OBSERVATIONS OF IMPLEMENTATIONS OF AN ACTIVE LEARNING MODULE IN INTRODUCTORY STATISTICS

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Middle Tennessee State University's Modules for Teaching Statistics with Pedagogies using Active Learning (MTStatPAL) project team is developing teaching modules for introductory statistics courses that help faculty create active learning classroom environments. MTStatPAL instructor materials include: 1) a video of an experienced statistics instructor implementing the classroom activity, 2) an online pre- or post-class activity that helps students develop a conceptual understanding of the topic, 3) a teacher activity implementation guide, and 4) a set of pre- and post-activity testing instruments for the assessment of student learning. Observations of implementations of the regression MTStatPAL module were made by persons trained in using the Reformed Teaching Observation Protocol (RTOP) instrument. This paper discusses how the MTStatPAL regression module helped instructors implement instruction that encouraged students make conceptual sense of statistical content.

BACKGROUND

Many disciplines now require students to have a working knowledge of statistical techniques and data analysis methods (Everson, Zieffler, & Garfield, 2008). As a result, the number of introductory statistics courses offered at universities and the number of students enrolling in those courses have both increased over the last 15 years. Many different types of faculty are called upon to teach introductory statistics courses -- from experienced statistics educators, to statistically literate graduate students who have little teaching experience, to tenured faculty with little experience teaching statistics, to both experienced and inexperienced adjunct and temporary faculty.

In an effort to provide pedagogical guidance for all instructors of introductory statistics courses, in 2005 the ASA endorsed the Guidelines for Assessment and Instruction in Statistics Education (GAISE) recommendations that encourage instructors to 1) emphasize statistical literacy and develop statistical thinking, 2) use real data, 3) stress conceptual understanding, 4) foster active learning in the classroom, 5) use technology for developing concepts and analyzing data, and 6) use assessments to improve and evaluate student learning (Aliaga et al., 2012). Advocates of reform-oriented instruction in K-12 mathematics and science classrooms encourage teacher practices that align with these guidelines (CCSSI, 2010; NGSS Lead States, 2013). When following the GAISE recommendations, we have realized that managing productive classroom discourse in support of student construction of conceptual understanding is quite difficult. Yet, managing such discourse is essential for successful implementation of active learning in the classroom (Garfield & Ben-Zvi, 2007; Niemi, 2002).

MOTIVATION FOR MTSTATPAL MODULES

In an effort to provide the increasingly diverse faculty who teach introductory statistics courses with resources for teaching in a way that aligns with the GAISE recommendations, a team of Middle Tennessee State University (MTSU) faculty initiated the Modules for Teaching Statistics with Pedagogies using Active Learning (MTStatPAL) project in 2012. The teaching materials developed by the project team are lesson modules that promote the use of active learning and stress student conceptual understanding of selected introductory statistics topics. Instructors face common challenges when implementing instruction in an active-learning environment. Perceived barriers include the amount of preparation time, the amount of classroom time used for implementation, the relinquishment of classroom and instructional control, and student resistance to nontraditional forms of instruction (Michael & Modell, 2003). Further pedagogical complications arise from the

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fact that student learning paths can be difficult to predict when subject matter is learned using student-directed classroom activities where the instructor acts as facilitator (Michael, 2007).

To address some of these difficulties, the MTStatPAL instructor materials include a video of an experienced statistics instructor implementing the classroom activity, an online pre- or post-class activity that provides students with the conceptual supports for the topic under study, and a description of how to use related technology tools. In addition, each module includes a teacher guide to implementation and a set of pre- and post-activity assessment instruments (with solutions).

The first MTStatPAL module (available at http://mtstatpal.com/modules/regression/) was developed to help instructors successfully teach descriptive linear regression using the *Regression on the Rebound* activity (Buskirk & Young, 2001). The MTStatPAL regression module was implemented in multiple sections of introductory statistics at MTSU in fall 2012 and spring 2013. The module's positive impact on student learning has previously been reported (Gerstenschlager et al., 2013). In this paper, we report preliminary results of an ongoing design experiment (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003) investigating the learning ecology of classrooms that implement MTStatPAL modules and the factors influencing subsequent modifications to those modules.

RESEARCH QUESTIONS AND METHODS

The following questions guided the MTStatPAL team's investigation of module implementation:

1. How can MTStatPAL modules help introductory statistics instructors successfully implement classroom activities and assessments that align with the GAISE recommendations?
2. How can MTStatPAL modules help increase the uniformity of the introductory statistics class experience across the many sections and different versions of this course at MTSU?

Members of the research team observed one experienced instructor and two inexperienced instructors teach the Regression Module in fall 2012 and spring 2013. Team members also observed these three instructors teaching a non-module lesson. Field notes were recorded during these six observations, and the Reformed Teaching Observation Protocol (RTOP) instrument (Piburn & Sawada, 2000) was used to provide a quantitative score of the extent to which the lessons aligned with reform-oriented instruction. Reform-oriented instruction (according to Piburn and Sawada) requires students to communicate their developing understandings of course content to one another and to the instructor as part of a learning community. The instructor shapes the ensuing classroom instruction based on this communication in order to further develop student understanding. In addition to providing an empirical basis for RTOP scoring, field notes were also open coded and analyzed using a qualitative theme analysis to find commonalities and differences among the lesson implementations.

FINDINGS AND DISCUSSION

The RTOP scores for the MTStatPAL module lesson were 75 for the experienced instructor and 64 and 34 for the inexperienced instructors. RTOP scores for these same instructors' non-module lessons were 41, 42, and 12 respectively (see Table 1). A larger score on the RTOP reflects instruction that is more reflective of reform-oriented instruction as defined by Piburn and Sawada (2000). The nature of the RTOP scoring process makes the comparison of module and non-module RTOP scores for each individual instructor more meaningful than instructor to instructor comparisons. Note that each instructor's RTOP score was larger for the MTStatPAL module lesson than the non-module lesson. The RTOP scores were helpful for measuring differences in module and non-module implementations. However, the MTStatPAL team determined it is beyond the design of the module materials to support a full implementation of the type of reform-oriented instruction envisioned by the RTOP for every statistics instructor who may use these materials. The team found that a robust qualitative analysis of the field notes provided the most useful answers to the research questions driving the investigation.

Table 1: Each instructor's RTOP scores were larger for MTStatPAL module lessons.

	RTOP Scores		
Instructor	MTStatPAL Module Lesson	Non-Module Lesson	Difference
Experienced Instructor	75	41	34
Inexperienced Instructor 1	64	42	22
Inexperienced Instructor 2	34	12	22

A theme analysis of classroom observation field notes revealed commonalities and differences across the six implementations of module and non-module lessons. During the MTStatPAL module lessons, instructors used whole class discussion to address the big ideas in the lesson *after* students had collected data and conducted their own analyses. Students in all three classrooms identified data collection difficulties during the lesson, and they made attempts to resolve those difficulties.

Differences between the implementations of the MTStatPAL module were observed with regard to who had the decision-making power during the lesson. In some instances the instructors empowered *students* to make decisions that resolved data collection or analysis difficulties. In other instances *the instructor* resolved those difficulties in an effort to keep the entire class together when going through the module. Students who were empowered by their instructor exhibited greater confidence when describing what they had learned at the conclusion of the lesson. Students who did not experience this empowerment were more concerned with making sure they were doing what the instructor wanted rather than making sense of the course content themselves. These students exhibited more difficulty coming to their own conclusions regarding the meaning of the course content in the classroom activity.

During all of the non-module lessons, instructors solved statistical problems and explained the steps for solving those problems. Instructors questioned the class as a type of formative assessment to see if students were following along. When students asked for clarification, all of the instructors overlapped speech with students. This overlapping speech occurred in three different ways. First, while a student was still asking their question, the instructor would begin answering. Second, the instructor would finish the student's question and then answer it. Finally, instructors often interrupted students when they answered teacher questions. That is, before the student completed an answer, the instructor would finish the student's thought and move on to the next part of the lesson. None of the instructors used overlapping speech in these ways in a rude or offensive manner. On the contrary, they used it as a pedagogical tool to move the lesson in the direction they wanted it to go.

Differences in the non-module lesson implementations had to do with the way instructors questioned students during solution explanations. Sometimes instructors asked "yes/no" conceptual questions, other times they asked if their explanations "made sense." In addition, some instructors provided all the answers, while others asked students to provide numerical answers using their calculators. Although there were some differences in the implementation of non-module lessons, the instructors were always the ones making sense of course content and communicating that to students.

CONCLUSION

The results of this investigation of MTStatPAL module implementation reveal that when students have statistical discussions with one another that require them to 1) make their own investigative decisions and 2) determine what content means, they take more ownership of their learning and exhibit greater confidence when communicating what they have learned. In light of these findings, the MTStatPAL team is developing, implementing, and revising three additional modules that address probability, the binomial distribution, and confidence intervals for proportions with the support of a National Science Foundation Division of Undergraduate Education Transforming STEM Education (TUES) grant (DUE 1245393). The team will continue

to investigate the implementation of MTStatPAL modules to gain further insight into the ways the modules can 1) support instructors who implement instruction aligned with the GAISE recommendations, 2) encourage statistically rich student conversations during active learning, and 3) create a conceptually meaningful, yet uniform learning experience for all students. Currently, the team conjectures that well-placed whole class discussions that require students to express their conceptual understanding of lesson content may be a key component of a successful implementation. The continuing project will investigate ways to effectively structure such statistical classroom discussions. In addition, the team will seek to maximize the modules' usefulness for instructors who do not have experience teaching with non-traditional methods.

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