Using Student Response Systems to Improve Student Outcomes

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For me, this was a moment of revelation…for the first time in over 20 years of lecturing I knew…that over half the class didn't "get it"…Because I had already explained the phenomenon as clearly as I could, I simply asked the students to debate briefly with their neighbors and see who could convince whom about which answer was correct. The class erupted into animated conversation. After a few minutes, I asked for a revote, and now over 90% gave the correct answer… (Wood, 2004)

Student response systems (SRSs) are described in current research as being instrumental to what is commonly known as "active learning" or "active student responding." A student response system is technology that "allows an instructor to present a question or problem to the class; allows students to enter their answers into some kind of device; and instantly aggregates and summarizes students' answers for the instructor" (Beatty, 2004; Burnstein & Lederman, 2003; English, 2003). These systems, in one form or another, have always been part of education. As Caldwell (2007) points out, "The idea behind [SRS] is not new – teachers have used interactive, instructive questioning to teach students since at least the time of Socrates" (p.11). Even the simple raising of hands is a student response system.

Educators recognized that methods that allowed all students to select an answer simultaneously would increase the opportunities for every student to participate. Early methods were a bit more high-tech than raised hands, but not by much. One popular approach was using colored construction paper. This worked well for multiple-choice questions: Students raised the piece of paper with the color corresponding to their answer choice, and the teacher could see the array of responses easily.

Technology devices that allow individual responses to questions have been used since the 1960s. In the early days, these types of units were used to record audience responses to pilot television programs and movies. One of the earliest applications of the technology in education took place at Rice University (Lane & Atlas, 1996), where students in a computer-equipped classroom answered questions about how well they understood portions of the lecture. Results were tallied and displayed to the class.

Since that time the technology has evolved, moving away from wired hardware to portable and wireless devices that work together with software, making integration of the process easier for those who use it. With the advent of easier systems, the use of these tools has spread to a range of topic areas in education, including science, math, business, communications, computer science, education, engineering, English, health professions, law, political science, psychology, and more. "Unfortunately, the majority of uses of technology in education consist of nothing more than a new implementation of old approaches, and therefore technology is not the magic bullet it is often presumed to be" (Mazur, 2009).

We will endeavor to review the history of these devices, along with successful implementations of these devices that improve student learning outcomes.

Current Status and Research

As of mid-2011, close to 30% of school districts in the United States had substantial implementations of SRSs. Not only do students and teachers who use SRSs think they are fun and prefer using them over traditional, non-interactive lectures (Cutts, et al. , 2004; Draper et al., 2002; d'Inverno et al., 2003; McDermott & Redish, 1999; Nicol & Boyle, 2003), but there is evidence that the use of SRSs is effective in improving student outcomes, as well (Caldwell, 2006; Draper & Brown, 2004; Knight & Wood, 2005). In addition, research suggests that daily use of an SRS contributes to increased attendance, particularly when participation in interactive instruction is linked to grade incentives (Burnstein & Lederman, 2001; Cue, 1998; Hake, 1998).

It is important to remember, as Beatty and Gerace (2009) remind us, that we should not confuse the technology with the pedagogy, as we consider the use of an SRS: "Like any tool, [an SRS] may be used in many possible ways for many possible ends" (p.147). The use of the tool does not guarantee positive student outcomes. In fact, Beatty and Gerace further point out:

We argue that tools should be evaluated on their affordances, whereas approaches and methodologies should be evaluated on their student impacts. In other words, don't ask what the learning gain from [SRS] use is; ask what pedagogical approaches an [SRS] can aid or enable or magnify, and what the learning impacts of those various approaches are. (p.147)

In the instances where using an SRS in education has shown itself to be most effective, instructors appear to be taking the advice of Beatty (2004):

[An SRS] can be used to insert occasional audience questions into an otherwise traditional lecture, to quiz students for comprehension, or to keep them awake. These uses are a waste of the system's potential. To truly realize the benefits of [an SRS], an instructor must rethink her entire instructional model and the role class time plays within it and make [SRS] use an integral part of an organic whole. (p. 3-4)

We agree, and endeavor to provide some guidance here about the pedagogical practices that have been identified as effective.

Peer Instruction

Eric Mazur's method of peer instruction (Mazur, 1997) involves regularly inserting multiple-choice questions into what he calls "strategic junctures" in Physics lessons. The students are required to choose an answer, using a show of hands, flashcards, or an SRS. If a number of students answer a question incorrectly, the group is asked to stop the lesson, discuss the question and its topic among themselves, and then reanswer the question. Mazur (1996) reports, "The proportion of students that choose the correct answer always increases after the discussion" (p. 14). Mazur (2009) further shares, "Data obtained in my class and in classes of colleagues worldwide, in a wide range of academic settings and a wide range of disciplines, show that learning gains nearly triple with an approach that focuses on the student and on interactive learning" (p.51).

The assertion that this increase in student interaction and feedback to the student increases student understanding (Crouch & Mazur, 2001; Fagen et al., 2002; Mazur, 1997) is supported by quantitative evidence from use in undergraduate science courses across multiple topics (e.g., Hestenes et al. 1992; Smith, Wood, et al. 2009). To be clear, this assertion does not suggest that use of the SRS itself is what improves student outcomes, but some feel that the availability of the SRS is what encourages the use of peer instruction (Burnstein & Lederman, 2001; Burnstein & Lederman, 2003).

Assessing-to-Learn (A2L)

In a separate effort, the University of Massachusetts Physics Education Research Group (UMPERG) developed a similar approach to using SRS in the classroom in 1993. This method, called Assessing-to-Learn, or A2L, included formative assessment explicitly. Dufresne et al. (2000) argued that this practice "informs teachers about what students think; it informs students what their classmates think; it informs individuals what they themselves think" (p.11). Similar to the peer instruction of Mazur, Dufresne's A2L has question cycles in which students read questions and then discuss those questions in small groups, enter responses, and view the results. Unlike Mazur's peer instruction, which includes instructor-led presentation of information interleaved with questions, in A2L the question cycle is the core class activity; instruction from the teacher is only added as needed.

Deliberate Practice

Perhaps the most interesting recent study examining the use of SRSs was conducted in 2011 at the University of British Columbia (Deslauriers et al., 2011). In this study, two groups of students were compared. Weeks 1-11 of the course were the baseline condition: Both the control and experimental groups received lectures from an experienced faculty member; SRS questions were used as summative evaluation, and participation credit was given for submitting answers. In week 12, the control group continued to get the baseline treatment and the experimental group received the intervention. During the intervention, the experimental group was taught by a postdoctoral fellow who used instructional methods based in learning research. These methods, known as "deliberate practice," required the students "to practice physicist-like reasoning and problem solving during class time while provided with frequent

feedback" (p.862). Students did pre-reading outside of class, moving the "simple transfer of factual knowledge" outside of class, and spent class time working on activities and tasks with feedback from peers and the instructor. SRS questions were used as in-class formative evaluations, followed by discussion and problem solving.

Results from the week of the experiment showed no change in engagement or attendance in the control section. However, in the experimental section, student engagement nearly doubled and attendance increased by 20%. Importantly, more than twice the learning occurred in the experimental group versus the control group, with an effect size for the difference between the two sections of 2.5 standard deviations. It is critical to note that both sections used SRSs. But the way in which those SRSs were implemented was very different.

A word to the wise when using these methods, however, is provided by Perez et al. (2010): Be careful about showing graphs of voting results to the class. In the common scenario of asking the students a question, displaying the responses, holding class discussion, and then re-asking the question, Perez et al. found that "if students saw the bar graph [with results from the first vote], they were 30% more likely to switch from a less common to the most common response." The effect was more pronounced in true/false questions (38%) than in multiple-choice questions (28%). The shift toward the most common response occurred even when that most common response was incorrect. These results suggest that seeing the most common response to a question can bias a student's second vote.

Why Does the Use of SRSs Improve Student Outcomes?

The compelling question about the use of SRSs is not whether it tends to improve student outcomes, but why it does so. Although the currently available research on the use of SRSs is inconclusive, there are two likely contributors that have long been recognized as critical in the learning literature: increasing the opportunities for students to respond and the role of feedback in instruction.

Increasing Opportunities to Respond

Barnett (2006) points out that SRSs are "a tool that provides for interactivity" (p.2). A number of strategies that increase the frequency of active student responding have demonstrated improvement in academic achievement (Narayan et al., 1990). These include class-wide peer tutoring (Cooke et al., 1983; Delquadri et al., 1986), computer-assisted instruction (Balajthy, 1984; Stallard, 1982; Tudor & Bostow, 1991), self-directed learning (Kosiewicz et al, 1982), use of response cards (Cooke et al., 1983; Heward et al., 1996; Munro & Stephenson, 2009), choral responding (Heward et al., 1989; Sindelar et al., 1986), timed trials (Van Houten et al., 1974; Van Houten & Thompson, 1976), and guided lecture notes (Kline, 1986; Lovitt et al., 1985; Yang, 1988). In all cases, the strategy is the same: increase active student responding. It is only the tactic used to increase the responding that varies.

Role of Feedback in Instruction

The performance data that are generated by active student responding provide the opportunity for feedback to both the students and the instructors. The fact that feedback changes behavior has been accepted in education for years, and is now part of common wisdom. The learning research literature addressing the important role of feedback in behavior change goes back some 40 years and spans a large number of areas, such as energy consumption (Bekker et al., 2010; Seaver & Patterson, 1976), infection-control procedures (Babcock et al., 1992), flight training (Rantz et al., 2009; Rantz & Van Houten, 2011), sports skills (Boyer et al., 2009; Brobst & Ward, 2002; Smith & Ward, 2006), teacher behavior (Cossairt et al., 1973; Harris et al., 1975), and student academic achievement (Fink & Carnine, 1975; Martin et al., 2002; Reichow & Wolery, 2011; Trap et al., 1978; Van Houten et al., 1974). The quantity of data provided by increased active student responding gives the instructor more awareness of student problems (Johnson & McLeod, 2004; Roschelle et al., 2004a, 2004b; Knight & Wood, 2005), and therefore more possible occasions to modify the instruction to address the learners' needs.

Benefits of High Tech Versus Low Tech

It is clear that there is nothing about using an automated SRS that is fundamentally better or more effective than using a lower-tech method (e.g., Lasry, 2008), just as it is clear that numerous methods allow for increasing active student responding and the associated feedback opportunities. In fact, Judson and Sawada (2002) point out that modern devices have changed little from lower-tech approaches, except for the display of the students' answers and the ease of the record-keeping, and that then, as now, multiple-choice questions remain the most common format for the student interaction.

So if high-tech solutions are not any more effective than low-tech solutions, why spend the money on the new devices? The simple answer is that there are advantages to using a high-tech SRS that cannot be accomplished with lower-tech approaches. We explore four benefits of using a high-tech SRS here.

The most important benefit is that using a high-tech SRS allows data to be collected automatically, saving the student response data to an onboard gradebook in the software. These data can be examined later by the teacher, allowing evaluation of each student's performance, diagnosis of any areas of difficulty for individual learners, and planning to address these difficulties. Not only is automatic data collection impossible with low-tech solutions, but manually recording responses from a low-tech solution, such as flashcards, is too labor-intensive and time-consuming to be amenable to the classroom. Moreover, there is no easy method for evaluating the data if they are collected manually.

The second important advantage of using a high-tech SRS is that the ease of implementing the tool and the convenience of collecting the data make it more likely that teachers will design and use activities that offer high numbers of student response opportunities in the classroom. Designing such activities can be time-consuming, and if using those activities leads only to difficult data collection and management, the appeal of these activities is likely to be low.

Third, a high-tech SRS allows for immediate feedback to every learner. Barnett (2006) points

out that "one of its major attractive qualities is the provision of swift feedback to students." Unlike the lower-tech approaches, in which one or several students may receive feedback from the teacher, with a high-tech SRS each and every student may receive immediate feedback directly from the device itself. A methodology that allows feedback to be delivered automatically and on an individual basis makes its implementation much easier for classroom teachers.

Finally, Barnett suggests that the privacy that a high-tech SRS allows a normally shy or reticent student increases the likelihood that such a student will participate. A lower-tech approach requires that learners perform a publicly-observable action, such as saying an answer aloud or raising a hand. Using a high-tech SRS allows each learner to respond to the device without being observed directly by his or her peers. The teacher may still see the individual responses of each learner through the data recorded in the gradebook. But the student may respond without fear of embarrassment when an incorrect choice is selected.

Conclusion

Student Response Systems (SRS) can be instrumental in ensuring that students are engaged, and in providing continuing formative evaluation of how well students are learning the material. SRS are flexible and can be used with large groups all at once, with small groups working collaboratively, or with individual students. When used with a carefully designed pedagogy, SRS can provide immediate observable outcomes in student performance. The following are selected best practices for helping to ensure the successful use of SRS.

These guidelines have proven useful when using SRS in the classroom:

1. Remember that the primary use of SRS should be for formative assessment. Increasing opportunities to evaluate student performance allows real-time adjustment of instruction.
2. Include only those questions that are pertinent to the targeted student learning outcomes; questions that are arbitrary or irrelevant should not be used.
3. Integrate questions throughout the lesson so that student understanding can be evaluated frequently and regularly. Leaving all questions until the end of the lesson does not allow for changing the instruction along the way.
4. Endeavor to write questions that target some of higher-level skills described by Bloom's Taxonomy (Pear et al, 2001). Multiple-choice questions are not restricted to low-level skills, if written properly.
5. When working on new skill acquisition, include enough questions with novel examples to ensure that students are getting sufficient practice and generalization opportunities.
6. Be careful not to give away an answer through irrelevant cues, such as a pattern of correct answers or the wording of the question.

7. If you include items in which the student must identify the answer that does NOT belong, write the word "NOT" in all capital letters and in bold, so that it is as clear as possible.

8. Ensure that the correct answer is clearly the best one, but do use plausible distracters. The point is not to trick the learners. The point is to use the questions to evaluate the instruction the learners have received.

9. When using Vote-Discuss-ReVote methods in class, do not show graphs of student response distribution following the first vote in order to avoid biased response shifting.

10. Make sure you review and analyze the data after the class is over. By examining the patterns of what worked and what did not, you can improve the instruction for next time!

11. If you want to increase attendance in your class, use the SRS daily.

12. Be willing to throw out or regrade questions that are unclear.

To learn about the MimioVote assessment system visit mimio.dymo.com/SRS

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Dr. Karen Mahon is a Learning Scientist and Educational Psychologist. She advises education technology companies in instructional design and digitized content practices. She is committed to instruction that produces meaningful and measureable student learning outcomes and has dedicated her career to helping kids and their teachers. Dr. Mahon blogs at www.KarenMahon.com and can be found on twitter @KarenLMahon.

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