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Main article

The advantages of combining mobile technology and audience response systems

Hong Fan, Xiaofei Song *

Department of Accounting, Sobey School of Business, Saint Mary's University, 923 Robie Street, Halifax, NS B3H 3C3, Canada

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ABSTRACT

This study examines the impact of integrating mobile technology with audience response systems (ARS) on students' performance and experience. By comparing students in classes using traditional single-purpose ARS (Clicker) with students in classes using mobile technology-based ARS (Mobile ARS), we find that the latter earned, on average, 3.6 percent more on their final examinations and reported a more positive experience in three different financial accounting courses. Our findings suggest that the benefits of ARS technology documented by prior studies not only survived but were also strengthened by combining ARS technology and mobile technology. Leveraging the two technologies within the classroom environment appears to provide an advantageous platform that improves students' grade performance and classroom experience.

1. Introduction

The positive impact of audience response systems (ARS) on students' performance and experience has been well established in the ARS literature. Most, if not all, of such empirical evidence is based on traditional single-purpose ARS (Clicker), which is used exclusively for participation in Clicker-related classroom activities[1]. With the rapid advances in mobile technology and the increasingly ubiquitous presence of mobile devices, Clicker has also gone mobile.[2] However, whether mobile technology-based ARS (Mobile ARS) is as effective as Clicker as a classroom teaching tool remains unknown. On the one hand, combining mobile technology and ARS could enhance the positive impact of ARS because mobile technology renders ARS more attractive and more interesting (e.g., touch screens, background music, and rankings of participants). On the other hand, mobile devices are known to be a huge distraction in classrooms.[3] When permitted to use mobile devices for ARS activities, students may use mobile devices more often for class-unrelated activities, leading to a decrease in the positive impact of ARS. Could Mobile ARS be an advantageous learning platform that retains the positive impact of Clicker despite the distractive effect of mobile devices or would the distractive effect of mobile devices diminish the positive impact of Clicker once the two

* Corresponding author.
E-mail addresses: Hong.fan@smu.ca (H. Fan), Xiaofei.song@smu.ca (X. Song).

[1] For example, see Anderson et al. (2015), Bode et al. (2009), Edmonds and Edmonds (2008), Oswald and Rhoten (2014), Premuroso et al. (2011), Sprague and Dahl (2010), and Stowell and Nelson (2007).

[2] Carnaghan et al. (2011) summarized the four main vendors of Mobile ARS by 2012. More ARS vendors have entered the Mobile ARS market over the past decade. In addition, textbook publishers have begun to provide Mobile ARS apps as supplement materials to textbooks.

[3] For example, see the survey by Tindell and Bohlander (2012).

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technologies are integrated? This study aims to answer these questions by examining the impact of integrating mobile technology and ARS on students' experience and performance in financial accounting courses.[4]

We conducted a controlled experiment in three different financial accounting courses. Each course had two sections (classes) offered in the same semester that were taught by the same instructor with the same structure and contents, except for that Mobile ARS was used for regular quizzes in one section, and Clicker was used in the other section. Our goal was to compare the impact of Mobile ARS with that of Clicker on student performance, which was proxied by their final exam grades, and student experience, which was based on a course-end survey. We found that the students in the Mobile ARS sections earned, on average, 3.6 percent more on their final examinations and reported a better experience with ARS than the students in the Clicker sections. These results suggest that the combination of mobile technology and ARS technology creates an advantageous classroom learning platform and that the positive effect of ARS is strengthened by mobile technology.

This study makes three important contributions. First, this study fills the gap in ARS research by providing evidence regarding the effect of the current iteration of ARS technology, i.e., Mobile ARS. Most studies investigating ARS have been conducted using Clicker as the delivery instrument. However, with advances in mobile technology, Clicker has become a thing of the past. To the best of our knowledge, few studies have focused on the impact of Mobile ARS. Thus, whether the positive impact of Clicker survives ARS' transition to mobile technology is undocumented and unknown.

Second, this study contributes to research concerning the impact of mobile technology on education by providing an example of the beneficial combination of mobile technology with other classroom technologies. Despite the immense potential of mobile technology (Cerratto, Pargman, Nouri and Milrad, 2018; Li and Song, 2018; Ryberg, Davidsen and Hodgson, 2018; Schachter, 2009; Sun, Lin, Wu, Zhou, and Luo, 2018), mobile devices have become known more as a source of substantial problem in education due to student's excessive preoccupation with them. A survey conducted by Tindell and Bohlander (2012) investigating mobile device use in college classrooms revealed that 95 percent of students brought their phones to class daily and that 92 percent of students used their phones to send text messages during class time. Furthermore, the students became distracted by other students' texting during class. Duncan, Hoekstra, and Wilcox (2012) established a negative association between in-class use of mobile devices and student performance. Specifically, students who reported regular cell phone use in class showed an average negative grade difference of 0.36 on a four-point scale of final grades in eight introductory science courses at a major U.S. university. Despite the intense debate regarding the effects of mobile devices on student classroom performance and experience, both proponents and opponents of this technology agree that mobile devices are here to stay and that keeping them out of classrooms is practically impossible. The findings that ARS mobilization strengthens the existing positive impact of Clicker reinforces the notion that if one cannot fight this technology, it is better to use it wisely.

Finally, this study provides a new perspective regarding the evaluation of classroom technologies. Most existing studies investigating classroom technologies focus on the effects of a single technology in isolation. The recent trend in consumer electronics development suggests that multifunctioning devices are rapidly replacing less integrated devices. Research concerning classroom technologies should consider the potential interaction of different technologies. To the best of our knowledge, this study is the first to focus on the impact of classroom technology integration.

The fact that accounting courses were chosen for our experiment also gives this study added relevance. In recent decades, there has been a decline in the quantity and quality of students who chose to study accounting, especially in the U.S., Canada and the UK (Salemi & Eubanks, 1996). Financial accounting courses are cumulative in nature and particularly benefit from the active learning approach. Effective teaching tools, such as ARS, which have a potential positive impact on students' experience and performance through better engagement, can help students succeed in their courses and stay in accounting programs. This study provides evidence that Mobile ARS is even more effective than Clicker in this regard.

The remainder of this paper is organized as follows. In the following section, we provide a review of the relevant literature and develop the two study hypotheses. Then, we introduce our research design and provide a description of our data. Next, we present the results of our hypothesis tests, and finally, we summarize and provide the conclusions of the study.

2. Literature review and hypothesis development

Previous studies have shown that ARS can improve students' performance and learning experiences in a wide range of courses (e.g., Anderson et al., 2015; Bode, Drane, Kolikant, & Schuller, 2009; Edmonds & Edmonds, 2008; Oswald & Rhoten, 2014; Premuroso, Tong, & Beed, 2011; Stowell & Nelson, 2007; Sprague & Dahl, 2010). For example, Edmonds and Edmonds (2008) provided evidence that on average, students using ARS earned 3.15 percent higher course grades than students who did not use ARS. Chui, Martin, and Pike (2013) found that students in ARS sections received higher quiz scores than those in sessions without ARS, although there was no significant difference in the two groups' final grades. These authors suggested that immediate feedback caused the positive effects of ARS on student performance.

Studies have also found that the effect of ARS may change students' study behavior. Bode et al. (2009) and Morse, Ruggieri, and Whelan-Berry (2010) found that the use of ARS increased students' willingness to participate in subsequent class discussions. However, Carnaghan and Webb (2007) found that class engagement, which was proxied by students' oral

[4] This study was approved by our university's research ethics board.

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participation, declined when using ARS, possibly due to the students' substitution of oral participation with ARS participation.

As mobile tchonology rapidly expands its applications, its potentials in education is undeniable (e.g., Cunningham, 2008; Cunningham, 2011; Looi, Seow, Zhang, Chen, and Wong, 2010; Schachter, 2009; Shohel and Power, 2010; Watty, McKay, and Ngo, 2016). We argue that the participation-inducing effect of a single-purpose ARS should persist when ARS is delivered through mobile devices. Furthermore, mobile ARS should enhance the positive effect of Clicker. Clicker is unsophisticated compared with mobile devices, which are intentionally and creatively designed to appear attractive and be pleasurable to use. A potential advantage of using Mobile ARS is that they capitalize on students' attraction to mobile devices. According to the theory of evaluative conditioning (De Houwer, Thomas, & Baeyes, 2001), a person is more likely to enjoy something if it is paired with another positive activity. For instance, Zellner, Rozin, Aron, and Kulish (1983) found in their experiment that after participants attempted previously deemed flavor-neutral tea paired with sugar, which is a positive stimulus, the participants' preference for the tea became positive. Similarly, Stuart, Shimp, and Engle (1987) found that consumers' attitudes towards a brand were more positive if a pleasant advertising component was repeatedly presented to the consumers. Based on the findings of this type of research, we argue that students are likely to enjoy using Mobile ARS more than Clicker and, therefore, benefit more from its use due to their fascination with and attachment to their mobile devices. Anecdotal evidence based on the authors' experience with using both Clicker and Mobile ARS supports this theory. One source of frustration when using Clicker is that students sometimes forget to bring the Clicker device to class and are then unable to participate in any Clicker exercises and activities. Neither author of this study experienced the frustration of having students not being able to participate in ARS exercises because they forgot to bring their mobile phones. Moreover, in our classes, the students felt excited about some new features introduced by Mobile ARS, e.g., they liked the ranking of participants based on the correctness and speed of their answers. We predict that the more enjoyable and less frustrating experience provided by Mobile ARS could lead to more engagement in class activities, which should translate into better performance among the students in the Mobile ARS sections than the students in the Clicker sections.

Additionally, Mobile ARS could mitigate the potential distractive effect of the class-unrelated use of mobile devices by interrupting any such uses. Studies have documented that mobile technologies in classrooms can be actively used to engage students in classrooms and to make learning more interesting (Cerratto, Pargman, Nouri and Milrad, 2018; Li and Song, 2018; Ryberg, Davidsen and Hodgson, 2018; Sun, Lin, Wu, Zhou, and Luo, 2018). We argue that once a student is engaged in class-related ARS activities, he or she is more likely to remain engaged, at least for a while. Both authors observed that some students in the Clicker section still had their phones on class-unrelated screens (e.g., browsing the Internet and checking messages) while participating in ARS activities. However, the students in the Mobile ARS section had to switch to the ARS App on their mobile phones to participate in class activities and, therefore, could not easily scan social media (out of sight is out of mind). If mobile ARS is more effective than Clicker in countering the distractive effect of mobile devices, it could also contribute to better performance among students in the Mobile ARS sections than students in the Clicker sections.

Although we expect Mobile ARS to be a more effective teaching tool than Clicker, we acknowledge that the distractive effect of mobile devices has been well documented and such effect could potentially render Mobile ARS a less effective teaching tool than Clicker. For instance, students may feel less inhibited in using mobile devices for class-unrelated activities, such as texting and browsing, because Mobile ARS legitimizes the presence of mobile devices. It is more tempting and convenient to sneak a peek when the devices are right there. Although we required that mobile devices not be used for class-unrelated reasons in all classes, this requirement is difficult to enforce.

Despite the potential distractive effect of mobile devices, we predict that overall the positive effects of Mobile ARS are stronger because of the significant impact of evaluative conditioning observed in classes. Therefore, we develop two general hypotheses accordingly in alternative form as follows:

Hypothesis 1: The use of Mobile ARS improves students' performance in financial accounting courses more than the use of Clicker.

Hypothesis 2: The use of Mobile ARS enhances students' classroom experiences in financial accounting courses more than the use of Clicker.

In summary, we predict that Mobile ARS will enhance the positive effect of Clicker documented in prior studies and designed our experiment, which is described in detail in the following section, to empirically test this prediction.

3. Research design

3.1. Description of the experiment

A controlled experiment was conducted during the delivery of three separate courses, all of which were taught at the same Canadian university. All three courses were financial accounting: a third-year intermediate financial accounting course; an elective third-year financial accounting theory course; and a financial accounting course for MBAs. Each course had two sections taught by the same instructor in the same term using the same textbook, course outline, supplementary materials, exercises, lecture notes, ARS quizzes and common final examinations. In addition to a few numeric changes in the calculation questions and the change in the order of multiple-choice questions in the ARS quizzes, the key difference between the two sections was that one section used a Mobile ARS for the quizzes, while the other section used Clicker.

To prevent information sharing between the earlier sections and the later sections of the same course, the question sequencing and numerical data in each quiz were changed, and the order of the Mobile ARS sections and Clicker sections were altered. The Mobile ARS section preceded the Clicker section for the financial accounting elective and financial accounting for MBAs courses. The Mobile ARS section followed the Clicker section for the intermediate financial accounting course.

During the first meeting of each class, all students received the course outline and instructions for the registration and use of the Mobile ARS or Clicker. The students in all sections were also given an identical paper pretest, which included five quantitative analysis questions. During the second class, the students were asked to answer a few simple survey questions using Mobile ARS or Clicker. Most students were proficient with their respective technology after this practice. Although the students could also use Mobile ARS via digital devices other than a cell phone, the instructors observed that all students used cell phones.

Throughout each course, the students completed a total of ten quizzes. Each quiz consisted of one to five questions, and the students were given one to three minutes to complete each question. The quiz questions were a mixture of topic-opening questions that were followed by the introduction of new materials and review questions to test the understanding of concepts and theories already covered in prior classes. The quizzes could be given at any time during the class.

After the students submitted their answers, the distribution of responses was shown, and the correct answer was immediately revealed. If the correct answer rate was less than 50 percent, the instructor explained the question in detail. If time allowed, the instructor also presented a similar question for additional practice. If more than 50 percent of the students answered correctly, the instructor invited the students to elaborate on their answers.

In the second-to-last class of each course, a survey asking the students to self-assess their experience with Mobile ARS and Clicker was given. According to the procedure established by the Research Ethics Board of the university, the instructors clearly stated that completing the survey was voluntary. The instructors also explained that they would not have access to the students' survey responses until the course grades had been submitted, and thus, the survey would have no impact on their grades. The instructors left the classrooms while a research assistant remained to collect the completed surveys. On average, 82 percent of the students were present on survey days, and all students who were present completed the survey.

The students in the two sections of each course completed the same cumulative final examination at the same time and location. The final examination grade rather than the ARS quiz scores was used as the measure of student performance in the course because ARSs were used as teaching tools; thus, ARS quiz scores are indicators of the learning progress. The final grade was chosen as the measure because this grade reflected the overall outcome of a student's cumulative efforts throughout the term and was relatively objective. After the course officially ended and the grades were posted, the research assistant returned the surveys to the instructors.

3.2. Test of Hypothesis 1

To test Hypothesis 1, the student performance, which was measured by the final examination grade in percentage form (*Final_Grade*), was used as the dependent variable in the regression. The independent variable of interest is a dummy variable, *Mobile_ARS*, that has a value of "1" for the Mobile ARS sections and "0" for the Clicker sections. A positive and significant coefficient of *Mobile_ARS* would support the prediction of Hypothesis 1, i.e., Mobile ARS has a more positive impact on student performance than Clicker.

Following prior research (e.g., Lepp, Barkley, & Karpinski, 2015; Premuroso et al., 2011), the variables used to control for other factors related to a student's performance included the GPA, pretest scores, quiz scores, student's gender, and dummy variables representing low course and high course load during the term of the experiment. A preliminary analysis suggests that the similarities within courses are high as indicated by an intraclass correlation coefficient of 0.447.[5] These within-course similarities challenge the assumption of ordinary least squares (OLS) that the observations of the final exam grades are independent. It is likely that the final exam grades within one course are correlated. For instance, MBA students are more mature and may motivate each other to work hard during the course. To address this concern, clustering was used in the linear model to group all observations into three categories according to the three courses. This approach relaxes the homoscedasticity assumption of the OLS regression analysis and allows the error terms to be heteroscedastic and correlated within courses (Schmidheiny, 2014, 1). Our regression model is as follows:

$$\begin{aligned} Final\_Grade &= \alpha + \beta_1 Mobile\_ARS + \beta_2 ARS\_Experience + \beta_3 Quiz + \beta_4 Pretest + \beta_5 Gender + \beta_6 GPA \\ &\quad + \beta_7 Low\_Course\_Load + \beta_8 High\_Course\_Load + \varepsilon \end{aligned}$$

[5] The intraclass correlation coefficient (ICC1) value is interpreted as "the total amount of variance in the dependent variable that is attributable to between-unit rather than within-unit differences over time. Higher value also indicates a nontrivial degree of observation nonindependence that, if found, renders traditional regression approaches inappropriate" (Hausknecht, Hiller, & Vance, 2008, page 1231). The intraclass correlation coefficient of Final_Grade is 0.45, suggesting that almost half of the variance was attributable to between-unit (i.e., between-course) differences, and half of the variance was explained by within-unit (i.e., within-course) variability. This phenomenon indicated that the average levels of Final_Grade differed between courses and suggested that considering this issue in the regression was warranted.

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where

Final_Grade = the student's final exam grade as a percentage (i.e., the actual final exam grades earned scaled by the total grades available);
Mobile_ARS = a dummy variable that assumes a value of 1 if the student used Mobile ARS during the term and 0 otherwise;
ARS_Experience = the average score of a student's responses to survey questions 1–11[6];
Quiz = the sum of the ten quiz scores divided by the total available scores on the ten quizzes;
Pretest = the actual pretest scores earned scaled by the total scores available;
Gender = a dummy variable that assumes a value of 1 if the student is female and 0 if the student is male;
GPA = the student's cumulative GPA before the experiment term;
Low_Course_Load = a dummy variable that assumes a value of 1 if the student took three or fewer courses during the experiment term and 0 otherwise; and
High_Course_Load = a dummy variable that assumes a value of 1 if the student took six or more courses during the experiment term and 0 otherwise.

The final examination grades and pretest and quiz scores are prepared by the instructors. The ARS_ Experience scores are computed based on the surveys collected. All other data are manually collected from our university information system. The GPA and number of courses taken concurrently are collected from the students' online transcripts. The gender information is collected from the students' information pages.

3.3. Test of Hypothesis 2

The test of Hypothesis 2 is conducted using the course-end survey data. The survey consisted of the following two parts: Part 1 consisted of 11 questions related to the experience of using ARSs in general and was given in both the Mobile ARS and Clicker sections, while Part 2 consisted of four questions related only to the Mobile ARS and was given only to the Mobile ARS sections.

To compare the experience of the Mobile ARS and Clicker subsamples, both *t*-test and Wilcoxon rank-sum test were used. Although the *t*-test is commonly accepted for survey data analyses in Clicker studies because each Likert question is viewed as unique and stand-alone, non-parametric methods focusing on medians, modes, and frequencies (Boone & Boone, 2012; Clason & Dormody, 1994; de Winter & Dodou, 2010) were used to ensure that the test results were robust and not specific to the test methods.

3.4. Sample

The total sample includes 228[7] students registered in the three courses. Forty-one students did not complete the course-end surveys, while 17 of the remaining students did not complete the pretest. The final sample size included in the regression analysis is 170. Table 1 summarizes the sample selection.

Among the 170 students, 54 percent were female, and 46 percent were male. Forty-six percent of the students used Mobile ARS, while 54 percent of the students used Clicker. Overall, the sample distributions based on gender and between the two ARS devices are reasonably even. Panel A in Table 2 presents a summary of the sample distribution.

4. Results

4.1. Descriptive statistics

The descriptive statistics of the continuous variables are reported in Panel B in Table 2. The differences between the means and medians of all variables are less than ten percent of the standard deviations (untabulated), indicating that skewness is minimal for the variables.

The *t*-test results of the continuous variables between the Mobile ARS students and the Clicker students show that there were no significant differences in the pretest, indicating that the two groups of students were similar in their preparedness for the courses before the experiment. The Mobile ARS students had a more positive experience with ARSs and earned higher scores on both the quizzes and final exam. These univariate test results are consistent with the prediction that Mobile ARS is more advantageous than Clicker.

Table 3 presents both the Pearson and Spearman correlations of the variables included in the regression. *Mobile_ARS* is positively correlated with *Final_Grade* at the one percent level of confidence, supporting Hypothesis 1. Two independent

[6] A higher score indicates more positive feelings about using ARSs for all survey questions, except for question 3, which is "I think Mobile ARS/Clicker was a distraction for me." A higher score on question 3 signals more negative feelings about using ARSs. To render all question scores consistent, we converted question 3's score by subtracting the raw response from 6 and used the converted scores in the calculation of ARS_Experience.
[7] No student registered in more than one experiment course in our sample.

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Table 1
Sample and sample selection.

Initial sample (number of students)		
Third-year Intermediate Financial Accounting	103	
Financial Accounting for MBA	43	
Third-year Financial Accounting Elective	82	
Total initial sample		228
Deletions due to missing data		
Students who did not participate in the surveys		−41
Students who did not complete the pre-test		−17
Sample size		170

Table 2
Summary statistics of the variables.

		Observation	Percentage
Panel A: Summary statistics of the discrete variables			
Gender	Female	91	54%
	Male	79	46%
	Total	170	100%
ARS Device	Mobile_ARS	78	46%
	Clicker	92	54%
	Total	170	100%
Course_Load	≤3 Courses (Low)	30	18%
	4 or 5 Courses	128	75%
	≥6 Courses (High)	12	7%
	Total	170	

Variable	Obs	Mean	Median	Mean Mobile_ARS	Mean Clicker	T-Test Mobile_ARS vs. Clicker
Panel B: Summary statistics of the continuous variables						
Final_Grade	170	0.637	0.645	0.675	0.604	**0.005*****
GPA	170	3.152	3.200	3.273	3.048	**0.025****
Pretest	170	0.581	0.600	0.604	0.554	0.196
Quiz	170	0.726	0.713	0.761	0.696	**0.006*****
ARS_Experience	170	3.871	3.909	3.970	3.788	**0.049****

*** and ** indicate that the test result is statistically significant at the 1% and 5% levels, respectively.

variables, *Quiz* and *GPA*, are relatively highly positively correlated with the dependent variable *Final_Grade*. Because all three variables are measures of student performance, such relationships are expected. The correlations between all independent variables are below 50 percent, except for that between *GPA* and *Quiz*. The correlations between *GPA* and *Quiz* are 0.550 (Pearson) and 0.604 (Spearman), suggesting a high correlation between historical performance and quiz performance. The results of the multicollinearity tests are discussed in the following section.

4.2. Regression results (Hypothesis 1)

The regression results for Hypothesis 1 are presented in Table 4. The regression sample includes 170 observations with complete data for all regression variables. The regression coefficient of *Mobile_ARS* (0.036) is positive and marginally significant at the ten percent level, suggesting that other things being equal, students using the Mobile ARS during the term received 3.6 percent higher grades on the final exam than students who used Clicker. This result supports Hypothesis 1, which posits that Mobile ARS incrementally improves student performance in financial accounting courses compared to Clicker. Note that a statistically insignificant regression coefficient of *Mobile_ARS* suggests that the impact of Mobile ARS on student performance does not significantly differ from that of Clicker, which has been established by prior studies to be positive. The positive regression coefficient of *Mobile_ARS* suggests that the positive impact of ARS not only persisted but was also strengthened by being combined with mobile technology.

Regarding the control variables, the students' performance is highly correlated with their past GPA. Students with higher GPAs also performed better in the experiment course. None of the other control variables are significant at the ten percent level of confidence. Given the relatively high correlation between *GPA* and *Quiz* shown in Table 3, we computed the variance inflation factors (VIFs) of all independent variables, and the VIFs are presented in the third column in Table 4. All VIFs are less than the thresholds of 2.342, which is computed following Freund and Littell (1986), indicating that multicollinearity is not a major concern.

Table 3
Variable Correlations (n = 170).

		Pearson Correlation								
		Final_Grade	*Mobile_ARS*	*Quiz*	*Pretest*	*Gender*	*ARS_Experience*	*GPA*	*Low_Course_Load*	*High_Course_Load*
Spearman Correlation	*Final_Grade*	1	0.214***	0.491***	0.129*	0.095	−0.137*	0.730***	0.229***	−0.090
	Mobile_ARS	0.222***	1	0.210***	−0.100	−0.018	0.011	0.172*	−0.086	−0.069
	Quiz	0.496***	0.261***	1	0.050	0.055	−0.063	0.550***	0.192**	0.024
	Pretest	0.141*	−0.093	−0.004	1	0.072	−0.028	0.012	−0.242**	0.058
	Gender	0.109	−0.018	0.014	0.051	1	0.241**	0.082	−0.064	0.027
	ARS_Experience	−0.124	0.049	−0.095	−0.005	0.198***	1	−0.143*	−0.164**	−0.121
	GPA	0.738***	0.174**	0.604***	0.031	0.065	−0.140*	1	0.280***	−0.148*
	Low_Course_Load	0.233***	−0.086	0.272***	−0.244***	−0.064	−0.183*	0.290***	1	−0.128*
	High_Course_Load	−0.095	−0.069	−0.033	0.047	0.027	−0.131*	−0.113	−0.128*	1

***, ** and * indicate that the test result is statistically significant at the 1%, 5% and 10% levels, respectively.

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Table 4
Regression results. $Final\_Grade = \alpha + \beta_1\ Mobile\_ARS + \beta_2\ ARS\_Experience + \beta_3\ Quiz + \beta_4\ Pretest + \beta_5\ Gender + \beta_6\ GPA + \beta_7\ Low\_Course\_Load + \beta_7\ High\_Course\_Load + \varepsilon$.

	Coefficient (P-value)	VIF
Mobile_ARS	**0.036*** **(0.065)**	1.11
ARS_Experience	−0.009 (0.619)	1.15
Quiz	0.105 (0.240)	1.52
Pretest	0.094 (0.226)	1.11
Gender	0.014 (0.576)	1.09
GPA	**0.161*** **(0.050)**	1.61
Low_Course_Load	0.033 (0.343)	1.25
High_Course_Load	0.002 (0.832)	1.09
Intercept	0.003 (0.974)	
Cluster by Course	Yes	
R^2	0.573	
F-statistic	21.54 (0.044)	
VIF Threshold		2.342
N	170	

1. * indicates that the test result is statistically significant at the 10% level.
2. The VIF threshold is calculated as 1/(1-R-squared) = 1/(1–0.573) = 2.342.

The regression model is statistically significant (F-statistic = 21.54, p-value = 0.044), and the independent variables in the model explain approximately 57 percent of the variation in the dependent variable *Final_Grade*. Our R-squared is comparable with similar studies (e.g., R-squared = 56% in Premuroso et al., 2011; R-squared = 45% in Lepp et al., 2015).

4.3. Survey results (Hypothesis 2)

Table 5 presents the results of the survey. The second column shows the survey questions concerning the students' experiences with ARSs. Of the 11 survey questions, three questions are related to the overall experience of using ARSs, five questions are related to class engagement, and three questions are related to learning outcomes. All evaluations were self-assessed. The students received the questions in random order; the 11 questions were organized and categorized into three parts as shown in Table 5.

The third and fourth columns show the average survey responses to each question in the Mobile ARS and Clicker groups, respectively. The superscript indicates the significance level of the *t*-test comparing each mean survey score with 3 (neutral). The mean survey scores of all questions in both the Mobile ARS and the Clicker groups significantly differed from 3 at the one percent level. This finding is consistent with the findings of previous studies showing that students generally have positive experiences using ARS and that ARS have a positive impact on class engagement and learning outcomes. This study extends this stream of literature by reporting that ARSs' positive effects persist regardless of how the ARS is delivered, i.e., via a mobile device or Clicker.

The fifth column presents the p-values of the t-tests comparing the experience of the two groups of students using their respective ARS. Compared with the students in the Clicker sections, the responses to the survey questions by the students in the Mobile ARS sections were either significantly more positive or not significantly different but were never less positive. Overall, the results support Hypothesis 2, which posits that Mobile ARS has an incrementally more positive impact on students' experience than Clicker.

Concerning the questions regarding the overall ARS experiences, the Mobile ARS students felt incrementally more positive about using the ARS in the course than the Clicker students. However, there was no significant difference between the two groups of students in their responses to the questions asking whether ARS made the course more interesting or served as a distraction.

Concerning the questions regarding the impact of ARS on class engagement, the Mobile ARS students indicated that they found that ARS enabled them to be incrementally more engaged and participate incrementally more in class and that the immediate feedback from using ARS was incrementally more helpful than the Clicker students. The Mobile ARS students did not believe that ARS helped them focus longer in class or motivate them to attend class more than the Clicker students.

Table 5
Survey results (n = 170).

	Survey Questions	Average Score of Survey Responses, Superscript Indicates the Significance of the T-Test Compared to 3 (Neutral)		P-Value of T-Test, Mobile ARS vs. Clicker	P-Value of Wilcoxon Sum Rank Test, Mobile ARS vs. Clicker
		Mobile ARS Subsample	Clicker Subsample		
Overall Experience with Clicker/Mobile ARS					
1	Overall, I am very positive about the use of Mobile ARS/ Clicker in this accounting course.	4.25***	3.86***	**0.003*****	**0.004*****
2	Using Mobile ARS/Clicker made the class more interesting for me.	4.03***	3.87***	0.255	0.399
3	I think Mobile ARS/Clicker was a distraction for me.	2.36***	2.30***	0.704	0.670
Class Engagement					
4	Mobile ARS/Clicker helped me be more engaged in the classroom.	4.29***	4.01***	**0.029****	**0.024****
5	I participated more in this course compared to other courses because of the use of Mobile ARS/Clicker.	3.85***	3.54***	**0.036****	**0.026****
6	I can focus for longer in class because of the use of Mobile ARS/Clicker.	3.63***	3.49***	0.368	0.310
7	Receiving feedback (seeing the answers) immediately from Mobile ARS/Clicker helped my study in this course.	4.21***	3.89***	**0.010****	**0.010*****
8	I was more likely to attend class because of the pop quizzes/ exercises using Mobile ARS/Clicker.	4.01***	3.87***	0.356	0.308
Outcome of Learning					
9	Practicing problems using Mobile ARS/Clicker in class was good preparation for quizzes and/or exams.	3.89***	3.75***	0.326	0.274
10	The Mobile ARS/Clicker questions we practiced in class helped my understanding of the course material.	4.13***	3.98***	0.267	0.279
11	Overall, I believe using Mobile ARS/Clicker was very effective in this accounting course.	3.83***	3.74***	0.526	0.516

1. Survey response scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree; 5 = strongly agree. Notably, a higher score indicates more positive feelings regarding the use of ARSs on all survey questions, except for question 3.
2. *** and ** indicate that the test result is statistically significant at the 1% and 5% levels, respectively.

Concerning the questions regarding the impact of ARS on the outcome of learning, the Mobile ARS students did not indicate that the ARS exercises improved their understanding of the course material more, were more helpful in preparing for exams or that, overall, ARS was more effective in the course than the Clicker students. This result may appear to contradict the regression result in Table 4, which shows that the final grade in the Mobile ARS group is higher. This contradiction in our findings could be explained by the difference between the performance measured objectively by the final examination grades and the outcome of learning measured subjectively by students' self-assessment. For example, a student may believe that he/she is not ready for an exam, but this belief does not necessarily imply that he/she is not sufficiently prepared for the exam. In this case, our regression clearly showed that all other variables being equal, the Mobile ARS students performed better on the final exam than the Clicker students even though the Mobile ARS students did not believe that the ARS helped them be more prepared.

The p-values of the Wilcoxon rank-sum tests are presented in the sixth column in Table 5. The Wilcoxon rank-sum test qualitatively yielded the same results as the *t*-test in terms of the difference in the two groups of students' self-assessment of the impact of ARS on their class engagement and learning outcomes.

4.4. Results of the survey questions for mobile ARS students only

Table 6 presents the survey results of four questions that can shed some light on the self-assessed reasons why Mobile ARS students experienced incremental benefits. The Mobile ARS students did not appear to take advantage of Mobile ARS's information-sharing features. Regarding the questions concerning the time students spent studying materials sent via Mobile ARS and the use of Mobile ARS to study for the course outside of class, the students' responses were neutral (the average score was not significantly greater than 3).

In contrast, the Mobile ARS students seemed to use their mobile phones to help with course-related activities in the classroom in addition to participating in ARS quizzes without succumbing to any distractions. The mean score of the question related to other in-class course-related activities, such as searching for unknown words, is significantly greater than 3 (neutral). The mean score of the question related to other activities unrelated to the course, such as checking text messages, is significantly less than 3 (neutral). Overall, based on the self-reported activities, allowing cell phone use for ARS in class did

Table 6
Results of the survey regarding mobile ARS (Mobile_ARS) (n = 78).

	Survey Questions	Mean	P-value of T-Test vs. Mean = 3
12	I spent more time studying the material sent to me via cell phone knowing that I would be asked to participate via Mobile ARS.	2.89	0.410
13	I used Mobile ARS to study for this course (e.g., reading slides) outside of class.	2.85	0.340
14	I used my cell phone more for class-enhancing activities, such as looking up unknown words, than for class exercises using Mobile ARS.	3.32	**0.017****
15	Since I am allowed to use my cell phone in class due to Mobile ARS, I used my cell phone more frequently for unrelated activities, such as checking and replying to text messages in class, compared to other courses in which cell phones are forbidden.	2.44	**0.000*****

1. Survey response scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree; 5 = strongly agree.
2. *** and ** indicate that the test result is statistically significant at the 1% and 5% levels, respectively.

not seem to induce any undesirable behavior from students. However, these activities were self-reported, and the students may not have wished to provide self-incriminating information.

5. Conclusion

Our study investigates whether Mobile ARS is more advantageous than Clicker. We found that the students in the Mobile ARS sections earned higher final exam grades on average and had a better classroom experience, i.e., more positive feelings due to being more engaged, participating more, and benefiting more from immediate feedback, than the students in the Clicker sections. The incremental positive effect of the Mobile ARS compared to Clicker suggests that the combination of mobile technology with ARS technology enhances the positive effect of ARS.

This study provides timely assessment information regarding emerging Mobile ARS. ARS in classrooms have evolved with the development of smartphones and cellphone networks (Carnaghan, Edmonds, Lechner, & Olds, 2011). More ARS vendors have entered the ARS market over the past decade. In addition, textbook publishers are beginning to provide Mobile ARS apps to assist instructors. Our study provides useful information regarding the effects of Mobile ARS in the classroom, which can help instructors decide whether to adopt Mobile ARS.

Given the current pervasive presence of mobile devices in most aspects worldwide, this study investigating the benefits of using Mobile ARS in accounting courses is highly relevant to the future of education. While studies have explored how to design better ARS questions and how to combine ARS with other teaching techniques (Bentley, Brewer, & Eaton, 2009; Carnaghan et al., 2011), our study is among the first to investigate the integration of educational technologies. Moreover, our study answers the call to study educational techniques beyond traditional teaching approaches and extend our accounting education research to mobile techniques (Apostolou, Dorminey, Hassell, & Rebele, 2015). If not productively engaged in classroom learning, mobile devices can be a distraction. The findings of this study suggest that there are potential gains to be harnessed and leveraged by combining and consolidating classroom technologies.

While we found that the benefits of Clicker are enhanced when ARS technology is combined with mobile technology, caution should be exercised in generalizing the findings of this study due to the relatively small sample size, the limited course choices, and the narrow focus of ARS technology. We call for future studies to extend this line of research by using larger samples that allow for a better delineation of the types of students that could benefit more from Mobile ARS (e.g., students in introductory vs. advanced level accounting courses, and business major vs. science major students). Moreover, technology integration is among the important developments in technology in education, but empirical evidence of the impact of teaching technology integration is sparse. Future studies using larger samples in wider selection of courses with more choices of teaching technologies could be extremely helpful for educators and technology providers to better utilize technology to help students succeed.

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