce learning gains in and of themselves, it is the nature of the instruction itself that is most important (Clark, 1994). While his writings deal specifically with different types of instructional media, it is not inappropriate to apply his conclusions to this example. In both classes, the one constant was the care and effort with which the instructional units for both groups were designed. In order to execute the study, the principles of sound instructional design were applied to the classroom instruction in a much more overt way than usual. Because the instructional experiences were carefully designed with learning outcomes in mind, both groups of students learned very successfully, regardless of the particular pedagogical approach. Richard Mayer concludes that, “the principles of instructional design do not necessarily change when the learning environment changes” (Mayer, 2003). Educators should be encouraged and challenged to strive to apply these principles to all of their classes, regardless of the instructional delivery method.

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References

Cho, J. & Yager, R. & Park, D. & Seo, H. (1997). Changes in high school teachers' constructivist philosophies. School Science and Mathematics, 97(8), 400-405.

Chung, I. (2004). A comparative assessment of constructivist and traditionalist approaches to establishing mathematical connections in learning multiplication. Education, 125(2), 271-279.

Clark, R. (1994). Media will never influence learning. Educational Technology Research and Development, 42, 21-30. Retreived October 3, 2006 from: http://www.usq.edu.au/unit/resource/vlark/media.htm

Davis, M. (1998). The electronic biology classroom: implementation and student opinion. Kapiolani, HI: ERIC Clearing House on Information & Technology. (ERIC Document Reproduction Service No. ED 449976)

Forster, P. (2002). Student participation: an exploration of the possibilities. Reflective Practice, Carfax Publishing Company, 3(2), 125-140.

Gadanidis, G. (1994). Deconstructing Constructivism. The Mathematics Teacher, 87(2), 91-97.

Halpin, R. (1999). A model of constructivist learning in practice: computer literacy integrated into elementary mathematics and science teacher education. Journal of Research on Computing in Education. 32(1), 128-138.

Johnson, S. & Aragon, S. & Shaik, N & Palma-Rivas, N. (2000). Comparative analysis of learner satisfaction and learning outcomes in online and face-to-face learning environments. Journal of Interactive Learning Research, 11(1), 29-49.

Mayer, R. (2003). The promise of multimedia learning: using the same instructional design methods across different media. Learning and Instruction, 13, 125-139. Retreived October 2, 2006 from: www.elsevier.com/locate/learninstruc

Montague, M. (2003). Teaching division to students with learning Disabilities: a constructivist approach. Exceptionality, 11(3), 165-175.

Moorhouse, D. (2001). Effect of instructional delivery methods on students achievement in a master's of business administration course at the Wayne Huizenga School of Business and Entrepreneurship. Ft. Lauderdale, FL: ERIC Clearing House on Information & Technology. (ERIC Document Reproduction Service No. ED 453728).

Palincsar, A. & Herrenkohl, L. (2002). Designing collaborative learning contexts. Theory into Practice, 41(1) 26-32.

Pankuch, B. (1998). Multimedia in lectures and on the world wide web. Princeton, NJ: ERIC Clearing House on Information & Technology. (ERIC Document Reproduction Service No. ED 437126).

Pearson, M. (1994). The relationship between student perceptions of the multimedia classroom and student learning styles. Washington, DC: ERIC Clearing House on Information & Technology. (ERIC Document Reproduction Service No. ED 374482).

Press, L. A Modular, web-based introductory programming course. California State University Dominquez Hills. Retrieved September 29, 2006 from: http://bpastudio.csudh.edu/fac/lpress/articles/drafts/modulepaper.htm

Schmittau, J. (2004). Vygotskian theory and mathematics education: resolving the conceptual-procedural dichotomy. European Journal of Psychology of

Education, 19(1), 19-43.

Snyder, K. (2001). An assessment of the role of computer technology in the classroom. Shepherdstown, West Virginia: ERIC Clearing House on Information Technology. (ERIC Document Reproduction Service No. ED 453727).

Twigg, C. (2003). Improving learning and reducing costs: lessons learned from round 1 of the pew grant program in course redesign. Center for Academic Transformation, Rensselaer Polytechnic Institute, Troy, New York.

Tynjala, P. (1998). Traditional studying for examination versus constructivist learning tasks: do learning outcomes differ? Studies in Higher Education. 23(20), 173-190.

Woodward, J. & Montague, M. (2002). Meeting the challenge of mathematics reform for students with LD. The Journal of Special Education. 36 (2), 89-101.