Introductory Statistics Students' Achievement in a Flipped-Concept Classroom Using Active Learning for Simple Linear Regression

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Abstract

The Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report recommends active learning in introductory statistics classrooms as a way to teach statistical concepts effectively. The Middle Tennessee State University (MTSU) Modules for Teaching Statistics with Pedagogies using Active Learning (MTStatPAL) team is addressing this recommendation by designing active learning modules for instructors of introductory statistics. These modules include learning materials for students and materials designed to support instructors in learning how to use active learning effectively to teach fundamental concepts in introductory statistics. The modules contain the lesson, a technology-facilitated pre- or post- class activity that covers concepts needed for the active learning lesson, and teacher support material such as a tip sheet and a video of an experienced teacher using the lesson. The module described in this paper covers the topic of linear regression as a descriptive measure. Student performance results from a pre-test and a post-test and final exam demonstrate the effectiveness of the implementation of this module. Additionally, data from student feedback forms regarding the modules demonstrate support from the students for this instructional method.

Key Words: statistics education, active learning, flipped classroom, teaching descriptive regression

1. Introduction

At Middle Tennessee State University (MTSU) and other colleges and universities across the nation, more and more students are taking introductory statistics courses (Aliaga, et al., 2005; Garfield, Hogg, Schau, Whittinghill, 2002). As the number of introductory statistics classes increases, more of these courses are being taught by adjunct faculty, graduate students, or full-time faculty (Lutzer, Rodi, Kirkman, & Maxwell, 2007) with little to no background in statistics or in teaching statistics. Because of this, some of these instructors at MTSU struggle with implementing the recommendations established by the American Statistical Association's endorsed GAISE (Aliaga, et al., 2005) document, specifically the active learning recommendation. To assist these instructors with implementing active learning effectively in their introductory statistics classrooms, the MTSU Modules for Teaching Statistics with Pedagogies using Active Learning (MTStatPAL) team are creating all-inclusive modules addressing introductory statistics

topics from an active learning perspective. The first module created introduces simple linear regression as a descriptive measure. To assess the effectiveness of this module, a pre- and post-test were administered to students. The results from these tests and student feedback from surveys are discussed in this article.

1.1 Current Situation

MTSU, the largest undergraduate institution in Tennessee, has a growing introductory statistics student population. In the 2007 – 2008 academic year, 766 students enrolled in the introductory statistics course. This number grew to 1,012 students in the 2011 – 2012 academic year. These students can enroll in four different versions of this class: on-campus traditional; on-campus enriched; online traditional; or online enriched. In the enriched course, students test into this course based upon their deficiencies as measured by ACT and/or COMPASS testing. These students spend extra time on algebra concepts that support their learning of statistics.

Because of this growth in the number of introductory statistics students at MTSU, more of these courses, in all formats, are being taught by adjunct instructors, temporary faculty, or graduate teaching assistants with either limited teaching experience or limited content knowledge, or a combination of both. In the 2011 – 2012 academic year, 45% of the introductory statistics courses were taught by part-time faculty and nearly 18% were taught by graduate teaching assistants.

1.2 Project Motivation

This project takes a two pronged perspective: student learning and teacher instruction in the introductory statistics classroom. At MTSU, university leaders are encouraging teachers of general education courses, such as introductory statistics, to improve student learning. To help facilitate this, the MTStatPAL group is committed to engaging the students in active learning and rich student-to-student, content-centered discussions. By developing these learning materials, the group seeks to support the implementation of the GAISE recommendations for using active learning, teaching with real data, emphasizing conceptual understanding over procedural knowledge, and developing statistical thinking in all students.

1.3 Obstacles

Many of the teachers of this course and other courses have concerns when it comes to using active learning in their classroom. One of these concerns is classroom control (Lafferty, Rozaitis, & Wilcox, n.d.). Teachers are concerned with the logistics of implementing a lesson using active learning and being able to manage the classroom simultaneously. Given the brevity of the introductory statistics class, teachers are concerned with using a potentially time-consuming activity in class and still being able to cover all of the required topics (Bonwell, C.C., & Eison, J.A., 1991). Teachers often also struggle with selecting an appropriate task, and if a task is found, finding supportive materials and equipment (Eison, J., 2010). Furthermore, many teachers are concerned with the overall effectiveness of this teaching method (Eison, J., 2010). The MTStatPAL modules are designed to address each of these obstacles.

2. Modules

2.1 Module Content

Each module consists of three components: the pre-class activity and/or post-class activity, instructor materials, and the in-class activity. If the module has a pre-class activity, this activity is designed to prepare students for the corresponding in-class activity. These activities could be videos that include on-line quizzes and a student note-taking template or specific instructions for using an applet. If the module has a post-class activity, this activity is designed to extend student learning of module content to a higher cognitive level than the level students were able to achieve in class. The instructor materials include a tip sheet with a script for the lesson, a video of an experienced instructor, activity solutions, and additional assessments that can be used for tests and/or quizzes. The in-class activity is a hands-on activity for students designed to promote student discourse. These activities help students gain an understanding of statistical concepts through an active learning process.

2.2 Measuring the Module

To measure effectiveness of the modules, data were gathered on four components. These components included a faculty and student ease-of-use survey, a measurement of student gains in content knowledge, a measurement of student performance with and without the module, and observations on the impact on the classroom environment.

2.1.1 Ease-of-Use Surveys

Two versions of the ease-of-use surveys were created, one for the instructors and one for the students. Both versions included questions on a four-point Likert-type scale and also included two free response questions. The student ease-of-use survey measures student perceptions of the module and their self-reported learning. An example statement students responded to is, "The pre-class activity helped me understand regression." Students responded to this by choosing "strongly disagree," "disagree," "agree," or "strongly agree." The faculty ease-of-use survey measures faculty self-reported usability. An example statement that faculty had to respond to is, "The in-class activity was easy to implement."

2.1.2 Student Gains in Content Knowledge

To measure student gains in content knowledge, a pre- and post-test were administered to all students enrolled in courses using the modules. The pre-test consists of five questions on module content, which either were selected from the Assessment Resource Tools for Improving Statistical Thinking (ARTIST) database (https://apps3.cehd.umn.edu/artist/publications.html) or were created by the project team to address topics covered by the module. This test is given to students prior to completing the pre-class activity. A five-question post-test with similar questions is given to students after the module is complete.

2.1.3 Student Performance

To evaluate the general education requirements for this course, six common final exam questions were given to all students of introductory statistics. The project team was able to use these questions to compare performance between sections that experienced the module and those that did not. Of these six questions, one relates to regression, the module content, and the other five were used to compare overall student ability of module and non-module sections.

2.1.4 Classroom Environment
The Reformed Teaching Observation Protocol (RTOP) (Sawada, et al., 2002) was used in module sections to ascertain the extent to which active learning was being used, the type of student-to-student conversations and discourse evident, and the level of student engagement. Each teacher implementing the modules was observed during the in-class activity and during a regular class session for comparison purposes.

This article's focus is on student results according to the pre- and post-test, final exam results, and results from the ease-of-use survey. Teacher materials or classroom observation results are not discussed in this article.

3. Regression Module

3.1 Content and Implementation

For the regression module, a pre-class activity was created using a Camtasia-recorded PowerPoint presentation with embedded quizzes. During the development phase of this project, the students' quiz results were sent to the researchers for data collection. (Note: The researchers are working on efficient ways to send the pre-class activity quiz results to the teachers prior to their in-class activity so they could use the results to inform their instruction.) The in-class activity (used with permission), "Regression on the Rebound" created by Buskirk and Young (2001), was modified to fit the time constraints of the course activity and included a student handout. This activity has students drop balls and record the height of the rebound for different drop heights. Students use regression to model the relationship between the drop heights and the rebound heights.

This module was implemented in three classrooms. The first classroom was in the fall of 2012 and was led by an instructor with over 20 years of teaching experience and over 5 years of teaching statistics experience. This professor had two sections of the traditional course. In the same semester, another instructor implemented the module, who had only one semester of experience teaching and had two sections of the traditional classroom. In the spring of 2013, a teacher with three sections of the enriched course implemented the module. This instructor had over six years of teaching experience and had taught introductory statistics six times.

3.2 Results

3.2.1 Student Ease-of-Use Surveys
Promising results from the student ease-of-use surveys were noted. Eighty-four percent of the students self-reported completing 100% of the pre-class activity. Sixty-nine percent of the students said that the *pre-class activity* helped them understand regression, and 87% said the *in-class activity* helped them understand regression. Also, 68% of the students said that they would prefer having lessons taught with this method.

3.2.2. Pre-test and Post-test
Both pre-test and post-test data were completed by138 students in module sections. For four of the five questions, students' scores from pre-test to post-test improved. One question about the interpretation of slope caused students' scores to decrease. After examination, this was attributed to answer order and poor question wording. Overall, student scores improved from 56% to 71% from pre-test to post-test. These results can be seen in Table 1.

Question Content	Pre-test, % correct (N=138)	Post-test, % correct (N=138)
Selecting Independent Variable	27%	65%
Graphical Correlation: None/Exact	74%	89%
Graphical Correlation: Strong	61%	62%
Predicting Using Equation	51%	85%
Interpreting Slope	66%	52%
	Overall: 56%	Overall: 71%

Table 1: Student pre- and post-test results from fall 2012 and spring 2013

3.2.3 Final Exam Results

Final exam results from the fall of 2012 were collected and analyzed. Results from this examination demonstrated that students in the module classrooms performed better on content explored in the modules (i.e. interpreting slope of a regression line) than students not in the module classrooms. Students in the non-module classrooms scored an average of 43% on interpreting slope as compared to the score of 62% by students in the module classrooms. Results from the final exam can be seen in Table 2. Note that on the final exam questions that were not related to the module, the treatment group actually performed less well than the control group. This indicates that the scores for the regression question are not due to differences in students' prior ability.

Question Content	Control Group (Without Module) N=277	Treatment Group (With Module) N= 82
Non-module content	75%	67%
Module Content: Interpreting Slope	43%	62%

Table 2: Student final exam results from fall 2012

4. Conclusion

Overall, student test and survey show promising results for the regression module. The student ease-of-use survey results indicated that a majority of students completed the pre-class activity, and most of these students indicated that this activity helped them to better understand linear regression. The results also indicated that many students actually preferred this type of method, which the MTStatPAL team found encouraging. Upon examining the pre- and post-test results, it is evident that the students performed better on all but one question, and this result has been attributed to poor question order and wording. The MTStatPAL group was pleased with these results. The final exam results demonstrated that although the treatment group did not perform better on all topics, they did perform better on the interpreting slope question, a focus of the regression module.

The MTStatPAL group is currently examining how to improve the regression module. This includes reviewing the lesson content, improving the pre-class activity, and retesting students with the pre- and post-test questions to determine the effectiveness of the module.

More modules are currently being created and tested for other topics in the introductory statistics class, including modules for probability, the binomial distribution, and confidence intervals for proportions. These three modules will be tested for student and

teacher usability as well as student learning with the design team teaching the modules in fall 2013 and for implementation effectiveness with other teachers at MTSU in spring 2014. This new work will be supported by a National Science Foundation Division of Undergraduate Education Transforming STEM Education (TUES) grant (#**1245393).**

A website is being created to house all of the modules and the corresponding documents for each module. The website will have separate access for students and teachers. The password protected site for teachers will contain all the teacher materials as well as solutions to the student handouts.

The MTStatPAL project shows promise in addressing the issue of getting inexperienced teachers to implement activities that aid student learning. If the future modules demonstrate the success in student outcomes that the first module shows, they will eventually be implemented in every section of this course. This will form the basis of a common learning experience for all students of this general education course and help ensure that teachers of introductory statistics at MTSU are following the best practices in statistics education.

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