Enriching the Synergetic Instructor-Student Assessments with a Web-Based Audience Response System

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Abstract

In recent years, higher education has experienced a rapid increase in the use of audience response systems. This is primarily due to their ability to actively enhance individual and group engagement and learning by providing critical and instant feedback. This instant feedback is critical to both students and instructors. Drawbacks of traditional feedback through homework and tests/quizzes include the slow response rate for students and the tediousness for instructors. Summative assessments in the form of tests and exams are not sufficient measures of students’ understanding and application of knowledge. Students need continuous formative assessments to monitor their learning by actively evaluating their level of understanding. Additionally, there is the present need to satisfy the dynamic technology-based demands of current engineering students.

In an attempt to address these challenges, a web-based audience response system was employed in an introductory engineering course at a large, land-grant university in the mid-Atlantic region. This introductory course is offered in multiple sections in the first-year engineering program. It is the second in a two-semester, two-course sequence and a prerequisite for all the majors in the engineering college. The web-based audience response system was employed over multiple years in multiple sections of the course.

This paper outlines the multi-year application of the system with an approach that can be utilized in any class size. An assessment of the impact on student learning, level of interest and satisfaction with the course are presented. It also discusses students overall assessment of the course. Finally, the strengths and limitations of the system’s implementation are discussed with recommendations for first-time users of the technology.
Introduction

Traditional instructor-student evaluations center largely on summative assessments. Since summative assessments only provide information on students understanding of domain knowledge, they are ineffective in evaluating learning because they do not provide opportunities for students to apply, revise and improve the quality of their knowledge and understanding. Research has shown that for students to gain insight into their learning and engage in the process of actively evaluating their current levels of understanding, they must be provided with formative assessments. These forms of assessments are among the most effective methods of supporting student learning and have been extensively employed in a variety of educational settings that include K-12 to higher education classes, small or large classes and in a wide array of STEM courses.

The current trend in providing formative assessments is using instant feedback through audience response systems (ARS). The literature is replete with studies of the use of ARS for instant feedback in higher education. Cited benefits of ARS use range from greater student engagement, increased insight and awareness of comprehension levels by both students and instructors, increased student understanding of complex concepts, and increased student interest, enjoyment and interaction in class. We noted most of these benefits from our experience with providing instant feedback without an ARS. However, this did not significantly affect course grades or student assessments. One of our on-going goals is to utilize the benefits of current technological instructional tools to the benefit of students and instructors alike. Therefore, it was necessary to find out what component of the ARS use would most significantly affect course grades and student assessments. The major components of current ARS are individual instant feedback to responses and group performance reports. Standard options for ARS use include levels of anonymity in the collection of responses, levels of anonymity in the display of responses, the type of responses displayed and the mode of display. The focus areas of this study are the type of responses displayed and the mode of display. The goal is to evaluate how the performance reports provided by an audience response system (ARS) affect the cooperative instructor-student assessments. Specifically, we are interested in how the public display of the performance reports affects these assessments.
Course Structure and ARS

The ARS was utilized in an introduction to MATLAB course, ENGR 102. It is a three-credit hour, project-based course and a prerequisite for all majors. Students complete three projects in addition to smaller assignments, quizzes and exams. It is offered in multiple sections each semester and students meet with instructors for a total of 1.5 hours each week.

The ARS that was utilized is Poll Everywhere. The software allows real-time interaction of the students and instructors. Some of its key features include, instructor registration of students, grading of students’ responses, students’ performance reports (histograms, PDF, Excel, CSV or screenshots), moderation of responses to open-ended questions before they are displayed to the public and team competitions. These features, except for the team competitions, were employed in the course. The software allows students to respond to instructor questions with smartphones, laptops or desktop computers via the internet. In this course, student responses were limited to the use of the laptops and desktops computers in a computer lab. The use of the ARS was mandatory as it was used to record students’ class attendance.

Approach

Each academic year, the author teaches at least two sections of ENGR 102. In the fall and spring semesters of each academic year, starting in fall 2011 (except fall 2013), students enrolled in ENGR 102 sections taught by the author, used the ARS in class. An average of 43 students per section was enrolled each semester. The same material was covered in each section and all students used the same textbook and completed the same assignments, quizzes, exams and projects. The ARS was used to provide formative feedback to students and instructor and to record class attendance.

During the first week of class, using the ARS, students are asked an open-ended question such as What are your expectations for this course? Student responses are displayed to the entire class. This activity serves to introduce students to the technology and as a segue to an instructor-led discussion on realistic expectations and what is expected of the students.
In subsequent classes, questions on difficult or current key concepts are posed to the students. Depending on the type of questions, students are given up to two minutes to respond. Through their responses, students automatically log their class attendance. To prevent the phenomenon of mass-appeal, where students who are uncertain of answers respond like the masses, no real-time display of responses is done. All the responses are recorded and once the questions/polls are closed, the students’ aggregate responses are displayed to the entire class. The frequencies of student responses are shown as bar charts with all personal identifiers removed and provide immediate feedback on students’ overall performance. While students’ responses are automatically graded, the accurate answers are not displayed with the frequency charts. The students’ performance is one of the items used to guide and refine the progress of the class. For instance, if the majority of students respond incorrectly to a question, a timed student-led discussion or activity follows. In such cases, students are encouraged to consult with peers and utilize any course material or resources in finding solutions. In cases where the majority of students accurately responds to a question, the instructor may ask any student to explain why his/her answer is accurate. These post-question activities only relate to conceptual or procedural questions. These types of questions were created using approaches described by Roselli and Brophy wherein popular misconceptions associated with key concepts were presented as options in multiple-choice questions or in incorrect or incomplete solutions to problems. The responses to five key conceptual or procedural-type questions (Q1-Q5) related to arrays, programming structures (sequential, selection and repetition) and functions were analyzed in this study. Students encountered each question via the ARS for attendance and then again during review sessions prior to mid-semester and final exams. The responses obtained at mid-semester were compared to responses on final exams. Therefore, a total of ten responses per student was possible. Responses were only evaluated if students responded to questions on both the mid-semester and the final exam.

In the control sections (hereafter referred to as control-ARS sections), the same approach was taken. The main difference was that the performance reports were not publicly displayed. In these sections, the instructor gave a short verbal report of students’ performance. The same questions were used and student responses logged class attendance. Students were given the same opportunities regarding post-question peer discourse. As in the case of the ARS, a total of
ten responses per student was possible and the responses were only evaluated if students logged responses to questions on both the mid-semester and the final exam.

The points that each student accumulate from responding to the questions are stored in a student credit bank. These points may only be used at the end of the semester when students may withdraw points to a maximum of 5% of their course grade, if they have good attendance as outlined in the course syllabus.

Surveys using a 5-point Likert scale, were administered via Qualtrics and used to access student’s level of interest, satisfaction and overall assessment of the course.

Results and Discussion

More than 4000 responses were collected in twelve sections (6 ARS and 6 control-ARS sections) of ENGR 102 between 2011 and 2014. Figure 1 shows the total number of student responses per semester for the ARS and the control-ARS sections. In both ARS and control-ARS sections, the response rate was over 80% (n=2206 for ARS and n=2184).

Figure 1  Total number of student responses per semester for the ARS (blue) and control-ARS (red) sections
The high response rate is primarily due to the responses being used to track student’s attendance, which is mandatory for the course, and students’ ability to bank credit points for use at the end of the semester. Students’ performance on the five key questions (Q1-Q5) is shown in figure 2.

![Bar chart showing student performance on Q1-Q5 on mid-semester final exams. Performance of the ARS sections on mid-semester (dark blue) and on final exams (light blue) compared to performance of the control-ARS sections on mid-semester (dark red) and on final exams (light red).]

Students who were shown the performance reports as part of their regular feedback during the semester, performed better on Q1-Q5 at mid-semester as well as on the final exams. The average scores on the final exam, however, were significantly higher for students in the ARS sections than those in the control-ARS sections, $p < 0.03$. The results are not surprising. They corroborate findings of other studies, which show that student participation in learning activities that provide rapid formative feedback is linked to better performance$^{1,18}$ because it allows for the long-term
retention of fundamental concepts. Students were given instant formative feedback with both the ARS and the control-ARS sections and were provided opportunities to be actively engaged in the learning process. Since the main difference between the sections was the display of the class performance reports, it is believed that the display of the aggregate class responses served as a focus-trigger, which encouraged or forced reflection. This resulted in students being more attentive to and engaged with the class material. Further studies are needed to elucidate the underlying causes but could be attributed to the curious and competitive nature of students.

Similar to claims made by deWinstanley and Bjork, the increased attention allowed students to appropriately process and place information into context thus facilitating effective learning. This argument is supported by student survey results. Students were asked if the feedback they received helped them to focus in class. Most ARS students responded positively to this question, with 69% of them either strongly agreeing or agreeing. Only 42% of the students in the control-ARS sections strongly agreed or agreed. In the ARS sections, a significantly strong correlation was observed between the feedback students received and their in-class focus, $p < 0.01, \rho = 0.681$. In the control-ARS sections, however, the correlation between the feedback and students’ in-class focus was significantly weak, $p < 0.02, \rho = 0.006$. Further support for this claim came from students’ responses to the question regarding the possibility of the display of performance results being a major distraction. An overwhelming 80% of the students in the ARS sections strongly disagreed or disagreed compared to 57% in the control-ARS sections. In addition, 32% of control-ARS students strongly agreed or agreed that displaying the performance results could be a major distraction. These results could be attributed to the fact that the control-ARS students did not connect the display of the performance reports with the other types of feedback. They did not envisage its use with peer discussions and hence could not immediately appreciate its benefits.

Peer discussion has been shown to improve student’s ability to solve conceptual and procedural problems. Therefore, it is expected that the peer discussions contributed to the positive gains observed in this study. The results from student surveys administered at the end of each semester showed a strong correlation between students’ participation in peer discussion and their performance on the final exams for both ARS ($p < 0.01, \rho = 0.546$) and control-ARS ($p < 0.01, \rho = 0.655$) sections. The majority of students in both sections liked the peer discussion sessions. Figure 3 shows the student ratings of peer discussion in the ARS sections. Over eighty percent
reported that they either strongly liked or liked the peer discussions. Similar results were obtained from the control-ARS sections.

We believe that the display of the performance reports combined with the peer discourse on solutions to questions provided increased sensory processing of information as outlined by the Atkinson and Shiffrin model of memory and learning. The proposition is that these combined activities facilitated more effective transfer of information from short-term to long-term memory, and allowed students to retrieve and apply the knowledge gained in the final exams. This accounted for the significantly higher final exam averages in the ARS sections.

Additionally, the majority of students in the ARS (87%, n = 223) and control-ARS sections (74%, n= 195) reported that the instant formative feedback and peer discussions made the class more interesting. It is interesting to note, however, that the mass appeal of peer discussion sessions did not compare well with students’ perceptions of the value of these activities. Most students reported that they think they would perform either better or at the same level without the peer discussions.

Our findings on the level of interest were similar to previous studies, which showed that the majority of students reported an increased interest in the class due to the ARS. When asked if the feedback they received with the ARS made them more interested in the class, 73% of the ARS students (p < 0.02, ρ = 0.607) and 59% of the control-ARS students (p < 0.01, ρ = 0.008) either strongly agreed or agreed. The significantly higher interest of the ARS sections could be linked to the greater focus resulting from the display of aggregate performance data to the class. The
performance reports, by their very nature, command attention, spark discussion and add another angle to the peer discourse. A corollary of this is an enhanced learning environment. This was absent in the control-ARS sections.

Overall course satisfaction was not dependent on the use of ARS. Survey results showed that students from both ARS and control-ARS sections overwhelmingly felt satisfied with the class. The majority of students in these sections consistently gave a high approval rating for both the instructor and instruction. Over 90% percent of students in the ARS sections and control-ARS sections stated that they were either very satisfied or satisfied with the course. This is not surprising and agrees with the previous findings. Similar high approval ratings were obtained on items such as instructor’s use of class time, quality of instruction and overall learning. On the item of instructor’s attitude towards students’ learning, more positive ratings were obtained from the ARS sections. Based on students’ comments, it was evident that they related the instructor’s use of performance reports directly to an attitude of care. Students’ comments included:

“I can tell that she truly cared about us and that she loves teaching. She put a lot of effort into making the class interesting and fun. She took the time to make sure that we understood programming... She always showed us how we were performing on the polls and she used it to give us feedback.”

“I like the way [she] uses the polls and the reports to make sure that we keep up with the work. After each poll she shows us how we are doing and makes sure we get a chance to clarify any issues. That says a lot to me. She really cares. She is awesome!”

“When I started the course I felt that the polling would be a waste of my time but I have learned so much with it. It is definitely worth the few minutes in class. Dr. Brown goes above and beyond to add it to the class and make us aware of our performance...”

“102 is no walk in the park but Dr. Brown made it fun! I like that she keeps showing us how we are doing on the polls and give us a chance to figure things out in class. She wants us to do well and obviously cares about her students.”

“I really don’t care about programming but I look forward to going to my ENGR 102 class. Dr. Brown truly cares about whether or not we learn the coursework. She has extra stuff like the
polling that helps me to revise out of class...She shows how we are performing and gives us time to clear things up in class.”

“I enjoyed ENGR 102...Dr. Brown] always used the poll reports to start class discussions and worked them into her lectures. You can see that she knows her stuff and she genuinely wants us to learn.”

Using the wealth of information provided in the performance reports, the instructor was able to refine class activities, which created immediate appreciation by the students. They noted the value of the performance reports and the willingness of the instructor to utilize that information, and caring attitude among the contributors to their overall satisfaction with the course.

**Challenges and Limitations**

A major challenge of our approach is securing the interest of academically advanced/well-prepared students. The display of results and peer discussions capture the interest of students, especially those who submit incorrect responses. The students who consistently submit correct responses seem to lose interest over time. Students commented:

“The report discussion gets boring after a while. The novelty wears off and it feels like a mundane routine because my friends and I always get the answers right.”

“I am the one who is always explaining to my friends. I don’t mind it but it seems like a waste of time because I can do that outside of class. I guess it is useful for the students who don’t get programming.”

“I always know the correct answers and I only submit my answers because it records my attendance. I sometimes don’t take part in the group discussion because I want to give others a chance to explain.”

While additional activities can be created for these students, it is desirable that they participate in the peer discussions. Another challenge is the need for the instructor to be flexible with the class material. The instructor must be willing to adjust teaching activities as dictated by the feedback
information. These however, do not undermine the main advantage of being able to control more parameters surrounding our study.

**Conclusions**

The use of instant formative assessments by both students and instructors is a mutually beneficial process. In addition to providing opportunities for critical instructor and student analyses of learning, it fulfils the demands of today’s *now-generation* students. A noteworthy finding of our study is that the inclusion of public displays of students’ performance reports as part of the instant feedback tasks played a critical role in the instructor and student assessments. In the ARS sections, there was a positive effect on instructor and student assessments, compared to the control-ARS sections. The instructor used the performance reports to evaluate students’ learning and make requisite in-class instructional modifications, which resulted in better and long-term gains in knowledge. This was evident from the higher final exam scores for the ARS sections. The students also used the performance reports as a learning gauge. Their display resulted in increased attention and greater focus in class and higher interest in the class material. Combined with the overall high satisfaction, this translated to higher ratings for the instructor and instructional method by students in the ARS sections. The findings from our study provide strong evidence of the enhanced synergetic instructor and student assessments that result from a well-crafted and strategic approach to the use of ARS in the classroom.

**References**


