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Evaluating the Effectiveness of Electronic Response Systems in Technology-Oriented Classes

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Abstract—Electronic Response Systems such as Kahoot, Poll Everywhere, and Google Classroom are gaining a lot of popularity when surveying audiences in events, meetings, and classroom. The reason is mainly because of the ease of use and the convenience these tools bring since they provide mobile applications with a simple user interface. In this paper, we present a case study on the effectiveness of using Electronic Response Systems on student participation and learning experience in a classroom. We use a polling application for class exercises in two different technology-oriented classes. We evaluate the effectiveness of the usage of the polling applications through statistical analysis of the students performance in these two classes and compare them to the performances of students who took the same classes without using the polling application for class participation. Our results show an increase in the performances of the students who used the Electronic Response System when compared to those who did not by an average of 11%.

Keywords—Interactive learning, classroom technology, electronic response systems, polling applications, learning evaluation.

I. Introduction

CLASS participation and discussion is considered one of the most important aspects in classroom learning. It is actually the only thing that separates conventional university education from distance learning. Class participation and discussions enrich the learning process and ensure the educator that the lecture materials are comprehensible and fully understandable by the students. It also allows for more points on the material to be raised through discussions which might have not been covered in the educator's original lecture notes. Even though participation and discussions are very important, they might not always be easy and straightforward to implement in a classroom, especially in technology classes. Unlike humanities classes, the material in technology classes is verifiable through laboratory experimentation and can be either verified or falsified. This certainty in results makes the discussions and participation not subject to ones interpretation and opinion. Instead, participation is always based on the students' understanding of scientific facts and the content introduced in the class.

In this paper, we present an evaluation of the usage of an Electronic Response System (ERS) in technology class in terms of its effectiveness in increasing class participation and students' performance. The remainder of this paper is organized as follows: Section II describes related research conducted in that area. Section III describes the methodology used to conduct our experiments. In Section IV we evaluate the proposed system and analyze the results. Lastly, the paper is concluded in Section V.

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II. Previous Work

Several studies have highlighted the effect of class participation and discussion on the learning process. In [1], Lebow states that constructive learning can be achieved through experiences gained in class. Klemm [2] argues that the learning process is based on the skills gained in class that help retain gained information rather than the information itself. Chickering et al. [3] highlight the importance of immediate feedback from teachers to students in order for them to retain gained information. Similarly, Boyd [4] found that immediate feedback increases the chance of material comprehension and retention. Kulhavy [5] argued that the learning process is not effective and complete if students are given the correct answers without trying to find it themselves first.

Even though class participation is essential to the learning process, as several studies have shown, it is not easy to get students involved and actively participate in class activities for various reasons. The study conducted by Karp et al. [6] showed that only 10% of students contribute to more than half of the class discussions and the remaining 90% mostly do not engage in class participation. Stones [7] explains the reason for the hesitation in class participation by some students to be due to the lack of confidence in their answer or the point they are making. Others do not participate out of the fear of being wrong in front of their peers.

Using technology as an educational tool has been essential for the learning process for the past decade or two. Schacter et al. [8] indicates that using technology can stimulate the critical thinking ability in students. ERS usage in classrooms is becoming more popular as a mean to increase participation and provide instant feedback to the students. Hinde et al. [9] conducted experiments on several classes which uses ERS and concluded that using ERS results in better grades for the students. The main reason for that is that ERS provide the means for shy and hesitant students to participate in classroom activities and discussion without fear since their response is anonymous. Duncan [10] in a similar study found that classroom response systems are a tool to be used that will give all students a voice in the classroom and take some of the stress away that comes with not being completely sure of an answer. Hake [11] conducted a study of over 6,000 students in both clicker and nonclicker classrooms and found that students using clickers scored 25% higher on exams.

Building on previous work presented, we want to evaluate the effectiveness of ERS in technology classrooms. The difference here is that we will be using a polling application, which can be installed on several platforms including smart phones, instead of a dedicated ERS devices.

III. Methodology

In this section we present our methodology on how we implemented the polling application in the classroom. We also describe the details and features of the Poll Everywhere application we chose, the classrooms in which our participation system is used, and the evaluation method of the participation system.

A. Poll Everywhere Application

Poll Everywhere is an ERS which can be directly integrated in popular slideshow applications such as Microsoft PowerPoint and Google Slides [12]. There are multiple benefits of using this application as the ERS method of participation in technology classes which can be summarized in the following points:

- Unlike other polling applications available on multiple platforms, the Poll Everywhere application is designed for professional applications. It provides multiple methods to create a question or activity through different visual aids.
- The application is free for the students and also for instructors with classes of 40 students or less.
- To use the application, students do not need to buy extra hardware, they can download the applications on their phones and use it in class when a question is asked.
- Students always have their phones, so they will not miss class exercises. And in case they forget their phone or it is not working for any reason, they can use a desktop or a laptop to access the exercise questions.
- Poll Everywhere integrates directly into PowerPoint so the questions are part of the slideshow presentation.
- The questions can be presented in multiple visual formats which helps keep the class interactive.
- The answers are stored in .CSV files which can be used to analyze the progress of each student and perform other statistical analysis.

B. Desciption of the Classes

The Poll Everywhere application was implemented in two different technology classes which we describe in the following subsections.

1) Introduction to Programming and Problem Solving Course: The Introduction to Programming and Problem Solving (CourseA) class is a core technology course in the School of Integrated Sciences at James Madison University. It is a sophomore level class which is designed to help students learn important analytical tools for being successful in this high-technology age. CourseA will afford the students the opportunity to add the knowledge and skills of procedural, object-oriented and declarative computer programming to their analytical problem solving knowledge and skill set. To accomplish this, the students use and build upon the knowledge and skills they developed in early analytical methods courses. More about this course can be found in [13]. The course is designed to be taught using a variety of programming tools to achieve the course learning objectives. However, this version of the course, where the Poll Everywhere application was implemented, uses Python as the language for programming.

2) Introduction to Telecommunication, Networking, and Security Course: The Introduction to Telecommunication, Networking, and Security (CourseB) course is another core technology class in the School of Integrated Sciences at James Madison University. It is a sophomore level class which is an introductory course to the world of telecommunication, computer networking and security. In this course, the students have the opportunity to explore some of the technical aspects of the cyber world and the Internet. Students learn how networked applications and services are designed, implemented and secured using wireless and wired networks, network services and protocols. Examples of topics taught in the class are Virtualization, Internet, Intrusion Detection & Prevention, Wireless Ethical Hacking, and Web Applications & Services. The course includes a lab component focusing on hands-on integration and troubleshooting of networked applications, network security methods and services. More about this course can be found in [13].

C. Experiment Setup

We implemented the usage of the Poll Everywhere application in both courses described above. In order to conduct our experiment, we created different in-class exercises to help the students learn the material and increase class participation. Both classes meet twice a week and each lecture would contain between 7 to 10 in-class exercises on the material taught on that day. We created two versions of the in-class exercises, one which requires the usage of the Poll Everywhere application (we refere to these as CourseA1 and CourseB1 for classes CourseA and CourseB respectively), and one which does not (we refere to these as CourseA2 and CourseB2 for classes CourseA and CourseB respectively) and implemented both versions in two different sections of both of the courses to determine the impact, if any, of the usage of the application on class participation.

The instructor simply displayed the exercises on the slideshow presentation during class and asked the students to participate in answering them. In the sections where the Poll Everywhere application was not used, the students participated by raising their hands to answer the multiple choice-style exercise question and the instructor would select one to answer the displayed question. If the answer was correct, the instructor would explain the question and the answer and if any further discussion or explanation is required, it would take place at that moment. In the event the answer was not correct, another student would be given the chance to answer the question and the instructor would proceed as explained above.

In the sections which use the Poll Everywhere application, the question, which was created on the application platform, would also be displayed on the slideshow presentation, since the application integrates well with Microsoft PowerPoint and Google Slides, with the instructor's code displayed at the top and the students would use their smartphones, laptops or desktops, if the class is equipped with them, to register their answers to the exercise question. This way all of the

students in the class are given a chance to participate in the exercise trying to answer it. Once all the students register their answers, the choices made by the students are displayed on the slides showing the percentage of each answer selected by the students. At this point, the instructor reveals the correct answer, explains it, and initiates any further discussions required.

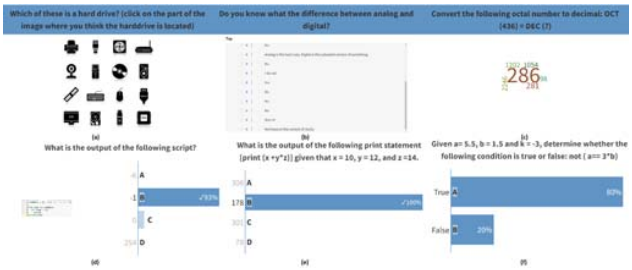

Fig. 1 Examples of the Exercise Questions Conducted in the Surveyed Classes

Given that there is a variety of visual formats to formulate an exercise using the Poll Everywhere application, the exercise questions are not limited to multiple choice questions as can be shown in Fig. 1. The sample questions in Fig. 1 show examples of exercises which can be formulated as a clickable image (a) where students select part of the image to reflect their answer, in survey format (b) where students submit a short answer to the question displayed, bubble format (c) where students type in their answers and the more of the same answer is input by the students, the bigger it gets displayed on the projector screen, in classical multiple choice format ((d) and (e)) where students simply select one of the available answers displayed, or by indicating whether a statement is True or False (f).

It should be mentioned that no written solutions are given by the instructor to the students other than the verbal answer given during class time in any section of the classes (i.e. the ones which use the Poll Everywhere applications and the ones that do not). It is up to the students to record the correct answers themselves for future reference and studies.

IV. Results and Analysis

As mentioned before, we conducted our experiment in two different courses (CourseA and CourseB) and created two different versions for each course, one which uses the Poll Everywhere application for students to use in class exercise participation (CourseA1 and CourseB1) and one which does not use the application for in class exercise participation (CourseA2 and CourseB2). The number of students in each section are 19, 18, 34, and 24 in CourseA1, CourseA2, CourseB1, and CourseB2 respectively. In this section, we present the effectiveness of our system in terms of the students' performance in class and the reception of the system by the students and analyze the results.

A. Performance of the Student Results

We selected 17 questions which appeared in the in-class exercises in CourseA1 and CourseA2 with a similar question appearing in quizzes or exams given to the students in CourseA. These questions were chosen randomly and represent about 50% of all the questions which appeared in both class exercises and tests given to the students in the course after filtering the questions in which not every student participated in the in-class exercises.

Table I represents the number of correct answers recorded for the students in CourseA1 and CourseA2 and their respective percentages. It can be shown that there is an increase in the students' performance from the number of correct answers recorded in CourseA1 compared to CourseA2 with the exception of the highlighted 3 questions in Table I where the students in CourseA2 performed better.

In CourseB, 15 questions were chosen according to the same criteria described for CourseA. Table II represents the number of correct answers recorded for the students in CourseB1 and CourseB2 and their respective percentages. Similar to performances in CourseA, there is an increase in the students' performance from the number of correct answers recorded in CourseB1 compared to CourseB2 with the exception of the highlighted 4 questions in Table II where the students in CourseB2 performed better.

TABLE I
Sample Questions Which Appeared in Both Version of CourseA and Also Appeared in Quizzes or Exams

Question	Number of Correct Answers in CourseA1	Percentage in CourseA1	Number of Correct Answers in CourseA2	Percentage in CourseA2
Question1	14	73.68%	11	61.11%
Question2	19	100.00%	17	94.44%
Question3	13	68.42%	12	66.67%
Question4	11	57.89%	8	44.44%
Question5	18	94.74%	16	88.89%
Question6	16	84.21%	13	72.22%
Question7	19	100.00%	15	83.33%
Question8	15	78.95%	14	77.78%
Question9	17	89.47%	14	77.78%
Question10	14	73.68%	17	94.44%
Question11	7	36.84%	7	38.89%
Question12	17	89.47%	15	83.33%
Question13	15	78.95%	11	61.11%
Question14	18	94.74%	12	66.67%
Question15	13	68.42%	13	72.22%
Question16	15	78.95%	10	55.56%
Question17	18	94.74%	11	61.11%

TABLE II
Sample Questions Which Appeared in Both Version of CourseB and Also Appeared in Quizzes or Exams

Question	Number of Correct Answers in CourseB1	Percentage in CourseB1	Number of Correct Answers in CourseB2	Percentage in CourseB2
Question1	30	88.24%	19	79.17%
Question2	31	91.18%	16	66.67%
Question3	26	76.47%	15	62.50%
Question4	22	64.71%	16	66.67%
Question5	33	97.06%	22	91.67%
Question6	25	73.53%	11	45.83%
Question7	29	85.29%	20	83.33%
Question8	33	97.06%	21	87.50%
Question9	16	47.06%	15	62.50%
Question10	29	85.29%	17	70.83%
Question11	27	79.41%	20	83.33%
Question12	27	79.41%	20	83.33%
Question13	34	100.00%	16	66.67%
Question14	30	88.24%	13	54.17%
Question15	24	70.59%	10	41.67%

The overall percentage of correct and wrong answers in both sections in CourseA and CourseB are shown in Tables III

and IV respectively. It can be shown that there is an increase in performances by about 10% in CourseA and 12% in CourseB when comparing the sections where the Poll Everywhere application was used and the ones in which it was not.

TABLE III
TOTAL CORRECT AND WRONG ANSWERS FOR BOTH VERSIONS OF COURSEA WITH PERCENTAGE

Section	Total Questions	Correct	Percentage	Wrong	Percentage
CourseA2	306	216	70.59%	90	29.41%
CourseA1	323	259	80.19%	64	19.81%

TABLE IV
TOTAL CORRECT AND WRONG ANSWERS FOR BOTH VERSIONS OF COURSEB WITH PERCENTAGE

Section	Total Questions	Correct	Percentage	Wrong	Percentage
CourseB2	360	251	69.72%	109	30.28%
CourseB1	510	461	81.57%	94	18.43%

B. Students Evaluation of the System

In addition to evaluating the performance of the students in both courses, we also asked the students in CourseA1 and CourseB1 to express their opinion on the usage of the Poll Everywhere application in terms of effectiveness, ease of use, and their preference on implementing the same system in other courses through a short survey. The survey 5-point scale is explained in Appendix A and the results of the survey are shown in Figs. 2 and 3 for CourseA and CourseB respectively.

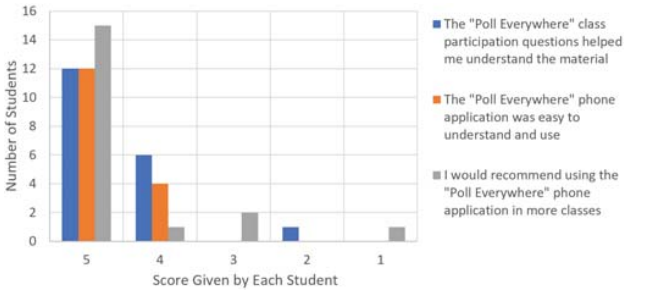

Fig. 2 CourseA Students Survey Results for Using Poll Everywhere Application on a scale of 1 to 5 (5 is Highest 1 is Lowest)

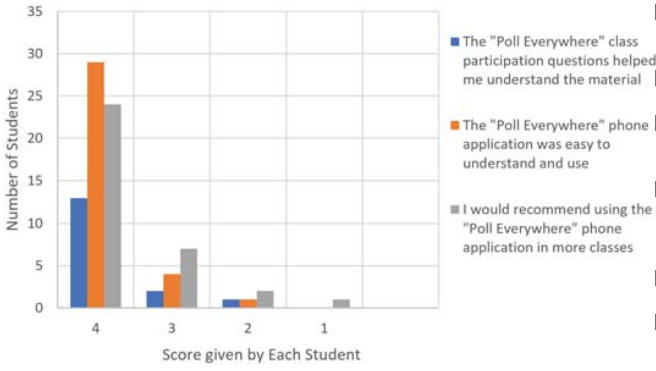

Fig. 3 CourseB Students Survey Results for Using Poll Everywhere Application on a scale of 1 to 5 (5 is Highest 1 is Lowest)

It can be shown that the vast majority of the class benefited from using the system and would like to see it implemented in other courses. It can also be shown that the Poll Everywhere application was easy to use by the students and required very little to no prior knowledge of the application or how to use it.

V. CONCLUSION

In this paper we presented an ERS to be used in technology classes. We used the Poll Everywhere application as our ERS system to evaluate its effectiveness in such classes. We implemented the system in two sections of two different technology courses and evaluated them against another two sections of the same courses which did not use the system. The results showed the system effectiveness in increasing the performance of the students by an average or 11% overall. It was also shown that the students benefited from the system through a short survey conducted by the students in both classes.

APPENDIX A
EXPLANATION OF THE 5-POINT SCALE

The 5-point scale is defined as follows:

5: Strongly Agree
4: Agree
3: Neither Agree or Disagree (Neutral)
2: Disagree
1: Strongly Disagree

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REFERENCES

[1] D. Lebow. Constructivist values for instructional systems design: Five principles toward a new mindset. *ETR&D*, 41:4–16, 1993.
[2] W. R. Klemm. What good is learning if you don't remember it? *The Journal of Effective Teaching*, 7(1):61–73, 2007.
[3] A. W. Chickering and Z. F. Gamson. Development and adaptations of the seven principles for good practice in undergraduate education. *New Directions for Teaching and Learning*, 1999(80):75–81, 2002.
[4] W. M. Boyd. Repeating questions in prose learning. *Journal of Educational Psychology*, 64:31–38, 1973.
[5] R. W. Kulhavy. Feedback in written instruction. *Review of Educational Research*, 53:211–232, 1977.
[6] D. A. Karp and W. C. Yoels. The college classroom: Some observations on the meanings of student participation. *Sociology and Social Research*, 60:421–439, 1976.
[7] E. Stones. Students' attitudes to the size of teaching groups. *Educational Review*, 21(2):98–108, 1970.
[8] J. Schacter and C. Fagnano. Does computer technology improve student learning and achievement? *How, when, and under what conditions? Journal of Educational Computing Research*, 20(4):329–343, 1999.
[9] K. Hinde and A. Hunt. Using the personal response system to enhance student learning: Some evidence from teaching economics. In D. Banks, editor, *Audience response systems in higher education: Applications and cases*. Information Science Publishing, Hershey, PA, 2006.
[10] D. Duncan. Clickers: A new teaching aid with exceptional promise. *Astronomy Education Review*, 5:1–24, 2006.
[11] R. R. Hake. Interactive-engagement vs. traditional methods: A six-thousandstudent survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66:64–74, 1998.
[12] Poll Everywhere Support, https://www.polleverywhere.com/ ,2019
[13] James Madison University Course Catalog, shorturl.at/fKMQV ,2019

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