Effectiveness and Efficiency Analysis of Keypad Response Technology in the Introductory Accounting Classroom

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Abstract

In an analysis of the efficiency and effectiveness of Keypad Response Technology (KRT) within an introductory accounting class, students were asked to use eInstruction's Classroom Performance System. Effectiveness of KRT was evaluated by comparing student performance in previous class sections not exposed to KRT (non-KRT, n=68) to the performance of students exposed to KRT (n=161). Efficiency was evaluated by manipulating the timing of questions given via KRT. Two KRT-class sections received questions periodically throughout class (PER, n=64), whereas three sections received KRT questions at the end of class (EOC, n=97). Student assessment performance was neither significantly different between KRT and non-KRT samples, nor was it significant between EOC and PER sections. However, student withdrawal rate was significantly higher in KRT sections (13.66%) versus non-KRT (4.41%). Withdrawal was also found to be significantly higher in PER (20.03%) and positively correlated with age. Lastly, participation in KRT was determined to be significantly correlated with assessment performance in PER, but not in EOC.

Keywords: Teaching; Learning; Keypad Response Technology; Clickers; Accounting Instruction; Education

Introduction

The phrase "chalk and talk" has been used to describe the classic classroom where an instructor explains concepts to a class while writing examples on a chalkboard (Ghosh and Renna 2009). It has been argued that students are limited by the passive style of learning (Cameron 1998). Unfortunately, as accounting classrooms have moved from chalkboards to PowerPoint™ presentations, teaching styles have gone from "chalk and talk" to "point and stare." One novel means of making students engage in presentation style lectures is keypad response technology (KRT), commonly known as "clickers." These devices allow students to answer questions electronically before, during, or after a lecture. The questions are visually broadcast to the class and students are able to answer anonymously, although some KRT methods encourage cooperative learning.

This study seeks to evaluate both the efficiency and effectiveness of KRT. The KRT device utilized for this study is eInstruction's Classroom Performance System™ (CPS). Previous research regarding KRT (Gagnon & Thivierge, 1997; Addison, Wright, & Milner, 2009; Hoekstra, 2008) indicates potential benefits in student perceptions and information retention. This study contributes to the existing literature in two ways. First, no previous research addresses the use of KRT in introductory accounting courses. Second, this study attempts to isolate the most effective delivery method for KRT by providing KRT questions to one section periodically (PER) throughout the class, and to another at the end of class (EOC).

Historical Review

Accounting education forces an objectivist pedagogical strategy, given the strict rules involving the existence and interpretation of an objective reality. The objectivist model assumes all users use the same process in interpreting information (Liedner and Sirkka 1995). In a learning environment, an instructor attempts to transfer, rather than create, information. Using questions, the instructor determines whether the transfer of information has occurred (Liedner and Sirkka 1995). However, it may be prudent to consider other pedagogical concepts in accounting education. As indicated by Leidner and Sirkka (1995), key response technology such as CPS allows for pedagogical methods contained within both the objective and other, more active and cooperative models of learning:

> "Key response pad technology assumes that the instructor is the nucleus of the classroom and that information is being delivered by the instructor. This pedagogical assumption is closely linked to the objectivist model of learning. By enabling an instructor to ask questions based on material being covered and to assess the degree of understanding by the responses, key response pad technology facilitates more effective knowledge transmission and comprehension. The technology is secondarily related to cognitive information processing. The technology promotes feedback on students' learning (pg. 275)."

Although primarily objective in form, the ability to vary the mechanism of information delivery during classroom interaction potentially allows for students with different methods of processing information to absorb data more efficiently. The assumption of limited attention provided by the cognitive information processing model provides a background for this study. Cognitive information processing theorizes that the rate in which a student processes information dictates the pace of learning. Instructional inputs that are not registered or processed by the learner will have no impact on mental models (Bovy, 1981; Brunning, 1983). Potentially, by diversifying the delivery of information, a student may not exhaust their theoretically limited information processing resources. Use of repeated questioning in an academic setting has revealed encouraging results. Kling et al (2005) presented a study of two sections of a marketing class taught by the same professor, one given twelve quizzes over the course of the semester, the other group given three exams. Both test formats encompassed the same amount of information. At the end of the semester, both sections were administered a cumulative final exam. Subsequent analysis revealed significant increases in final exam scores in the section given twelve quizzes versus the three-exam section.

Furthermore**,** Tuckman (2000) produced dramatic results in a study comparing a population of students required to take a quiz at the beginning of each class against a separate population required to submit homework every class. The study found that students in the same class with previously low GPAs given frequent tests outscored individuals with similar GPAs given homework. In respect to KRT, Addison, Stephen, and Wright (2009) engaged one section of an introductory biology class using KRT. The performance of the KRT section was then compared to previous course sections receiving the same material and assessments without KRT. The study showed that while the section did not demonstrate significantly different test scores as a class in respect to previous sections, there were a greater percentage of students scoring above 90% on the tests. Other studies have subjectively demonstrated, through survey results, positive perceptions of KRT. Hoekstra (2008) surveyed Chemistry students, while Gagnon and Thivierge (1997) surveyed Continuing Medical Education for medical practitioners. Both showed via survey that the subjects viewed the use of keypad technology favorably.

Although not the primary focus of their articles, research seems to show collaborative learning impacts student performance when used in conjunction with KRT. For example, Chan and Snavely (2009) used the devices in a highly controlled environment, using no means of collaborative learning to maximize similarities between the control non-KRT and test KRT classroom environments. The questions were given at the beginning of class and discussion was not allowed. The study found no difference in average course scores between a non-KRT and KRT introductory finance course. Alternatively, in a much larger study, Morling et al (2008) show a modest increase in assessment performance for KRT compared to control classes. Questions were also given at the beginning of class. Although discussion was not encouraged, the professor did provide additional instruction later in the class for subject areas showing low student KRT scores at the beginning of class. The instructor modifying the class material in response to student needs is the primary element of just in time teaching, a collaborative learning pedagogical method (Morling et al 2008).

Furthermore, Salemi (2009) concluded from his own experience teaching a Principles of Economics class that KRT can be used to increase student collaboration via in-class experiments. He also realized a 96 percent retention rate and 92.3 percent average attendance rate, making note of how "remarkable good these attendance data are (page 403)." Previous research does not address the effectiveness in terms of assessment performance for novel educational vectors such as KRT in transference of accounting knowledge. Research addressing the most efficient means of utilizing KRT (i.e. question distribution during class-time) was also not found.

Method

This paper attempts to study the effects of question timing structure in regards to accounting student performance, using a novel approach to accounting classrooms, key-pad response technology -- specifically eInstruction's Classroom Performance System.

For this paper, student performance is defined as both assessment performance and persistence (i.e. not withdrawing from the course) for the semester. Introductory Accounting was selected as the most suitable course in which to examine a student's ability to absorb accounting knowledge. Student exposure to accounting knowledge prior to the class is at its lowest level versus other, more advanced accounting classes. The initial low-level of accounting-related knowledge suggests student performance on assessments will more likely be due to knowledge acquired in-class, as opposed to previous experience. All students were given the same tests, taught using the same presentations (the non-KRT group did not have questions distributed within the presentation) and professor. In addition, students self selected which class section to attend with no knowledge of what type of KRT structure would be provided in their respective section.

The students within the KRT class sections were asked to purchase eInstruction's Classroom Performance System (CPS) Keypad Response Device, typically known as "clickers." The KRT classes in this study had five sections, two in spring 2009 and three in fall 2009. Two class sections received the questions at relatively even intervals periodically throughout class time (PER, n=64), while the other three sections received the same questions at the end of class (EOC, n=97). Each section received, for each chapter, the same five questions during class time selected from a database provided by the textbook publisher. One minute to answer each question was allotted to the students. A bonus was awarded to students participating in the CPS questioning. If a majority of students using clickers answered four of the five questions correctly, the bonus was doubled. Given that this was based upon aggregate classroom performance, these bonus points will not be included in the performance assessment for this paper.

Students are evaluated based on their performance in three non-cumulative assessments evenly distributed throughout the semester (Tests) and one cumulative assessment at the end of the semester (Exam). Only the assessment scores for students completing the final exam, and therefore completing the course, will be used in the analysis. Students attempting at least one test without attempting the final exam were considered to have withdrawn from the class. The average score on all assessments a student completed will be used to analyze each student's performance. In some cases, students failed to take a test and elected to have the final exam score replace the missed test in the student's final grade calculation. In other cases, students dropped the classes and did not take the final exam. Only students who completed the final exam and only completed assessments scores will be used in calculating average assessment performance.

Withdrawal of students is a concern when bringing new technology into the classroom. While the assessment performance cannot be measured for a student who withdraws from a section, the act of withdrawing may be construed as a lack of performance in terms of the course. Therefore, this analysis will also compare student attrition or "drop" rates, as well as assessment scores. For this analysis, the non-KRT students will function as the control, as they received the same tests and final exam, had the same scoring structure for final grades (apart from CPS bonus points), and were taught using the same PowerPoint™ presentations (without CPS questions inserted) as the KRT sections.

Effectiveness of KRT

Differences in student performance between course sections using KRT and those not exposed to the technology may demonstrate the effectiveness of KRT. Therefore, students in the KRT section will be compared to the previous semesters' student who did not engage in KRT (non-KRT, n=68).

Efficiency of KRT

However, many studies have attempted to demonstrate the effectiveness of KRT. This study expands upon this research and attempts to determine if a more efficient question distribution method exists. Therefore, both PER and EOC section performance will be compared against non-KRT performance in an attempt to determine if one distribution of KRT based questions during class time is more effective is more effective than the other. Furthermore, the bonus system for KRT participation allows for the examination of how the level of KRT participation influences assessment performance. Participation percentage will be calculated as follows; the number of days an individual student earned any bonus points over the total number of days the student had the opportunity to earn to earn bonus points.

Table 1 provides a summary of the variables used in this analysis and their descriptions.

Insert Table (1) about here

Results

Table 2 provides the average GPA, average assessment scores, and attrition rate for the various class sections used to test the efficiency and effectiveness of KRT.

Insert Table (2) about here

Next, a correlation matrix was created to discern other factors influencing assessment performance (Table 3). It shows student GPA is positively correlated with assessment scores.

Insert Table (3) about here

Because GPA is correlated with performance, it is important to show an equal distribution of GPA between the samples being tested. A one by three (1 X 3) ANOVA shows that GPA is not significantly different between non-KRT, EOC, and PER students ($p = 0.170$), and a Student's T-test shows no significance between KRT and non-KRT ($p=0.489$). Both groups also do not present a statistically significant Levene's statistic. These results suggest the distribution and values of student GPA within each sample group are approximately the same.

Effectiveness of KRT

The results of a Student's T-test suggest no significant difference in assessment performance between the means of the KRT and non-KRT control sections ($p=0.180$). However, the test does suggest the means are not similar for attrition rates between the KRT and non-KRT control sections ($p=0.013$). The results suggest no difference in terms of assessment performance for those students who actually finished the course. The percentage of students who failed to complete the course, however, is shown to be significantly higher in those sections utilizing KRT.

Efficiency of KRT

Similar to the test of effectiveness of KRT versus the non-KRT control, a test of efficiency using a one by three (1 x 3) ANOVA shows no significant difference in assessment performance between EOC, PER, and non-KRT control sections ($p=0.333$). However, once again, we see a significant difference in drop rates, with one by three (1 x 3) ANOVA revealing a Welch's statistic of 4.041 ($p=0.020$). The Levene's statistic was significant, indicating heterogeneous variances between the sample groups, therefore a robust test for equality of means must be used. Subsequent post-hoc analysis between the three sample groups using Dunnett's T3 test that addresses the heterogeneous variances reveals a statistically significant difference ($p=0.018$) between the attrition rates of non-KRT (rate = 0.044) and PER (rate = 0.203). This is a difference in attrition rate of 0.159. In other words, approximately 16 out of one hundred more students withdraw from a class using KRT with a PER question distribution than from a class with no KRT utilized. However, EOC distribution did not create a significant difference in student assessment performance or statistically change student withdrawal. It is interesting that PER affected student withdrawal rate while EOC had almost no obvious influence. Perhaps an attempt at understanding participation in KRT within the timing sections will reveal additional information.

Participation and Performance

The correlation matrix in Table 4 shows how participation impacts performance in the PER and EOC samples. This correlation matrix demonstrates the level of participation in KRT is significantly, positively correlated with assessment performance for all KRT users. However, by dividing the sample by question distribution, participation only remains positively correlated with performance in PER sample sections. Furthermore, controlling for potential partial correlations with GPA and age, PER participation percentage retains its correlation with average PER assessment score (Pearson Correlation = 0.316, $p = 0.014$).

Insert Table (4) about here

Regression analysis demonstrates the dramatic difference between KRT participation and performance between question timing distributions. A linear regression between participation and assessment performance in EOC sections produces an R^2 of 0.000 ($p = 0.933$) whereas PER shows an R^2 of 0.226 ($p = 0.001$) (see Figure 1). These results show assessment performance is only related to KRT participation in the PER sample sections.

Insert Figure (1) about here

Sensitivity analysis

The salient difference between the two timing sections is the greater number of students dropping out of PER sections. (For the purposes of this study, "drop" or "withdrawal" is defined as a student attempting at least one test and failing to attempt the final exam.) Despite having a greater number of student in EOC sections (EOC: n = 97; PER: n = 64), more students failed to complete the course in PER. Thirteen students left PER (20.3%) whereas only 9 students (9.28%) dropped in EOC ($\chi^2 = 4.802$, $p = 0.028$). Based on the study of participation, the results suggest that a student's willingness to use a KRT device is the driving factor for success in a class using KRT. Working from this postulation, differences in student withdrawal rates between KRT users and non-users within KRT sections demonstrates a statistically significant relationship between students electing not to participate in KRT (CPS user/ non-user) and students dropping the course.

Thirteen of 34 non-CPS students failed to finish the course, as opposed to 10 of 128 CPS users ($\chi^2 = 20.411$, $p < 0.001$). Considering the significance shown in drop rates between PER and EOC sections as well as between CPS users and non-users, analysis of drop rates within timing sections between CPS users and non-users is also prudent. Table 5 shows the count of students who did or did not drop the course for each type of class section. Dividing the data in this manner reveals a significant relationship between failure to finish the course and CPS use in both EOC and PER sections (EOC: $\chi^2 = 9.364$, $p = 0.002$; PER: $\chi^2 = 13.902$, $p < 0.001$).

Insert Table (5) about here

Because failure to purchase a KRT device could easily be more indicative of a poor student rather than the KRT questions interfering with the students learning process, the magnitude of how the timing structure influences non-CPS students to drop must be isolated. Using Goodman and Kruskal tau to show reduction in error (RIE) of drop prediction when CPS use is known, EOC demonstrates a 9.7% RIE ($p = 0.002$) whereas PER shows a 21.7% RIE ($p < 0.001$). While both samples show significance, the magnitude of the interaction is not as great in EOC as in PER. Ultimately, PER question distribution appears to increase student withdrawal, most notably in students that failed to purchase the device. The relationship between withdrawal and lack of a device further suggests utilization of KRT is more important to success in a class with PER questions than a class using EOC.

Finally, the common assumption that as a person ages their inclination to use new technology may diminish was analyzed using the correlation between dropping the course and age. Controlling for GPA, age and withdrawal rate were correlated only in PER sections, albeit at 10% confidence level, showing a positive Pearson correlation coefficient of 0.198 ($p = 0.063$). The positive correlation between age and withdrawal rate in PER sections indicates as students increased in age the drop-out rate increases as well. Alternatively, EOC shows no significant correlation and the non-KRT sections suggest a negative correlation. This last analysis may tenuously suggest, assuming PER distribution is more dependent on novel technology, that as individuals grow older, they become less receptive to KRT being used in the classroom and subsequently withdraw from the course. However, that assumption certainly requires further research.

Discussion

The results of the study were surprising. Student assessment performance was not significantly affected by timing or the use of KRT in general. However, student withdrawal rate was significantly influenced by timing. Age was also found to be positively correlated with student withdrawal in PER sections. Of the students who did participate in KRT, their participation level was only positively correlated with assessment performance in the PER sections. EOC assessment performance demonstrated no significant relationship with participation level. Less surprising was the significantly lower performance among students not choosing to purchase a KRT device. Given the affordability of the device, $25 for the device and $15 to register for the course, and the bonus points available (again, not considered in assessment score analysis), failure to purchase the device is possibly more descriptive of the caliber of the student than the effectiveness of KRT.

Regarding the relationship between drop rate and timing, the significance may indicate several factors for student motivation to continue in the class. Using the pedagogical model of Cognitive Information Processing, perhaps the students in PER sections were experiencing knowledge reinforcement too soon, creating unproductive interruptions. However, if this was the case, a significant reduction in assessment performance in PER would be expected. Alternatively, in-class observation showed students in the EOC sections were more prone to engage other students during the question period. Having students discuss the questions may have further reinforced information gleaned during class time. The students' professor speculates that the questions asks sequentially allowed the students to become more receptive to discussion; although, once again, EOC should have shown statistically higher assessment scores than non-KRT sections. Conversely, if KRT has negative effects, the class discussion may have buoyed the student retention rate. Further research is required on this topic.

The significantly higher drop rate in PER timing section for non-CPS users may be relevant to the higher overall drop rate overall within PER sections. This may suggest PER is more technology centric than EOC. Recall that 70% of non-CPS users failed to complete the course in PER sections whereas only 25% of non-CPS users withdrew in EOC. Also, assessment performance was positively correlated with percent KRT participation only in PER sections. A relationship that remained when controlling for GPA, showing the effect existed apart from the students' historical performance. This suggests periodic timing causes KRT technology to become a more significant aspect of the class. Furthermore, age was also positively correlated with course withdrawal. Assuming as a person ages, they become less receptive of new technology, the positive correlation between age and class withdrawal seen in PER is also explained by PER question distribution making keypad response technology an integral part of the class.

While the withdrawal rate was not significantly lower than that of non-KRT in EOC sample sections, no correlation existed between KRT participation and assessment performance either. This again may suggest the use of KRT in EOC timing did not have any meaningful effect on the student's classroom experience, or that the conversation EOC appears to foster at the end of class offsets any negative impact of KRT. Using variations in question distribution for keypad response technology, the effects of each timing method have been demonstrated. Although PER can increase assessment performance with participation, it also increases attrition.

Alternatively, EOC seems to reduce the impact of KRT; it neither affects attrition, nor impacts assessment performance. At this time, it is impossible to determine if EOC simply marginalizes KRT or if the collaborative element it fostered during class compensated for the possible attrition causing elements of KRT seen in PER. Ultimately, the effect of using new vectors to convey accounting education can be substantial. This research suggests that as a novel technology becomes more prevalent in the class environment, students are more inclined to withdraw from the class. Furthermore, this effect is partially mediated by age, indicated by significant positive correlation between the age of the student and their tendency to drop the class. However, the more a student participated in the new technology (i.e. PER), the higher the student assessment scores.

Conclusion

PER distribution showed higher withdrawal rates, positively correlated with age. However, there was also a positive correlation between assessment performance and KRT participation only within the PER section. EOC distribution did not show any significant difference from the non-KRT control sections. It is unknown if this is due to this timing structure being an inefficient usage of KRT, or if the conversations between students during the questions offset the possible negative effects of KRT seen in PER. The analysis suggests that PER distribution makes the class more about KRT and less about the traditional elements of a classroom, such as lecture, based upon the student withdrawal rates. However, the results of this research did not show any impact on student assessment performance, either positive or negative, due to the use of KRT regardless of timing structure.

KRT has demonstrated its usefulness in numerous studies. This research attempted to analyze the effect of KRT in the accounting classroom, as well isolate the optimal means of question delivery during class time. Although effects were found in student withdrawal rates as well as level of participation in PER, no significant difference was seen in overall average student assessment performance between non-KRT, EOC, and PER sections. Ultimately, the choice of use and implementation of KRT is contingent upon the course material and the professor's individual teaching style. Some factors to consider would be age and perhaps the disposable income of the students, but in the end, it seems that regardless of the technology used, any student willing to put forth the effort is able to succeed. Even in a classroom heavy on keypad response technology.

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Table 1: Variable names and descriptions*

Variable Name	Description
Total Avg	Average performance for all assessments attempted for students completing final exam
KRT	Students in class section using KRT
non-KRT	Students in class section not using KRT
CPS	Student in KRT section who elected to purchase CPS device
non-CPS	Student in KRT section who did not elect to purchase CPS device
EOC	Students in KRT section receiving CPS questions at the end of class
PER	Students in KRT section receiving CPS question periodically throughout class
Male	Male students
Female	Female students
GPA	Students' prior average grade point average before entering introductory accounting

*Note: Variables may be combined to identify specific groups of students, i.e. “Male PER HGPA” represents male students in the KRT section receiving question periodically who have a historic GPA greater than or equal to 3.0.

Table 2: Key Values Used in Analysis

Class Section	*Average GPA*	*Average Assessment*	*Attrition (Drop) Rate*
KRT	2.84	58.06	13.7%
Non-KRT (Control)	2.96	62.73	4.4%
EOC	2.81	59.36	9.3%
PER	3.02	61.37	20.3%
Non-KRT (Control)	2.96	62.73	4.4%

Table 3: Other possible factors correlated with assessment score

	Average Score	*Age*	*GPA*	*Gender*
Average Score	-			
Age	0.045	-		
GPA	0.311***	-0.192***	-	
Gender	-0.031	-0.104	0.223***	-

**Note: categorical variable “Gender” was coded 0 for males and 1 for females.*

Table 4: Average KRT user assessment scores by question distribution

Distribution		*Average Score*	*Age*	*GPA*	*Part. %*
All Users	*Average Score*	-			
	Age	0.063	-		
	GPA	0.235***	-0.168**	-	
	Participation %	0.235***	0.073	0.282***	-
EOC	*Average Score*	-			
	Age	0.296	-		
	GPA	0.296***	-0.176*	-	
	Participation %	0.138	0.161*	0.235**	-
PER	*Average Score*	-			
	Age	0.061	-		
	GPA	0.310**	-0.144	-	
	Participation %	0.417***	-0.178	0.292**	-

* p< 0.100, ** p < 0.050, *** p < 0.010

Table 5: Count of student withdrawal in respect to CPS participation and question distribution

Distribution		*non-CPS*	*CPS*	*Total*
EOC	*non-drop*	18	70	88
	drop	6	3	9
	total	24	73	97
PER	*non-drop*	3	48	51
	drop	6	7	13
	total	9	55	64

Figure 1: Regression between KRT participation and assessment performance by timing distribution