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Advances in technology have transformed both students and their learning environments; the technological environment in which 21st-century learners have grown up means that their aptitudes, expectations, and learning styles are very different from those of their teachers (Oblinger and Oblinger 2005). These students expect that their educators will shift from traditional lecture-based teaching to a pedagogy that creates learning environments where students interact with the material, the instructor, and their peers (Dede 2005; Oblinger and Oblinger 2005). At the same time, instructors must integrate a variety of pedagogical approaches and strategies to create rich learning environments that can address cultural, demographic, and skill-based differences among students (Dunn and Griggs 2000) as well as individual learning styles and multiple intelligences (Gardner 1993; Gardner 1999; Gardner 2004).

Student response system (SRS) technology is one of the many tools available to help instructors create a rich and productive learning environment even within the framework of a traditional lecture-based lesson. The SRS presents questions to the class, prompts students to enter responses using a pocket-sized keypad transmitter (Figure 1), and provides aggregated feedback regarding student responses to the instructor. An SRS can be used to assess students' comprehension of complex material, affording both the instructor and the students immediate feedback so that instruction can be tailored to student needs. Furthermore, the question-and-feedback process has the potential to promote greater student engagement in class discussions, and group activities in which students solve problems together and submit answers using the SRS can promote active learning. The primary goal of this study is to examine the extent to which SRS can impact student motivation and foster active learning.

Background

SRS has been used to enhance learning across several disciplines, including biology (El-Rady 2006), earth sciences (Greer and Heaney 2004), communications (Rice and Bunz 2006), and family and consumer science education (Gentry 2007). A number of studies have demonstrated the acceptability of SRS to students. While some students in one study reported not liking the fact that they cannot "hide" if the SRS is being used to take attendance, most participants reported enjoying the interaction and appreciating the dynamic feedback (Duncan 2006). Graduate students enrolled in two courses (Research Methods and Mediated Communication in Organizations) had similarly favorable reactions to the SRS, indicating that the system reinforced class material and aided in studying for exams (Rice and Bunz 2006).

The immediate feedback produced by SRS can also create more engagement among students. Master's students who initially gave an incorrect response to an SRS-administered question were more attentive to follow-up questions and corresponding explanations (Rice and Bunz 2006). Similarly, Pargas (2005) describes how class participation and collaboration increased when instructors used an SRS as an assessment tool by polling students and obtaining feedback and opinions on specific topics.

Researchers have also reported real pedagogical advantages to the use of SRS although Duncan (2006) acknowledges that some instructors may find the technology a distraction because it requires them to do two things at once. Abrahamson (2002) describes how this technology can transform the classroom by helping instructors become more aware of students who are having problems with the material. The use of SRS provides opportunities for the instructor to receive immediate feedback, which allows for more focused

instruction on the concepts that students have difficulty understanding (Demetry 2005).

While researchers and users of SRS generally indicate that the technology in combination with sound pedagogy can increase learners' motivation and satisfaction, most studies do not provide an empirical examination of those claims using an experimental design. Our study seeks to address this need by empirically examining the effects of SRS on student motivation, student interest, and learning outcomes in our organizational behavior class.

Student Response Systems and Pedagogy

Ample evidence from the learning and psychological literature suggests that providing more practice and feedback enhances the learning process (e.g., Kuh et al. 1994). Studies generally confirm that externally provided feedback enables learners to be more effective (Kulhavy and Stock 1989). Butler and Winne (1995) argue that decreasing the temporal spacing between the presentation of learning exercises and performance feedback may promote a deeper processing of the material by guiding the cognitive activities necessary to learn effectively. Allowing students opportunities to respond to questions and receive immediate feedback on their responses also gives them control over their own learning, which, in turn, facilitates comprehension (Locke and Latham 1990).

The provision of immediate feedback by SRS technology represents a significant advantage in light of the constraints that instructors may otherwise face. Instructors typically provide exposure to practice questions through study guides that are often included with the textbook. Leaving aside the question of whether students actually use these guides, one limitation of this format is that a significant amount of time must pass between the coverage of the relevant material in class and the student's review of the practice questions. Similarly, feedback in the classroom is usually provided by a graded exam or quiz that is returned some time after the test is completed, missing the opportunity to present immediate feedback in a way that would allow students to engage in a deeper process of knowledge construction (Butler and Winne 1995). SRS offers a technological solution to this pedagogical dilemma.

Methodology

Our study was designed to investigate the potential for SRS to increase student motivation and interest and to foster learning. We incorporated an SRS into one section of our organizational behavior class at Montclair State University, embedding multiple-choice questions at key points in the lecture; in turn, we taught another section of the same class without such technology. We then used a survey to compare both student groups in terms of their self-reported interest in the class and their performance expectations for an end-of semester retention test while also comparing both groups in terms of their actual performance on the retention test as well as on a midterm exam.

Implementing the SRS

After selecting and setting up an SRS (Exhibit 1), we employed it in the classroom by inserting question prompts in the PowerPoint presentations used during lectures; these prompts cued the instructor to toggle over to the SRS software application to display one or more multiple-choice questions (Figure 2). Students viewed the questions and entered their responses on their keypads within a specified period of time with the

monitor indicating the frequency count of their responses as they did so (Figure 3). When the time limit expired, the correct answer was shown (Figure 4). Through this format we sought to determine whether the technology could provide sufficient real-time assessment of learning and whether it would allow students to engage in a deeper processing of the material by making adjustments to their knowledge construction.

The SRS also allowed individual student scores to be downloaded to a gradebook application (Figure 5) and offered various reporting options for individual item analysis (Figure 6).

Participants and Procedures

The 145 participants in this study all took the same undergraduate organizational behavior class. Half of the participants (n = 70) were in the control group that took the class in the fall semester without the use of the SRS. The second group (n = 75) took the class in the spring semester with the use of the SRS; this was the testing or "clicker" group. There were no meaningful statistical differences between mean SAT scores and ages for the two groups, suggesting that the two groups were comparable in ability at the beginning of the semester as well as in other demographic characteristics (Table 1).

The quasi-experimental design meant that the groups were not randomized but were comprised of students enrolled in specific courses through the normal student registration process. Both groups were taught by the same professor and received the same lectures and exams. The only difference between the two groups was that the SRS was used to present multiple-choice questions to the SRS group before and during the lecture. The questions focused on recall, recognition, and potential application of the material covered in the class. The control group had access to the same questions outside of class for independent review.

We established a detailed timeline of procedures for the study (Table 2). During weeks 1-7, both groups received the same lectures using the same PowerPoint slides. However, the SRS group was presented with multiple-choice questions on the material both before and during the lecture; the grades of these students were recorded in the electronic grade book, and they were also provided immediate feedback on their responses. Both the SRS and the control group took a paper-and-pencil midterm exam during week 8. For the remainder of the semester, weeks 9-13, the classes proceeded normally, creating a buffer of time to allow for more effective assessment of knowledge retention. During the final week of class in each semester, students in both groups took a survey in which they indicated their level of interest in the class and their expectation of success on a subsequent retention test (Exhibit 2). Each student then completed a retention test that included items from the midterm exam administered in week 8.

Results

Quantitative Evidence

In the main analyses, we compared the means, standard deviations, and *t* values for the SRS and the control group (Table 3). The SRS group averaged 28% on the pre-lecture questions and 66.67% on the questions presented during the lectures. Since the control group had access to these questions only outside of class, their responses were not recorded.

On the midterm exam, the SRS group (M = 82.72) scored higher than the control group (M = 78.83) by a statistically significant margin ($t(143) = 2.40$ $p < .05$). Thus, exposure to the multiple-choice questions and immediate feedback in class had an important effect on subsequent test performance. A more interesting

finding was the statistically significant ($t(143) = 5.40$ $p < .01$) difference between the SRS group ($M = 48.47$) and the control group ($M = 34.86$) on the retention test. Although the percentage of course material retained among both groups was not outstanding, using the SRS had an important influence on the extent to which students were able to remember the information six weeks after their midterm exam.

Additional analyses were performed to determine if exposure to the multiple-choice questions delivered with the SRS in class had any influence on students' interest in the class or their expectations for success on the retention test. On a seven-point Likert scale, the results showed that students in the SRS group ($M = 4.13$) had greater interest in the class than the control group ($M = 3.51$), which was statistically significant ($t(143) = 2.28$ $p < .05$). Similarly, there was a significant difference ($t(143) = 2.78$ $p < .01$) between the SRS group ($M = 5.11$) and the control group ($M = 4.36$) regarding student expectations for remembering the content from the midterm exam.

In summary, the results indicated that those students who used the SRS as an integral part of class reported greater interest in the class, higher expectations of success on a retention test, and higher levels of test performance on the midterm exam. More importantly, students who used SRS were able to perform better on a knowledge retention test administered at the end of the semester, five weeks after the material was initially tested in a midterm exam.

Qualitative Evidence

At the end of the semester, students in the SRS class were asked to provide anonymous feedback regarding the SRS as an attachment to the university-issued course evaluations. These comments generally noted increased attention and engagement, appreciation for the opportunity to practice for the test, and usefulness of the feedback. This student comment was representative:

The clickers [SRS] were great! I could focus on the lecture more instead of daydreaming. Plus, I could compare myself with others. It was a relief to know that I wasn't the only one who did not know all of the answers. I was better prepared for the test because the clickers [SRS] constantly had me in the study-mindset. I only wish all my professors used clickers.

However, the instructor had both positive and negative reactions. On the one hand, the technology offered many benefits. The SRS was very engaging and made the class more interesting, and it was very easy to use in the classroom. The RF keypads functioned effectively since students did not have to point directly at the receiver. Finally, the ability to capture student responses in a gradebook and provide visual feedback to students was a distinct pedagogical advantage; the system allowed the instructor to monitor student learning in real time. As a result, misunderstandings could be addressed immediately and the instructor did not gloss over important material under the assumption that students understood the concepts.

On the other hand, learning the application and entering questions was time-consuming. Furthermore, the professor had to bring spare batteries to class. We concur with Duncan's (2006) recommendation that ample time should be provided for both the student and the instructor to get used to the teaching and learning environment using this technology.

Discussion

Our findings support previous SRS research that demonstrates the benefit of this technology in terms of

student motivation and engagement. For example, our findings are consistent with both Duncan (2006) and Rice and Bunz (2006), all of whom found positive benefits for students in terms of making class more interesting and aiding in exam preparation. However, our findings go beyond previous research and make a unique contribution to the literature on SRS by demonstrating that students who used an SRS retained significantly more of their knowledge from the midterm than did the control group. Thus, the SRS positively impacted not only students' expectations of success and interest in the class but also their retention of knowledge.

Overall, the findings from this study indicate that SRS can be effective in enhancing student engagement and learning. In the traditional classroom where lecture is the preferred mode of instruction, SRS technology can provide another mode of learning that may help students engage with the material and let instructors see where learning needs more support. These findings are consistent with the notion that externally provided feedback enables learners to be more effective (Kulhavy and Stock 1989). It may be the case, as Butler and Winne (1995) have proposed, that using SRS to provide feedback immediately after the learning exercise may afford students the opportunity to engage in a deeper learning process than is typically experienced in the classroom. That is, the feedback provided by SRS may facilitate more effective comprehension.

Although our study employed a quasi-experimental design to address the impact of SRS on learning outcomes, there were some limitations that must be addressed. For example, the primary distinction between the treatment group and the control group was the presentation of multiple-choice questions in class to the SRS group. The control group was not made responsible for reviewing the multiple-choice questions outside of class. It may be possible that making time in class for these questions to be delivered to the control group even without an SRS would have affected the results. Nonetheless, this delivery option still would not have afforded visual and normative feedback as efficiently as the SRS did.

Conclusion

This study provided empirical evidence that SRS may play an important role in increasing student engagement and interest, improving performance on traditional exams, increasing confidence in remembering the material, and most importantly, increasing retention of that material. It is important to note that the SRS may not necessarily be the most innovative technology available to educators, but this study demonstrates that it is an effective technology when supported by sound learning principles.

Future research could expand on our findings by examining the impact of SRS in different disciplines or using different types of questions beyond factual multiple-choice questions. Alternatively, researchers may also consider the impact of other technologies that can provide immediate feedback. For example, cell phone technology is nearly ubiquitous, easy to use, and inexpensive. This technology, like the SRS, offers users the ability to participate in polling activities. Future research endeavors could help determine if one system is more advantageous than the other.

Technology has become a staple of the 21st-century learning environment, and as technology changes, so do the opportunities for instructors to empower students to engage in successful learning. Based on the findings from this study, SRS offers one such opportunity for educators to adapt to the changing learning environment.

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