An Assessment of an Innovative Student Response System on Student Learning and Performance

David Calamas

Abstract – Student response systems are often utilized in undergraduate classrooms to increase student engagement and assess student understanding of course concepts. Student response systems frequently require undergraduate students to purchase additional hardware or software. In this paper, an assessment of a free smart student response system on student learning and performance in an undergraduate heat transfer course was performed. Students were able to access the smart student response system in question via an internet browser or through an app on web enabled mobile devices. To assess student performance, students were given the opportunity to complete an optional online concept review via an online student response system in advance of classroom examinations. In a preliminary study, students who utilized the online response system were found to have improved their total examination grades by an average of 7.54% when compared with students who failed to take advantage of the optional online concept review.

Keywords: Classroom Technology, Student Response Systems, Student Learning, Mobile Devices

INTRODUCTION

One of the National Academy of Engineering Grand Challenges for Engineering is to advance personalized learning which often involves the use of technology. Technology is often incorporated into the classroom through the use of student response systems intended to increase student engagement and assess student understanding. Student response systems are often used to augment existing pedagogical practices in higher education [1]. A University of Wisconsin study found 94% of faculty agreed or strongly agreed that there was greater student engagement in their classrooms as a result of the use of student response systems [2]. In the same study 100% of the faculty polled appreciated the ability to assess student's knowledge and understanding through the use of student response systems. Incorporating student response systems in lectures have been found to significantly improve classroom interactivity [3] and facilitate classroom discussions [4]. Increased use of student response systems in classroom lectures has also been found to have a positive influence on students’ performance on examinations [5, 6]. While the use of student response systems may not always result in improved performance on examinations their use can help promote a more active and friendly learning environment [7]. While there is a large body of literature pertaining to the implementation of student response systems in classroom settings [8, 9] there is still a need for research that explores conditions of use across diverse settings and pedagogies [10].

Student response systems, while desirable in an undergraduate classroom setting, frequently require undergraduate students to purchase additional hardware or software. With the widespread use and availability of internet capable mobile and non-mobile devices it may be desirable to incorporate a smart student response system that can utilize the aforementioned devices at no cost to the student [11]. There are several student response systems currently available that do not have licensing or software costs associated with their use. Additionally, many of these student response systems are not restricted to specific hardware and can be used with any internet capable mobile or non-mobile device via an internet browser or an app. One of these student response systems, Socrative ©, was recently used in an undergraduate heat transfer course in the Department of Mechanical at Georgia Southern University to increase student engagement and reinforce course content outside of the classroom. While there have been numerous studies on the benefit of using student response systems during course lectures [1-11] there has not been a

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significant investigation into their use outside of the classroom. In this paper, an assessment of a smart student response system on student learning and performance in an undergraduate heat transfer course was performed. To assess student performance, students were given the opportunity to complete an optional online concept review that utilized Socrative ©, a currently available smart student response system, in advance of classroom examinations.

**METHOD OF REINFORCING COURSE CONCEPTUAL CONTENT**

It is critically important to stress the physical significance of heat transfer phenomenon in undergraduate heat transfer courses. For example, upon completion of an undergraduate heat transfer course students should be able to identify the impact that the development of a thermal boundary layer has on the effectiveness of heat transfer. Similarly, students should be able to identify the physical significance of the Nusselt number which is the ratio of convective to conductive heat transfer. Anecdotal evidence suggests that undergraduate mechanical engineering students often try to memorize solution procedures without ever fully understanding the physical significance of the problem they are tackling or its results. In order to encourage students to become more familiar with course conceptual content an online concept review was made available to students before classroom examinations. It is hypothesized that reinforcing course concepts may result in improved student performance on examinations. In addition, if a student is able to identify the physical significance of heat transfer phenomenon they will be able to carry that knowledge with them to their future careers where they will face problems without a textbook solution procedure.

**Student Response System Overview**

The student response system utilized in this study, Socrative ©, can be accessed via any mobile or non-mobile internet browser or alternatively through a free app on the Google Play © store for those with Android © mobile devices or on the Apple App © store for those with iOS © mobile devices. Instructors have a substantial amount of flexibility pertaining to how they would like to use the online student response system. For example, instructors are able to create quizzes consisting of multiple choice, true/false, and short answer questions. Instructors can get an overview of student understanding through real time formative assessment. After an activity has ended instructors can view reports online as a Google © spreadsheet or emailed to them as a Microsoft Excel © spreadsheet. The aggregated reports are auto-graded and include a breakdown of student responses on a question by question basis. This allows instructors to identify specific areas where students are struggling with course content and subsequently allows the instructor to reinforce this content in ensuing lectures. The feedback that an instructor gains from these reports allows corrective action to be taken immediately before proceeding to new content that often builds on previous content that students have been identified through the online student response system to be struggling with.

**Optional Online Concept Reviews**

In advance of classroom examinations students were given the ability to complete online concept review sessions at their convenience and from any location via the online student response system. The online concept reviews consisted of a selection of multiple choice concept questions from each chapter of the text that would be covered on the examination. A representative sample of the material covered in the online concept reviews can be found in the Appendix. The online exam review via the student response system was optional and students were not rewarded or encouraged to participate. Students were made aware of the presence of the optional review session three days in advance of classroom examinations. There was not a limit to the number of times a student could complete an online concept review. As previously mentioned, students could access the review via an internet browser or an app on internet capable mobile or non-mobile devices. Upon starting an online concept review student’s names and student identification numbers were recorded to track their performance. As students progressed through the concept review they were given automatic and immediate feedback on the correct answer and subsequent explanation of each question. The immediate feedback allowed students to self-reinforce conceptual content they may not have understood previously.

**EFFECTIVENESS OF STUDENT RESPONSE SYSTEM**

In order to assess the effectiveness of student response systems used outside of the classroom to reinforce course content before examinations the participation and performance of 44 undergraduate students enrolled in MENG 3233 Heat Transfer within the Department of Mechanical Engineering at Georgia Southern University was tracked.

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Student Opinion of Question Format

In order to accommodate student preferences pertaining to concept review question format the following five questions were handout out and the responses collected on the first day of class:

1. I prefer concept questions on examinations of the following format:
   a. Multiple choice.
   b. True/false.
   c. Fill in the blank.

2. I have to study the most for concept questions on examinations of the following format:
   a. Multiple choice.
   b. True/false.
   c. Fill in the blank.

3. I perform the best on examinations when concept questions are of the following format:
   a. Multiple choice.
   b. True/false.
   c. Fill in the blank.

4. I feel the following question format on concept reviews helps prepare me the most for examinations:
   a. Multiple choice.
   b. True/false.
   c. Fill in the blank.

5. I feel the following concept question format on reviews most ensures my long term understanding of course material:
   a. Multiple choice.
   b. True/false.
   c. Fill in the blank.

The results for the survey on student opinion of question format can be seen in Figs. 1-5 for the above survey questions 1-5 respectively.

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The students polled were found to strongly prefer examinations with multiple choice concept questions but believed they had to study the most for examinations with fill in the blank concept questions. The students polled believed they performed the best on examinations consisting of multiple choice concept questions. The students supposed that concept reviews containing multiple choice concept questions helped prepare them the most for examinations and better ensured their long term understanding of course material. It should be noted that while students believed they had to study more for examinations consisting of fill in the blank concept questions they alternatively believed concept reviews consisting of multiple choice concept questions helped them better ensure long term understanding of course material, a somewhat contradictory result. In spite of this, as long term understanding of course material was the primary goal of the instructor, concept questions of multiple choice format were selected and utilized for all examination reviews.

**Student Participation**

Student participation was tracked for each concept review that was made available online to students subsequent to each of the three examinations, excluding the final exam, that were given in class. The percentage of students who participated in the online concept reviews via the student response system increased as the semester progressed as can be seen in Fig. 6. Of the 44 students enrolled in the course, 36%, 48%, and 59% participated in the online concept reviews for examinations 1, 2, and 3 respectively.
Student Improvement

In order to assess the effectiveness of the online student response system as a tool for review of conceptual content before classroom examinations the scores of students who participated in the optional online concept reviews were compared to the scores of students who failed to take advantage of the availability of the online concept review. Exams were composed of multiple choice concept questions as well as problem solving questions. Students who took advantage of the concept review via the online student response system performed 7.85%, 7.70%, and 8.45% better on the multiple choice concept question portion of the exam when compared with students who chose not to take advantage of the optional review for exams 1, 2, and 3 respectively. Similarly, students who took advantage of the online concept review performed 6.89%, 7.83%, and 7.35% better on the problem solving portion of the exam when compared with students who chose not to take the optional review for exams 1, 2, and 3 respectively. The average percent improvement in examination grade that students achieved by taking advantage of the online concept review via the smart student response system can be seen in Fig. 7.

The distribution of the raw exam scores for students who participated as well as students who failed to participate in the online concept reviews can be seen in Figs. 8-10 for exams 1, 2, and 3 respectively.
Figures 8-10. Grade Distributions for Examinations 1-3 (left to right, top to bottom).

Statistical Significance

A t-test was performed to assess the statistical significance of the results. The t-test resulted in a p-value of 0.0008. The effect size was calculated to be 0.63.

Student Background

As seen in Figs. 7-10, students who participated in the online concept reviews via the student response system generally improved their examination grades. It is possible that some of the improved performance could be attributed to student aptitude. Students who participated in the concept reviews had a higher average GPA when compared with students who failed to participate (see Fig. 11). Unfortunately, it is not possible to interpret how much of an impact this had when evaluating examination performance. It should be noted that the GPAs of students who participated as well as for students who failed to participate in the online reviews were most similar during the concept review for the first examination. The difference between the average GPAs of participating and nonparticipating students increased as the semester progressed. A possible explanation for this could be student motivation and dedication towards the course. Regardless, the average percent improvement in examination grade for participating students was fairly consistent from the beginning to the end of the semester. On a similar note, the average course load of students who participated in the online concepts reviews was generally lower than students who failed to participate (see Fig. 12). It should be noted however that the difference in average course load was less than 1 credit hour. In addition, the number of hours students worked at internships, co-ops, or jobs were unavailable.
Student Opinion on Usefulness of Student Response System

At the end of each online concept review students who participated in the review were asked how useful they found the student response system as a tool to review course content before examinations. Students were given the option to complete the following statement, “I found this form of automated and optional concept review through the student response system to be (a) extremely useful (b) somewhat useful or (c) not useful.” As the semester progressed students found the smart student response system increasingly useful. Incidentally, the number of students who participated in the online concept reviews also increased as the semester progressed. Student perception of the usefulness of the student response system as a concept review tool subsequent to examinations 1, 2, and 3 can be seen in Figs. 13-15 respectively.

Figures 13-15. Student Opinion of Student Response System Usefulness (left to right).

CONCLUSION

An online student response system was utilized to enhance student understanding of course content outside of the classroom. Students were able to access the student response system online before classroom examinations. Through a classroom survey students were found to believe concept reviews consisting of multiple choice questions most ensured their long-term understanding of course material. As the semester progressed the number of students who chose to take advantage of the online concept reviews via the student response system increased. Students who participated in the online concept reviews were found to perform 8.00% better on concept questions and 7.36% better on problem solving questions on examinations when compared with students who did not utilize the student response system. While the exam reviews consisted of multiple choice concept questions alone it is hypothesized that student understanding of course concepts resulted in an improved ability to identify pertinent heat transfer phenomena when solving problems. By the end of the semester 59% of the students enrolled in the course were
participating in the online concept reviews and 85% of those students found the student response system to be an extremely useful tool.

REFERENCES


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David Calamas is an Assistant Professor in the Department of Mechanical Engineering at Georgia Southern University. He received a BS in Mechanical Engineering from Clemson University in 2010 followed by a MS and PhD in Mechanical Engineering from The University of Alabama in 2012 and 2013 respectively. His research interests are in biologically-inspired thermal transport, heat transfer, and thermal management. He currently teaches undergraduate heat transfer.

APPENDIX

Representative Sample of Concept Questions

1. Heat generation is a
   a. Surface phenomenon.
   b. Volumetric phenomenon.
   c. Point phenomenon.

2. Thermal contact resistance can be minimized through the use of
   a. A poorer conducting gas.
   b. A hard metallic foil.
   c. Thermal grease.

3. A Lumped System Analysis assumes
a. The interior temperature is uniform and a function of position only.

b. The interior temperature is uniform and a function of time only.

c. The interior temperature is non-uniform and a function of position only.

4. The boundary layer is the flow region adjacent to the wall in which
   a. Viscous effects are negligible.
   b. Viscous effects are significant.
   c. The flow is turbulent.

5. The Nusselt numbers in the thermal entrance region are
   a. Much higher than the Nusselt number sin the thermally fully developed region.
   b. Much lower than the Nusselt numbers in the thermally fully developed region.
   c. Approximately equal to the Nusselt numbers in the thermally fully developed region.

6. Regarding an inclined plate heated from the bottom , as a result of the formation of plumes the boundary layer thickness
   a. Increases and the rate of heat transfer increases.
   b. Decreases and the rate of heat transfer increases.
   c. Decreases and the rate of heat transfer decreases.

7. When considering film condensation over horizontal tubes in a vertically stacked tube bank, the average thickness of the liquid film at the lower tubes is
   a. Much larger and therefore the average heat transfer coefficient is much larger.
   b. Much smaller and therefore the average heat transfer coefficient is much smaller.
   c. Much larger and therefore the average heat transfer coefficient is much smaller.

8. In a counter-flow double-pipe heat exchanger the two working fluids flow
   a. In the same direction and parallel to each other.
   b. In opposite directions and parallel to each other.
   c. Perpendicular to each other.

9. The term spectral is used to denote
   a. Frequency dependence.
   b. Wavelength dependence.
   c. Amplitude dependence.

10. A nonparticipating medium
    a. Does not absorb, emit, or scatter radiation.
    b. Absorbs, emits, and scatters radiation.
    c. Does not absorb or emit but can scatter radiation.