USING RFID TECHNOLOGY TO TRACK ATTENDANCE

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Abstract

The relationship between class attendance and academic performance continues to be of interest. The most common methods of tracking attendance, however, have their shortcomings and biases. We provide researchers with a method to collect unbiased and reliable attendance data. Late arrivals and early departures can also be recorded with ease, allowing researchers to evaluate these behaviors as well. Our method is intended to collect valuable attendance data at a minimal cost of time or money: setup takes 10-20 seconds per student initially, with no time lost subsequently, and the monetary cost is less than 29¢ for each student. An Excel-based version is discussed. Software code is provided, open-source, for instructors to implement.

Key Words: Electronic attendance, RFID, education

JEL Classification: A2

Introduction

Research on the relationship between attendance and academic performance requires data. Traditional methods of data collection include roll calling, circulating a sign sheet, assigning specific seats to students, and clicker systems. Calling roll is time consuming and may not be optimal for larger classes. Circulating a sign sheet is open to bias since friends may sign for each other. Assigning specific seats may not be pleasing to the students. Finally, clickers are expensive and multiple clickers can be carried by students. Every researcher comes across intriguing questions in their lifetime that cannot be answered due to lack of data. We suggest that the question of attendance-performance is an area that could advance with more reliable data. Our contribution to the existing literature may not answer a specific question or test a hypothesis. However, we provide a foundation for more research on the attendance/ performance question via a reliable and extended data collection method. That is, we answer a need rather than answer a question.

In this study, we provide a radio frequency identification (RFID) based electronic attendance system to solve the data collection problem. The system is implemented with a $20 RFID reader, 29¢ RFID key fob for each student and an Excel macro. The system does not require institution-wide support and can be implemented at the instructors' own initiative. This voluntary system can also track late arrivals and early departures: valuable data that are not easily available with traditional attendance tracking methods.

There is also a second benefit, perhaps appealing to a wider audience, of the suggested electronic attendance system: tracking attendance in large, or even medium sized, classes can be very costly in terms of effort and class time. Thus, many professors choose to forgo taking roll. It is important, however, to follow students' attendance. In fact, the ability to automatically notify

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students of their attendance habits could contribute to their presence in class. There are other reasons to keep records of attendance. For instance, many universities require it for athletic participation. Furthermore, US Federal law requires that instructors take attendance in order to verify that students are not fraudulently using student-loans.

Northern Arizona University (NAU) has implemented an eighty five thousand dollar electronic attendance system to improve student attendance and retention rates (Kraker, 2010). Ryman (2010) reports that the NAU system uses sensitive readers that do not require the IDs to be removed from students' wallets. This feature creates tension with the student body for fear of invasion of privacy. The concern is the potential surveillance of students' every movement through readers placed around campus. Thus far, unlike NAU, we have never had a complaint about our electronic attendance system. Instead, our university's student run newspaper published an article about this "beneficial" technology with a "fruitful future", commending the implementation of the new system. (The citation is suppressed to ensure anonymity during the review process).

In this study, we initially provide a brief literature review about the benefits of classroom attendance. The system is explained in detail within the subsequent section. This is followed by the results of a student questionnaire. Concluding remarks are provided with the final section. The survey questionnaire is provided as part of the appendix, as are some comments from other professors who helped pilot our attendance system.

Literature Review

The correlation between attendance and performance seems now to be beyond dispute.[3] The question of causation is still being investigated. One possibility is that when students attend class, they learn more, and therefore earn higher grades. Another possibility is that good students tend to get better grades, but that they also tend to come to class. That is, the relevant variable is the students' unobserved characteristic--their seriousness of purpose, for example. As it is an unobserved confounding variable, its impact becomes reflected in the regression parameters of the variables with which it is correlated.

Most recent studies attempt to control for student unobservables. Some, such as Romer (1993), do so by including variables that are correlated with student attitudes. Others, such as Davedoss and Foltz (1996), estimate a two-stage IV model. Still others estimate panel models (ex. Rodgers, 2001; Stanca, 2006).

One of the best-structured studies of attendance/performance is by Marburger (2001). He considers that it is unlikely that smartness varies with the type of economics question that students answer correctly. Marburger kept track of each lecture topic for each day. He then checked to see whether students were more likely to miss questions related to that topic when they missed that particular lecture. Even after controlling for additional student fixed-effects, he found that this was, indeed the case: attending lecture makes one more familiar with the material, and therefore more likely to correctly answer questions about that material.

Marburger (2006) builds on his earlier (2001) study to examine the effect of mandating attendance. Marburger (2006) finds that students are more likely to answer questions related to material that was discussed on days they attended. Marburger finds that sections that have mandatory attendance policies, and those that do not, have similar attendance rates at first, but

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[3] See, for example, Bratti and Staffolani (2002); Chan *et al*. (1997); Davedoss and Foltz (1996); Durden and Ellis (1995); Moore (2003); Moore *et al*. (2003); Rodgers (2001); Romer (1993); Schmidt (1983); Stanca (2006) all of who find that there is a statistically significant relationship between attendance and grades.

these rates tend to diverge dramatically as the semester progresses. The implication is that the policy increases attendance, and that attendance increases performance.

Attendance is also an important issue for on-line lectures, especially for those that involve multi-campus teaching. With the advancements in technology, the experiment described by Freeman (1998) for multi-campus video conferencing is now common. The attendance tracking of the 330 students in Freeman (1998) experiment would have been costly using traditional methods. Our suggested system, however, simplifies the process and enables off-site attendance tracking.

Overview

The consensus among scholars is that attendance is positively correlated with higher grades, and that there may be a causal connection running from attendance to performance.

We developed an automated attendance tracking system using RFID technology. It is, in effect, a magnetic barcode. The RFID tags that we use are little chips, approximately the size of a US quarter, which fit onto a keychain. The RFID scanner is about the size of a deck of playing cards. Each student is given the option of participating in the system. If they do not wish to participate, or if they forget their RFID one day, they have the option of signing in on a sheet of paper.

At the beginning of the semester, each student chooses an RFID tag. The instructor then registers each tag's 10-digit id code with the student's name. Once this is done, each time the student taps his RFID tag onto the reader, the reader emits a "beep" and sends the 10-digit code to a database which records the id-code and the precise date and time that the person beeped in. This is stored as text, which is exportable to any statistical software. Once there, the data can easily be sorted by name, id, date, or time. Thus, we can easily see how many times a student has "beeped in" during the semester, generate a list of all the students who "beeped in" on a particular date or create a list of students who habitually arrive late or depart early.

How the Attendance System Works
Hardware

The necessary hardware for this system is inexpensive and easily obtainable on-line. (We have used eBay, as well as several other vendors.) We use a USB 125Khz RFID proximity reader. The reader connects via USB to any computer, and is the size of a deck of playing cards. The tags we used were 125Khz RFID Proximity ID Keyfobs (tokens or key tags). These fit nicely on a keychain and are the size of a quarter. In general, the weaker the signal, the closer the tags must be to the reader for the tags to be "read." The weakness of the signal ensures that students are not tracked around campus, and thereby increases their willingness to participate. You can currently buy the tags for as little as 29¢ and the reader for less than $20.

The 125Khz system was chosen because it is easily obtainable, relatively cheap, and relatively weak. This means that students must approach the podium, where the scanner is located, to beep in. In this way, it is more obvious to the professor if a student tries to beep in twice (once themselves and once for a friend). Moreover, the fact that it is a relatively weak signal means that students need not worry that all their movements are being tracked across campus. (As mentioned earlier, Northern Arizona University tried implementing a high powered RFID system with multiple scanners that could track students throughout campus. This was a very controversial program which generated a lot of resentment among the student body.) Since

our goal is simply to keep track of attendance in our particular classes, a weak 125Khz system is strong enough for our purposes, but not so strong that it invades students' privacy

Software

The suggested electronic attendance system is based on a set of Excel macros. It is important to note that the RFID reader we are suggesting reads the RFID keyfobs as keyboard entries. Therefore, whenever the keyfob is within the proximity of the RFID reader, 10-digit code (and return character at the end) on the keyfob is sent to the computer as if it is a keyboard entry. This means that the instructors can take RFID attendance on a simple text editor, such as Windows Notepad. However, there would be no date or time stamp. The provided Excel macros are a simple way to read the keyfobs via the RFID reader and provide a date and time stamp for each attendance entry. The Excel macros are provided as a suggestion and instructors can write their code using any programming language. The Excel Macro-Spreadsheet can be obtained from the authors.[4]

Registering students

When the instructor first opens the Excel file, they see something like Figure 1, but without any names or RFID numbers in the "Students" worksheet. The instructor then has to register each student to an RFID number. Simply enter the student's name in column A, and the id-number in column B. Rather than typing the number, the instructor can simply place the cursor in the appropriate cell in column B and then scan the RFID tag. Scanning is accomplished by placing the RFID tag within an inch of the reader. The RFID reader will automatically enter the 10-digit RFID number into the cell. Registration takes approximately 10-20 seconds per student. If, in the course of the semester, a student loses or breaks their RFID tag, the instructor can simply replace the old number with the new one in the "Students" worksheet.

Figure 1: Screen shot of taking attendance.
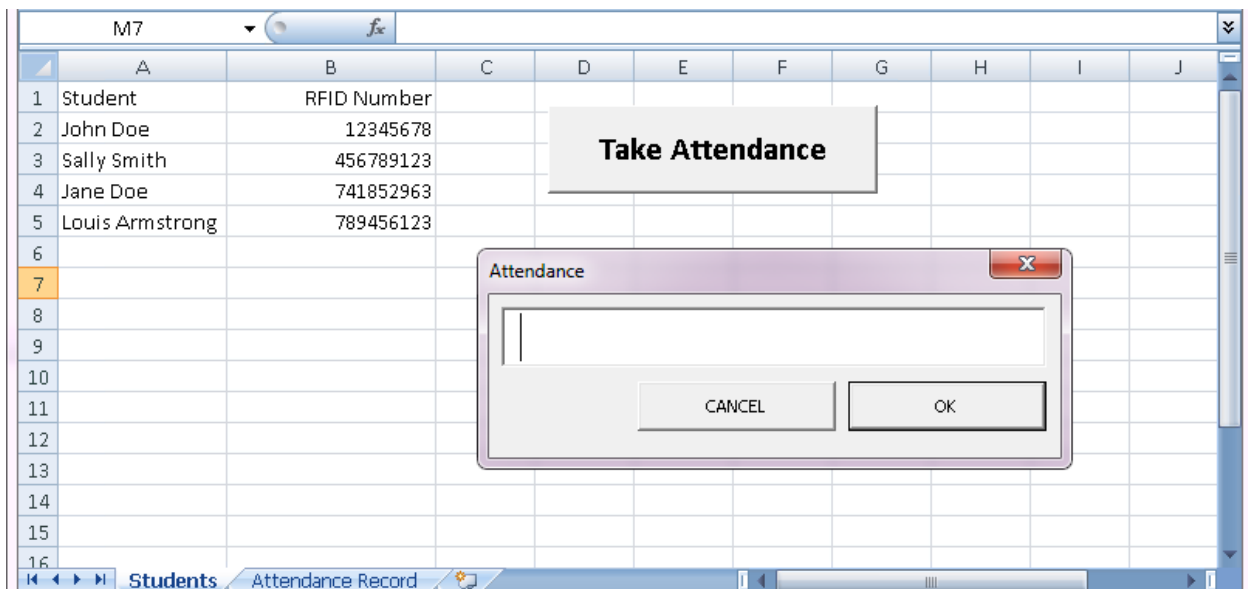
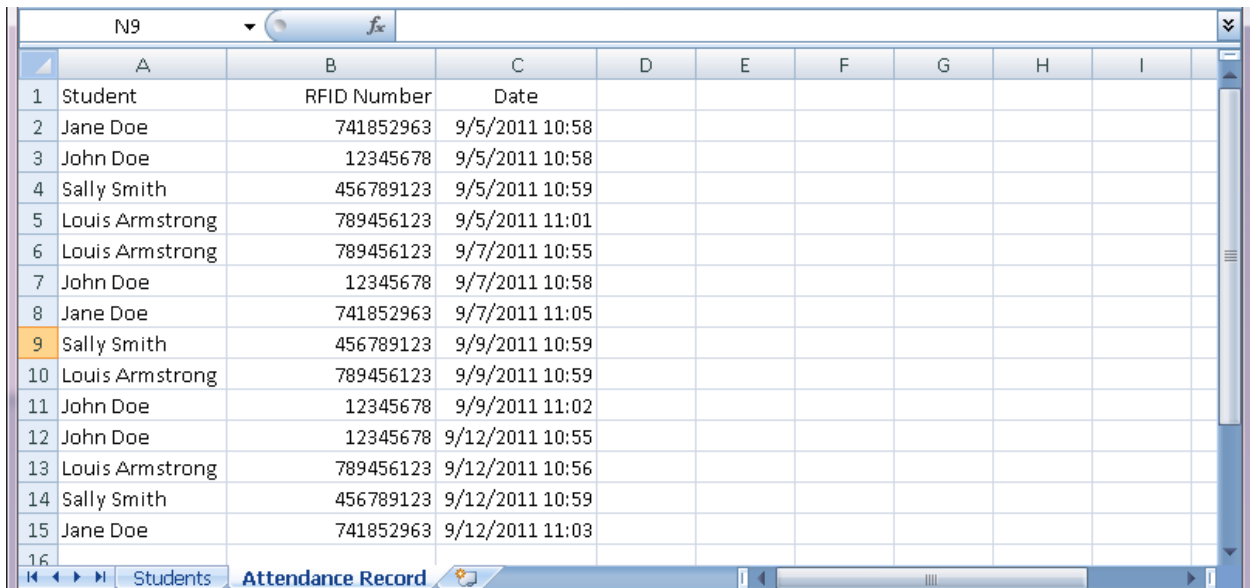[4] The URL is suppressed to ensure anonymity during the review process.

Tracking attendance

In order to take attendance, simply click on the "Take Attendance" button, and the "Attendance" dialogue box pops up. (The cursor is automatically inserted into the window, but be sure not to click the mouse outside this window when taking attendance.) Once the cursor is positioned in the "Attendance" dialogue box, the process is automatic. The student only needs to "beep in" at the beginning of every class session for their attendance to be tracked.

When a student "beeps in", the date and time of the beep, as well as the student's name are recorded on the second worksheet in Excel, the worksheet entitled "Attendance Record." On that worksheet, you will see something like Figure 2, a list showing the students' name, RFID numbers, and the times they scanned their RFID tags. Given that these attendance data are already in Excel, it is easy to sort by date to get a list of students who attended on a particular day, or to sort by name, to see which classes a particular student attended.

What prevents a student from scanning in their friends? The system reads only one RFID tag every three seconds. If you wanted to scan yourself and your friend in, there would be a long awkward pause in front of the podium as you waited three seconds for the scanner to reset. Unlike if you were signing two names on a sheet, you'd be pretty conspicuous.

Figure 2: Screen shot of attendance records.

Performance

Given the digital nature of the attendance system, it is easy to correlate student attendance with their grades. In Table 1 we provide the results of a linear regression of each student's final class grade on the percent of classes attended. To be clear, attendance, itself, was never graded; it was simply monitored.

Table 1: Student Attendance and Grades

	Grade (on a 4.0 scale)
Attendance pct	0.72***
	(0.000)
Fall 2011	-0.57***
	(0.000)
Fall 2012	0.28**
	(0.016)
Constant	2.42***
	(0.000)
Observations	377
R-squared	0.137

p-values are in parentheses. * significant at 10%;
** significant at 5%; *** significant at
1%
The dependent variable is the student's grade,
calculated on a 4.0 scale.
Attendance is measured continuously from 0 to 1.

Questionnaires

We asked students in several sections to complete a questionnaire on the RFID system. (See Appendix for a copy of the questionnaire.) Of the 234 students enrolled, 172 students were present on the last day of class and responded to the questionnaire. Of those 172 students, 159 (92%) were RFID users. (See Table 2.) Of the RFID users, when asked why they chose to use one, the most common response was some version of "Because it was easy." In fact, the word "easy" showed up in 47% of the responses.

Table 2: Did you use the RFID system?

Response	Frequency	Percent
No	13	7.56
Yes	159	92.44
Total	172	100.00

Students were then asked whether they liked the RFID system. (See Table 3) The allowable answers were "no," "low," "neutral," "ok," and "yes." The results were heavily skewed toward the positive responses "ok" and "yes." In fact, only one student answered "no" or "low." When asked "why", again the most common response was that it was "easy." Thirty-two percent of RFID users' answers included the word "easy."

Table 3: Did you like the RFID system?

Response	Frequency	Percent
No	1	0.63

Low	0	0.00
Neutral	10	6.29
OK	19	11.95
Yes	129	81.13
Total	159	100.00

We then asked the students whether the RFID system encouraged them to change their attendance habits. Allowable answers were: "no," "not much," "somewhat," and "yes." (See Table 4.) One-third of students indicated that the electronic attendance system changed their attendance.

Table 4: Did your attendance habits change because of the RFID system?

Response	Frequency	Percent
No	85	53.80
Not much	23	14.56
Somewhat	34	21.52
Yes	16	10.13
Total	158	100.00

Finally, we asked whether students would suggest adopting the RFID system in other courses? Allowable answers were "no," and "yes." (See Table 5.) One hundred and fifty-five of the 159 students (97.5%) indicated that they would suggest using this technology in other classes. In fact, of the thirteen students who chose not to use the RFID system, only two said they would not recommend the system; two were neutral; and nine indicated that they would suggest the RFID system to other classes. In followup discussions with some of the students who chose not to participate, the consensus was that it seemed invasive, with one student likening it to a "lo jack." This was not the common opinion of the majority of the class, however.

Table 5: Would you suggest the RFID system?

Response	Frequency	Percent
No	4	2.52
Yes	155	97.48
Total	159	100.00

It is our belief that merely taking roll encourages attendance, which in turn can boost learning. This is clearly fodder for future research—research made easier with our electronic tracking system.

Concluding Remarks

The technology that we use is called Radio Frequency Identification, or RFID. It is similar in concept to a barcode. Each student is given an RFID tag, which is the size of a quarter and fits easily on a keychain. Each RFID tag has a magnetic signature which corresponds to a

10-digit ID number. When the tag is placed within one inch of an RFID scanner, the scanner "reads" the number, beeps, and makes note of the 10-digit number, and the time and date when it was scanned. This is not GPS. It doesn't track a student's movement around campus. It only makes a note of the instant that the tag was voluntarily placed within one inch of the reader.

Registering an RFID tag to a student takes between ten to twenty seconds per student. After this, the system runs itself and takes no class time at all. The number of students who opt out has been very low, so we don't have to keep track of many signatures, names, and attendance sheets.

The RFID technology has some advantages and disadvantages relative to the increasingly popular "clicker" technology. It is not unusual for instructors to require the expensive clickers, while using them only for attendance. The RFID tags we use retail for approximately 29¢. On the other hand, these tags are not interactive: they can't answer multiple choice questions. They do one thing, but they do it well and without controversy: they are simply for attendance management.

Most importantly, the RFID attendance system provides reliable and unbiased attendance data which includes time of arrival or time of departure. This is important for future research on the attendance/performance relationship.

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Appendix: Questionnaire

This survey is about the RFID electronic attendance system developed by Drs. XXXX and YYYYY. Your response will be used in an academic research article to present and to discuss the system.

Did you prefer to have an RFID tag?
No   Yes
Why or why not?

Did you like the electronic attendance system?
No   Low   Neutral   OK   Yes
Why or why not?

Did your attendance habits change because of the electronic attendance system?
No   Not much   Somewhat   Yes
Why or why not?

Would you suggest adopting the electronic attendance system in other courses?
No   Yes
Why or why not?

Appedix: Comments From Peers

In the course of development, our electronic attendance system was used by some of our peers. They generously agreed to provide comments regarding their experiences with the system.

"The system is inexpensive, easy to implement, and makes use of a technology that many businesses including Wal-Mart are trying to introduce in their operations. We feel that you have done an excellent piece of work in bringing this technology to fruition." (Kamal Hingorani, Ph.D., Alabama State University)

"I use the system to take attendance for all my classes. Students are issued RFID cards for a fee of $1.00, fully refundable upon returning the card at the end of the semester or upon dropping the course. Students appear to like the system and I think attendance has been great, mostly due to the system. Timed check-in allows for coding such as on-time, tardy, very tardy, and absent. There have been no complaints from students. The system forces me to get to class about 10 minutes early for the 5-minute set-up and to facilitate check-in before actual class time. It is practical, time-saving, and it allows me to provide uncontested attendance data to administrators when necessary. Thank you for thinking about it and for sharing your knowledge." (Kwesi Aggrey, Ph.D., North Carolina Central University)

"Enhances accountability and frees the professor for more meaningful between-class and beginning-of-class interactions. I was surprised but my (non-business, this semester) students overwhelmingly embraced the novelty of the RFID cards." (William W. Jennings, US Air Force Academy)