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Please Play with your Phones – Using Student-Owned Personal Electronics to Enhance In Class Activities

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Smartphones, laptops, and tablets are ubiquitous among students of the current generation. Although there has been a movement toward using individual students' electronics in K-12 settings, or requiring students to purchase particular devices, there has been little work on harnessing the array of personal electronics already carried by the typical college student. This work discusses the use of students' existing personal electronics as tools to enhance in-class cooperative learning activities. The course in question is a junior level course in Measurement and Analysis. Initially only calculators were allowed in class, and the use of phones and other personal electronics forbidden. In subsequent course offerings, students were allowed to use tablets to take notes in conjunction with PowerPoint lectures posted on the course website. Most recently, students have been encouraged to use programs such as Notability to take notes, and are also given in-class activities in statistics, graphing, and other data analysis tasks that are best done on a laptop. Additionally, 'mini-experiments' involving downloaded measurement applications, such as accelerometer data recorders, have been used to provide students with the opportunity to do real time measurement inside and outside of class. The result has been increased engagement in class discussions and improved scores on certain in-class activities. In addition, increasing numbers of students are using smart devices in independent projects. Although the risk of student distraction is still present, there seems to be evidence that encouraging the use of these devices for specific tasks can aid student learning and increase interest in classroom topics, without infrastructure expenditures by the college. In addition to managing distraction, careful thought must also be given to providing equal opportunities for learning to students who have a wide variety of devices, or who lack smart devices of their own. Through careful design of activities and encouraging collaboration between students, these drawbacks can be managed.

Introduction

Education at all levels is being impacted by student owned electronics. On the K-12 level, several large school districts are starting to develop 'Bring your own technology' or BYOT initiatives as a way of avoiding costs associated with providing students with school owned computers. At the K-12 level, this tends to mean directing students to apps or websites that students can use to do research, practice drills of key concepts, and communicate with teachers and fellow students.[i]

At the higher education level there have also been a number of studies on strategies to bring students' devices into the arsenal of learning tools.[ii] The EDUCAUSE Center for Applied Research recently completed an extensive report on important BYOE (bring your own everything) IT issues in higher education and recommended practices for managing these issues.[iii] They concluded that device proliferation is growing at a "manic" pace, and that while it is manageable with proper IT supports, thought needs to be given on how best to harness this new force. Their data indicates that 15% of undergraduates own some sort of tablet device, while 62% of undergraduates own a smartphone. They further discuss the importance of creating a learning environment that is "mobile-friendly" which can tap into what students already do with their devices. According to this study, individual faculty members are by and large responsible for allowing or disallowing mobile devices in their classrooms, and there are few wide ranging institutional rules about the use of these individual devices.

Alongside the voices calling for more use of students' own electronics, there have been studies which have shown that students' learning is impacted by their use of electronics for non-class activities during class. Whalen et.al. demonstrated that students in a freshman engineering course performed worse on content retention tasks when distracted by their own personal electronics.[iv] This study points out the need for clear rules by which personal electronics are incorporated into class activities and the need for highly structured activities which use the electronics as tools rather than allowing them to be distractions.

The benefits of active and cooperative learning are well known.[v] The central tenets of positive interdependence, face to face promotive interaction, individual accountability, social skills, and group processing have been used in numerous situations to enhance both learning and student engagement. A number of works have focused on computer supported cooperative learning (CSCL).[vi,vii] Topics that are difficult for students to learn, such as statistics, have been shown to benefit from a combination of cooperative techniques and computer based feedback.[viii] Historically, the focus of these works has been on e-learning, typically defined as on line and/or distance learning. However, BYOE initiatives tend to fall under the umbrella of mobile learning or m-learning. M-learning is different in that it can be used for both distance and in-class learning, and assumes easy access to online tools and content.[ix] Although this type of learning is characterized as more private and less collaborative by some sources, it can be used for cooperative activities if those activities are properly designed.

BYOD in the Measurements and Analysis Course

Measurements and Analysis with Thermal Science Application is a required junior level course for mechanical engineers at Northeastern University. The course consists of three lectures and one lab section per week. It covers topics such as statistical data analysis, experimental design, and measurement of engineering quantities such as pressure, temperature, strain, fluid flow, and heat transfer. Seven lab experiments are performed in teams of 3-4 students during the course of the term. Each team is also required to do a term project in which they design, execute, and report on a measurement experiment of their choosing. These projects have ranged from measurements of the dampening properties of various bicycles, to the heat transfer in coffee mugs, to the sound levels in local campus study spots. Students may either perform experiments during open lab times, check out equipment to perform off-campus experiments, or use their own equipment to make their measurements.

This course has been taught by the author since Fall 2010. The course has always used active lecturing techniques, but prior to Fall 2011the in class activities did not form part of the grade. Typically, each lecture has either a discussion question, problems worked individually or in groups, or a short, low stakes quiz. More extensive activities include demonstrations of lab equipment, or measurement activities that allow students to get hands on experience with measurement equipment. As of Fall 2011 all of these in-class activities are graded, and the in-class participation grade makes up 20% of the final grade. Individual activities and more difficult computational problems are weighted more heavily than simple discussion questions.

At first the policy on electronics in the lecture section was ‘nothing but calculators’. This was in response to numerous situations in which students were busy texting or surfing the web instead of being engaged with the class material. In Fall 2011 new labs and activities were introduced.[x] One key change was that a Data Analysis lab activity was moved into the classroom in order to demonstrate statistics concepts. It became evident quickly that requiring students to solve statistics problems in class using calculators was tedious and error-prone. For subsequent terms, students were encouraged to bring in laptops for this activity. Since the activity was a group activity, one laptop per group was generally sufficient, and students without laptops were asked to partner with those who did.

The PowerPoint slides for the lectures have always been posted on the course management system. The author noticed that in the last few years more and more students are using tablet devices to annotate the slides as part of their note taking. After several students demonstrated the usefulness of this technique, it became a standard feature of the opening lecture to encourage electronic note taking if the students desired it. Students who had the tablets for note taking started using them to look up constants during group assignments, and otherwise find outside references in order to improve their understanding. It was this student-led use of these devices that led to the current study.

Another way in which electronics have been incorporated into the class is through hands on mini-experiments. Purchasing accelerometers for experimentation is expensive, and typically requires programming that students may not have been exposed to at the time they take Measurements and Analysis. However, every smart device contains an accelerometer, and accelerometer apps can be found for free that log the data from the onboard accelerometer. As part of learning about these sensors, students were asked to use their smartphone to track five minutes of their commute to class, graph the data, and comment on what the data indicated. Students who did not own a smart device could borrow an iPad from the instructor, or have sample data emailed to them by the instructor. For the two terms in which this activity has appeared so far, only 2-3 students per term have needed to get sample data from the instructor. In addition, several student groups used smartphone accelerometer apps to gather data for their term projects.

It is important to emphasize that no particular device is required for this class. The university does have a very good wireless network accessible from all classrooms. Use of the Blackboard course management system is required for all instructors, but otherwise there is no particular university requirement for the use of electronics in the classroom. The current study does not seek to determine the efficacy of any particular device. Rather, the central questions are 1) What types of devices do students in Measurements in Analysis own? 2) What are their attitudes toward the use of electronics during in-class activities? and 3) Is there a measurable effect on student outcomes as a result of electronics-enhanced cooperative in-class activities?

Methods

The students in the Fall 2013 offering of ME4505 Measurements and Analysis were surveyed to determine which devices they owned, as well as attitudes about electronic devices and learning. This survey was administered midway through the course. The survey can be found in Appendix A. Students were asked which devices they owned choosing from among iPhones, other smartphones, iPads, Windows Surface tablets, other tablets, and laptops. Students were also asked whether or not they used electronic devices for note taking, and to explain why or why not. Finally, students were asked to rank their agreement with a number of statements, shown in Table 1, on a five point Likert scale.

Table 1: Survey questions to determine students' attitudes toward electronics and learning.

Questions
Electronic devices are a helpful learning tool in the classroom
Electronic devices are a distraction in the classroom
I like being able to use Excel for in-class activities
In class activities using electronics help me learn
Electronic devices help me stay engaged in the course material.
I would like to see more activities that incorporate my personal electronics.
I think the use of personal electronics is unfair for those who lack specific devices.

In addition, average in-class grades for each term were examined for trends. In-class grades were calculated after removing students who had dropped the course mid-term. Any optional or extra credit activities were also removed from consideration. Although minor details were changed, the same concepts were covered in the in-class activities each term. The principle changes made in the electronics based activities were to either add difficulty, or to provide less information that the students were required to find. Despite these additions, the assignments were similar enough in form and concepts covered to form a basis for comparison before and after electronics were encouraged.

As a final measure, the average number of student absences per term was calculated. Early offerings of this course had difficulties with high student absenteeism, although the exact attendance was not tracked for Fall 2010 and Spring 2011. Tracking the attendance as the in-class activities become more involved and interactive may give an additional indication of student engagement in the course.

Results of Student Survey

Figure 1 shows the percentage of students who reported owning each kind of device. There were 69 respondents to the survey. Of the respondents, every one owned at least one of the devices mentioned. Only two students, or 3%, did not report owning a laptop. In addition, only 6% of the students do not own a smartphone of some type, with iPhones being the most popular. Tablet devices such as iPad, Windows Surface, and other tablets were owned by 37% of the students, with iPads being the most popular. Given this data, it seems that gearing in-class use of devices towards smartphones and laptop computers would allow the majority of students to use currently existing devices without having to purchase something special for the class.

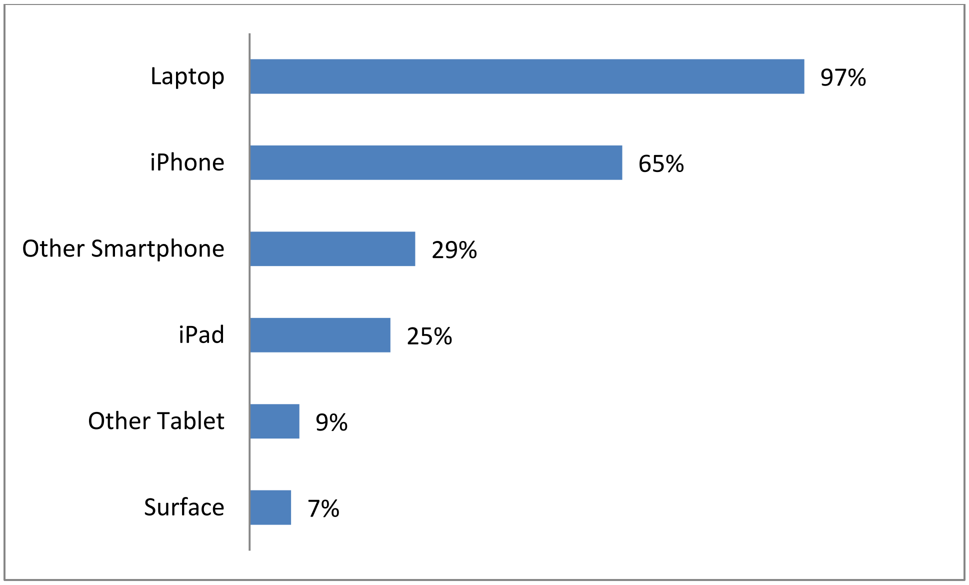
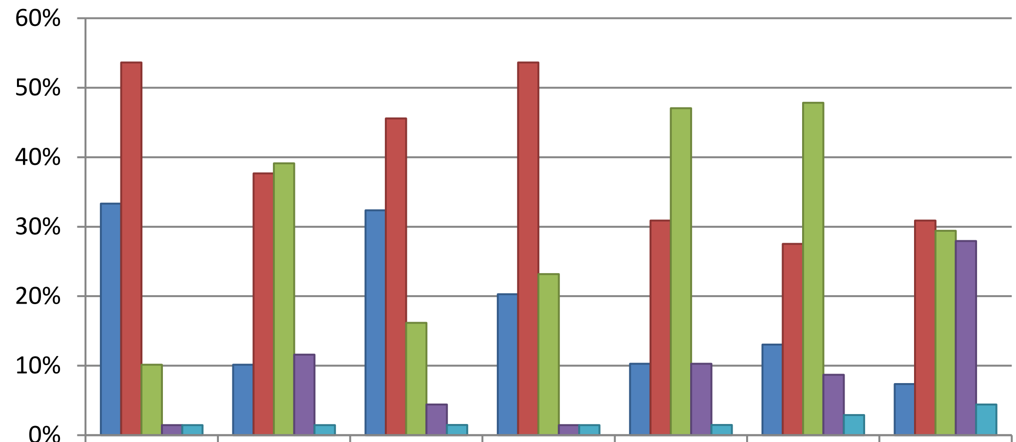


Figure 1: Percentage of respondents who own various devices. Note that most students own multiple devices.

In answer to the open-ended question about electronic note taking, 71% of the respondents indicated that they did not use electronic devices to take notes. Typical reasons for not taking notes electronically included the need to constantly charge devices, the difficulty in writing equations, or the poor quality of handwriting recognition in certain devices. Other students found they retained more information when they wrote things on paper. Of the 29% who did report regularly taking notes electronically, some were extremely enthusiastic. Often they cited their preference for carrying one tablet versus five notebooks, or the fact that they were less likely to lose things. In general, electronic note taking tended to be more preference based, rather than based on the technology per se.

Figure 2 shows the aggregate survey results. Student agreement with the statements "Electronic devices are a helpful learning tool in the classroom" and "Electronic devices are a distraction in the classroom" are shown in the first two columns. It can be noted that a majority of the students agree or strongly agree that electronics are a valuable learning tool. Slightly less than half of the students agree that electronics are a distraction in the classroom. Of the remaining students, most of them are neutral about the distraction of electronics.



	Electronic Devices helpful learning tool	Electronic Devices distraction	Like Excel for inclass	Electronics help me learn	Electronics help me stay engaged	Want more electronics	Unfair for those who lack devices
%Strongly Agree	33%	10%	32%	20%	10%	13%	7%
%Agree	54%	38%	46%	54%	31%	28%	31%
%Neutral	10%	39%	16%	23%	47%	48%	29%
%Disagree	1%	12%	4%	1%	10%	9%	28%
%Strongly Disagree	1%	1%	1%	1%	1%	3%	4%

Figure 2: Aggregate survey results showing student attitudes toward electronics in the classroom.

The next three questions explored students' views about their learning and engagement in the class activities in relationship to the use of electronics. In response to the question "I like being able to use Excel for in-class activities", only 6% of the students disagreed or strongly disagreed with this statement. The statement "In class activities using electronics help me learn" probed the students' feelings about these activities in general, as opposed to specifically using a particular software application such as Excel. Students seemed favorably disposed to these types of activities, with only 2% disagreeing or strongly disagreeing. Interestingly, students agreed much less with the statement, "Electronic devices help me stay engaged in the course material", although the majority of the students were neutral about this.

The final two statements tried to gauge whether students thought these types of activities were worth continuing in the future. The largest percentage of students was neutral about wanting to see more of these types of activities. It is acknowledged that this question was somewhat vague – examples of specific activities might have elicited a more favorable response. The final question addressed a common concern about BYOE activities, namely whether it is fair to include these activities when not all students may own such devices. The responses show a fairly even split between those who agree with the statement, those who disagree, and those who are neutral.

Results of grade study

Figure 3 shows the change in the average in-class participation grade over time. The participation grade is determined by the percentage of total possible in-class points earned. This grade combines individual quizzes, individual computational problems, group computational problems, and group open ended discussions. In Fall 2011 the labs were changed and graded in-class activities were introduced, however electronics other than calculators were not allowed. During Spring 2012 and Fall 2012, electronics were allowed, but not particularly encouraged. Starting in Spring 2013, electronics for note taking and certain in-class activities were actively encouraged. The number of in-class activities designed to involve user electronics was increased further in Fall 2013.

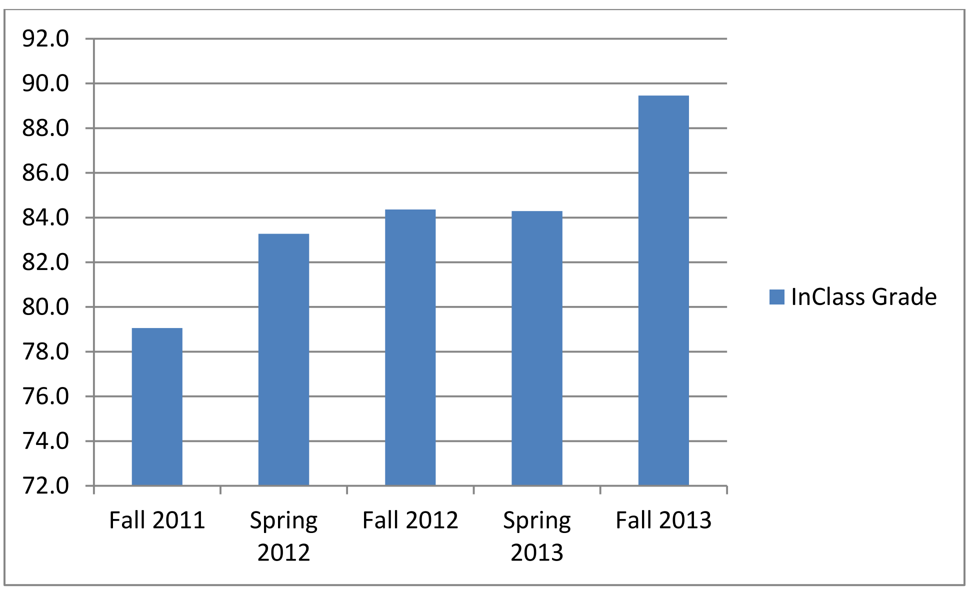


Figure 3: Average final in-class participation grade percentage

The average number of absences per student is shown in Figure 4. In all the terms shown participation during in-class activities made up 20% of the final course grade. This calculation does not include students who withdrew from the course. It should also be noted that students who were absent for a legitimate reason were allowed to make up in-class quizzes and numerical calculation problems.

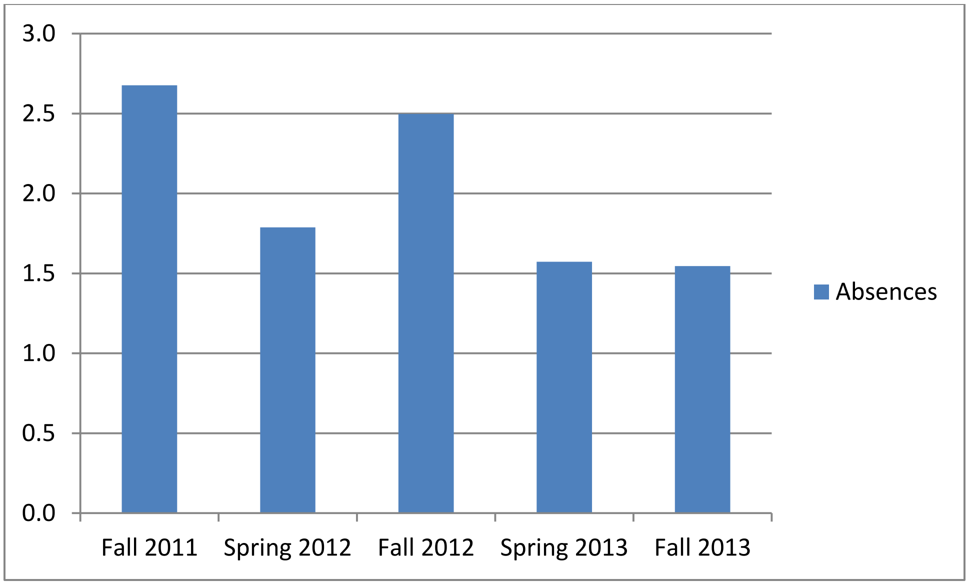


Figure 4: Average number of absences per student.

Figure 5 shows the average grades on the data analysis quiz that is given every term immediately following the lectures on statistical data analysis. This 10 point quiz is unannounced, and is taken by the students individually. Books and notes are allowed, and laptops running excel are permitted for calculating statistical quantities, provided the equations and methods are clearly explained. The use of Excel was not permitted in the first two terms, but was allowed, and then encouraged as time went on. The same quiz and quiz format was used every term, with sufficient changes to prevent students from obtaining the answers from previous students.

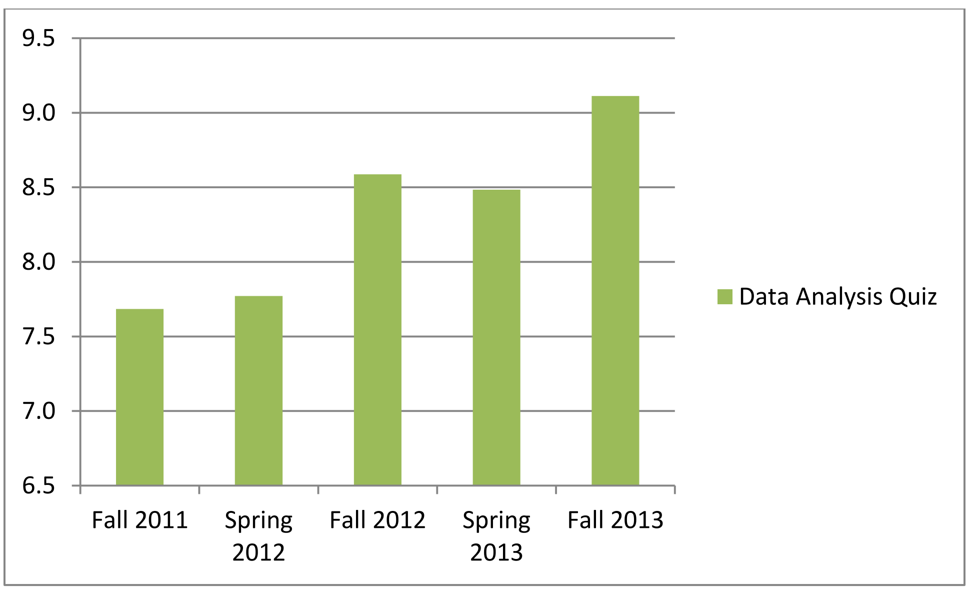


Figure 5: Average grade on individual data analysis quiz. The quiz is worth 10 points total.

Discussion

The survey of student electronics ownership showed that for this particular student population, laptops and smartphones were ubiquitous. The report from EDUCAUSE found that 15% of their surveyed undergraduate population had tablet devices, compared to 33% in this course. In addition, 94% of the students in Measurements and Analysis had a smartphone, compared to 62% in the EDUCAUSE study.[iii] In addition, 97% of the students in Measurements owned a laptop, and no students reported owning none of the devices. This may be due to the fact that this is a private institution, rather than a public institution, and students are likely to be of a higher economic class. Whatever the reason, the results speak to the fact that designing in-class activities using the students' own devices should not be difficult. Although students have to be prompted or reminded to bring laptops in some cases, it was observed that tablets and smartphones are carried almost constantly by those who own them, allowing for both planned and spontaneous activities.

Students find that the devices are helpful and do not see them as a classroom distraction. However, many professors are understandably concerned about students texting in class, surfing the web, or otherwise disengaging with the course material. Although no data was taken on this, the author has noted that the number of students who are distracted or disengaged in a particular lecture is not very different than it was when electronics were forbidden. Then students who were bored in class would doze, or draw, or work on homework for other classes when not engaged. If the in-class activities are frequent enough and well structured, the students engaged with them. When a difficult computational problem was given to the class, all students worked on it in their groups. Typically one person would be scribing the answer, one would be plugging numbers into Excel, and a third might be looking through the electronic copy of the notes to make sure they were using the correct equation or looking up a constant online. The electronics allowed them to tackle harder problems and split up the work, rather than giving them something to do other than the in-class work.

A number of activities were decidedly enhanced by the addition of internet resources. One example was the calculation of theoretical strain in the strain measurement unit. Before electronics were allowed, so much information had to be given to the students that the problem tended to become a relatively simple 'plug and chug' type of problem. Once every group had at least one person with an internet connection, the problem could be reframed as, "You studied something like this in Mechanics of Materials. If you can't remember how this works, try looking it up online." This often led to considerable discussion among the students as they tried to remember their past courses, debated the merits of various online sources, and checked with each other and with the instructor about whether a particular approach made sense. Another good use of technology was to have them look up sensor specifications on manufacturers' websites. These specs are often confusing to students who are new to them, and they can be difficult to find and comprehend. By having the students look at these in class, with instructor guidance and assistance from their classmates, the learning curve is shortened.

The benefit of the in-class use of electronics was particularly noticeable when it came to learning statistical data analysis. The students typically have not had a formal class in statistics prior to Measurements. In order to give the students practice in manipulating statistical data, an in-class activity has students get an individual bag of candy, weigh it on one of 4 scales and record their measurement (followed of course by eating the candy). This data is then turned into an excel sheet and emailed to the students prior to the second lecture in statistics. They are also requested to bring laptops to that lecture. During the lecture students are given group activities including developing histograms, producing descriptive statistics, and performing t-tests to see if there is any statistical difference between the various scales. This gives students a chance to actually attempt the skills, with an instructor roaming around to troubleshoot difficulties. There is a large difference between telling students how to plot a histogram and having students notice that they have to have the right plug-ins installed, that they have to choose the right bin size, and that there is a difference between the program's defaults and what they get if they choose parameters on their own. Subsequently, students require much less assistance on homework and lab reports when it comes to this type of analysis. Groups of two or three, each with at least one laptop, can easily see what the other is doing, point out errors, and compare answers. When the students get to the quiz on this topic, the results show that the time spent on struggling with the mechanics of the statistics in class was well spent, as the grades on that quiz have been increasing over time. Prior to the change in electronics policy, students struggled to do statistics using calculators. Having the students work in groups helped, as they could spread out the hand calculations, but many students disengaged from the activity midway through, preferring the risk of earning fewer points to trying to figure out the mechanics of using the calculator for statistics. Concepts such as chi-squared tests for data normality were nearly impossible without some sort of software, and also required copying large numbers of tables. Many online tables and calculators are available for statistics operations, which reduces the burden on the instructor to provide them.

Another example of a simple in-class activity with a large payoff was that of calibrating a scale. The instructor produced the calibration data in real time at the front of the class. The class then graphed the data, produced a calibration curve, and then corrected additional data to account for the bias in the scale. All this can be done on paper or with a graphing calculator, but students were encouraged to use Excel or the equivalent. This allowed the instructor to point out the difference between x-y scatter plots and line graphs, to show students how to put the equation of the line on their plots, and other small technical details that can throw a student off the correct answer. Because they were required to calibrate sensors in nearly every lab experiment, this activity allowed the instructor to make sure that everyone had this concept solidly in place, before the first lab occurred.

It is important to note that the devices themselves do not particularly keep the students engaged. This is borne out by both the survey data and the instructor's observations. Designing activities to make use of the students' devices allowed for more involved activities to be developed. A computational problem can have the added instruction that the students use the internet to find the required constants. This forces the students to be able to find this information, and to compare the sources. Students were quick to point out when a particular website contradicted their heat transfer textbook, for example, and steered other students away from erroneous or non-user-friendly sites. Activities were task based, i.e. use the internet, use a spreadsheet, find the spec sheet online, rather than device based, i.e. use a tablet running this particular application. This was easier for both the instructor and the students. It wasn't necessary to find a single application that could do one thing well, such as simulate a process. Instead, students were given the problem and given strategies for using the electronic resources at their disposal to solve that problem in whichever way worked best for them.

One common concern with incorporating electronics is that of academic dishonesty. Several measures were taken to ensure that individual accountability was maintained. Since in-class assignments other than quizzes were typically designed to be done in groups, simply walking around and asking disengaged students to "Show me where you're at" does a lot to make sure that everyone is working. In class work is still turned in as a paper copy in most cases, with all students in a group being required to sign their names on the response turned in. This prevents absent students from getting a friend to electronically attach their name to an activity they missed. Quiz cheating was managed by several means. Quizzes were unannounced, but low stakes, with no quiz worth more than 10 points. Quizzes were all open book/open notes, and the instructor monitored the quiz taking closely. There was very little incentive to cheat, as each individual quiz was such a small portion of the grade. It is conceded that electronics could aid cheating. However, the room in which the course was offered is usually so small that physically looking at the next paper was a much greater concern. In general, very few instances of academic dishonesty were detected or suspected on the quizzes, provided the instructor was vigilant.

One truly heartening finding was the reduced number of absences as the number of in-class electronics based activities increased. Although this cannot be proven to be a direct causal relationship, it is encouraging. This course comes rather late in the curriculum for some students. For students who have already been out on two co-ops, much of the course material is at least somewhat familiar to them. In addition, the two lecture sections have always been scheduled at 8:00 am and 9:15 am respectively, which are highly unpopular times for the students. Absenteeism, particularly in the earlier section, has been a severe problem in the past. As the in-class activities became first required, and then required and more involved, the number of students skipping class has decreased. While it may be merely due to self-preservation instincts on the part of the students, it is very encouraging.

During the time the author has been teaching this course, the enrollment in the course has increased significantly. During the first offering in Fall 2010, there were 63 students between the two sections. In Spring 2014, there are 112 students. These in class activities have scaled well as the number of students has grown. Because many in-class activities are done in groups of 2 or 3 students, there are just more groups of students in larger classes. Grading individual quizzes does take more time, but this has proved to be manageable. The computational type of problems could be adapted to a number of different subjects. In particular, questions that ask students to make connections to previous courses in their curriculum could benefit from guiding them to look for online sources of information to refresh their memories. The hands-on sensor based activities tend to be unique to this particular lab course, but lab based courses in other disciplines could potentially find ways to bring some of their lab equipment or activities into the classroom as demonstrations or as the starting point for in-class discussions.

Conclusions

Student owned electronics are here to stay, and the array of electronic devices available to students is growing daily. Group cooperative learning activities, combined with electronics, can deal with the fact that not everyone has the same devices. If each group has at least one internet device, real time research and fact finding can be easily incorporated into a number of activities. By taking advantage of the fact that 97% of the students own laptops, in-depth data analysis, heat transfer calculations, and other difficult concepts were practiced by the students while getting prompt feedback and troubleshooting help from the instructor. Moreover, this can be done without requiring a dedicated computer classroom or any particular required device. In this study, student absences dropped to 1.5 per student from 2.5 in previous terms, and in-class participation grades improved by 4 percentage points. These and other measures showed improved understanding and engagement from incorporating carefully designed cooperative learning activities that took advantage of student-owned electronics. Engineering educators should be encouraged to find activities and problems that will benefit from students' constant electronic connectivity. In short, there are many benefits to allowing the students to use class time to 'play' with their phones.

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Appendix A: Survey on Technology in the Classroom

I am working on ways to increase the use of students' personal technology in the classroom to aid learning. Your participation in this survey is voluntary, but highly appreciated! All responses are anonymous, so please answer honestly.

1. Which of the following devices do you own? (Check all that apply)
    a. iPhone_____________________________
    b. Other Smartphone (specify)____________________
    c. iPad_________________________________
    d. Windows Surface_____________________
    e. Laptop______________________________
    f. Other tablet device (specify)_________________________
2. Do you use an electronic device for note taking? Yes/No (Circle one)
3. Explain why you do or do not use an electronic device for note taking (Preference? Don't have one? Find them helpful/annoying?)

Please rate the following statements on how strongly you agree or disagree with them. By 'electronic devices' I mean any of the student-owned personal devices listed above.

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Electronic devices are a helpful learning tool in the classroom					
Electronic devices are a distraction in the classroom					
I like being able to use Excel for in-class activities					
In class activities using electronics help me learn					
Electronic devices help me stay engaged in the course material.					
I would like to see more activities that incorporate my personal electronics.					
I think the use of personal electronics is unfair for those who lack specific devices.					

Thank you so much for your participation!