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# Class Participation and Student Performance: A Tale of Two Courses

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## Abstract

Student performance in classes can be affected by lack of attendance and attention while in class. This paper examines the effect of student participation on performance in two Computer Science classes. Attendance and attentiveness are automatically recorded by the videoconferencing software used for the classes. Student participation is measured by multiplying the scores for attendance and attentiveness. In the one class, we found a positive relationship between participation and scores on the final examination. This class is a concepts type class, focusing on theoretical information presented in lecture format. In the other class, we did not find a relationship. This class is a skills type class, focusing on practical skills and involving more hands-on work. The relationship may have been masked by the associated lab and relatively late dropping of the class by multiple students.
We discuss the strengths and limitations of this new measure of student participation. Automatic recording of class participation frees up faculty time, which can be used to increase the quality of instruction. Low participation scores early in the course can help identify students at risk. Finally, we make recommendations to record attentiveness even more accurately.

**Keywords:** participation, attendance, attentiveness, distraction, student performance

## 1. INTRODUCTION

Student class participation has long been a subject of research. Before the advent of Distance Education (DE), participation was first measured in terms of coming to class (attendance), followed by the influence of different measures to increase attention while in class (hand raising, response cards, clickers). Ignoring previous DE forms like correspondence courses, the appearance of the Internet provided opportunities to offer asynchronous, usually text-based, courses as alternatives for face-to-face (F2F) classes. Measures of attendance then focused on time spent on the course site, clicks, and pages visited. Participation shifted to making meaningful contributions in email conversations and on discussion boards.

Overall, research showed that active participation in class improved subjective and objective student performance. Students perceived that they did better in class, and objective criteria like Grade Point Average (GPA) and scores on final exams confirmed this (Duncan, Kenworthy, Mcnamara, & Kenworthy, 2012).

As networks have improved in bandwidth, stability, and accessibility, the distinction between DE classes and F2F classes is starting to blur. Our regional university in the SouthWest now offers online courses (asynchronous), blended courses (part asynchronous, part F2F), interactive videoconferencing (ITV) from multiple campus locations, and virtual class meetings (VCM) as distance learning course types (Northeastern State University, 2019). Moreover, videoconferencing tools with screen sharing offer superior presentation compared with traditional blackboards, whiteboards, overhead projectors, and even smartboards. Using these tools both for F2F and DE courses is now a realistic option. Offering both options in the same course may increase attendance for students who miss class for employment reasons (Lukkarinen, Koivukangas, & Seppälä, 2016; Paisey & Paisey, 2004), while accommodating the majority who prefer lectures over web-based lecture technologies (Gysbers, Johnston, Hancock, & Denyer, 2011).

This paper presents a comparison of two Computer Science classes we used a video conferencing and collaboration tool, Zoom (Zoom Video Communications, Inc., 2019), to communicate with the students. Data available in the Pro Version are used to objectively measure student participation as the product of attendance (coming to class) and attentiveness (paying attention when in class). Levels of participation are related to performance in the class as measured by the score on the final exam, and differences in results for the two classes are discussed. To the best of our knowledge, this is the first time that coming to class (attendance) and paying attention (attentiveness) are combined to a single measure. It is also one of the few studies where participation is objectively measured only, without interpretation by the researchers.

## 2. LITERATURE REVIEW

Participation in class is a combination of coming to class and paying attention once there. Mere attendance may not matter until too much class time is missed (Durden & Ellis, 1995), but is a better predictor than SAT, high school GPA, study habits, study skills (Credé, Roch, & Kieszczynka, 2010), self-financing, and hours worked (Devadoss & Foltz, 1996). The research literature also supports that class attendance improves student performance (Romer, 1993; Coldwell, Craig, Paterson, & Mustard, 2008; Landin & Pérez, 2015; Teixeira, 2016; Yakovlev & Kinney, 2008; Landin & Pérez, 2015).

Once in class, being active matters. Beaudoin (2002) found that mean course grades were higher for learners who are actively involved in online discourse than for learners who just do the work. Participation is important both in synchronous and asynchronous conditions (Duncan et al., 2012). Multitasking with technology negatively affects participation and student performance, subjectively (Junco & Cotten, 2011) and objectively (Junco & Cotten, 2012). Typical non-class related multitasking includes use of instant messaging (IM) , FaceBook (Kirschner & Karpinski, 2010), and texting on cell phones . This is complicated by the use of some of these technologies for class purposes (Kraushaar & Novak, 2010). Using Facebook for class may have a positive effect, while using it for socializing may be negative (Junco, 2012b). Overall, using social media for class purposes may not be effective (Lau, 2017).

Meta-analysis show that student performance tends to be slightly better in DE courses (Allen et al., 2004) or positives cancel out negatives (Bernard et al., 2004), but this may be due to additional tasks for the students. When the task load is identical, for local and distant students in a videoconferencing setting, student performance is the same (MacLaughlin, Supernaw, & Howard, 2004). Interaction may be essential: DE with collaborative discussions is more effective than independent study only (Lou, Bernard, & Abrami, 2006).

### Class Participation

Class participation is treated as the independent variable in the research. The definition of the term has developed over time. Before the introduction of the Internet in education, participation could mean use of response cards and hand-raising (Christle & Schuster, 2003; Gardner, Heward, & Grossi, 1994; Narayan, Heward, Gardner, Courson, & Omness, 1990). Once computers entered the classroom, participation might be measured by using tools like clickers (Stowell & Nelson, 2007). In the early days of DE, when most classes were conducted asynchronously, participation was typically measured with pages visited, tools used, messages accessed, discussions posted, and email contacts (Coldwell et al., 2008; Douglas & Alemanne, 2007; Romero, López, Luna, & Ventura, 2013).

Novel tools are now sometimes used to measure participation. Kassarnig, Bjerre-Nielsen, Mones, Lehmann, & Lassen (2017) used location and Bluetooth data from cell phones to measure attendance, and Kraushaar & Novak (2010) used spyware installed on students' laptops to check browsing and application use. Unfortunately, these tools may be good for research but not necessarily for day-to-day teaching.

Finally, a significant number of studies rely on self-report by students (Junco & Cotten, 2011), including self-report of GPA and hours spent studying (Kirschner & Karpinski, 2010).

**Student Performance**

On the other side of the relationship, student performance is used as the dependent variable. The most frequently used objective measures of student performance are items like course grades (Beaudoin, 2002; Durden & Ellis, 1995; Kassarnig et al., 2017; Teixeira, 2016), term GPA (Wang, Harari, Hao, Zhou, & Campbell, 2015), cumulative GPA (Lau, 2017), self-reported GPA (Kirschner & Karpinski, 2010), GPA obtained from registrars (Junco, 2012b) ,course credits (Giunchiglia, Zeni, Gobbi, Bignotti, & Bison, 2018) , scores on final exams (Duncan et al., 2012; Lukkarinen et al., 2016) and finishing the course (Coldwell et al., 2008; Junco, 2012a). Occasionally, pre-tests and post-tests (Omar, Bhutta, & Kalulu, 2009), student ranking (Felisoni & Godoi, 2018) or multi-item scales are used (Yu, Tian, Vogel, & Chi-Wai Kwok, 2010).

**Multitasking**

Using computer lab desktops or personal laptops does present new problems. Students often alternate between class-related and non-class-related computer use (Fried, 2008; Grace-Martin & Gay, 2001; Hembrooke & Gay, 2003).

Like class participation, this multitasking has evolved with the technology of the day. When laptops entered the classroom, instant messaging and web browsing were major distractions (Fox, Rosen, & Crawford, 2009; Hembrooke & Gay, 2003). Later, Facebook became a major distractor (Kirschner & Karpinski, 2010). Now, mobile phones provide yet another source of distraction (Chen & Yan, 2016; Harman & Sato, 2011). The negative effect of using cellphones is especially high when it takes place in class (Felisoni & Godoi, 2018), and lower performing students are especially at risk (Beland & Murphy, 2016; Chiang & Sumell, 2019). Beland and Murphy (2016) also found significant improvement in high stakes exam scores after mobile phones were banned.

Students do not necessarily recognize the negative effect. In a study of Malaysian university students, respondents felt that they performed better as Facebook usage increased (Ainin, Naqshbandi, Moghavvemi, & Jaafar, 2015).

The general research consensus holds that multitasking does have a negative effect on student performance (Bellur, Nowak, & Hull, 2015; Burak, 2012; Junco & Cotten, 2012; Kraushaar & Novak, 2010; MacLaughlin et al., 2004), although the causality has not yet been established (van der Schuur, Baumgartner, Sumter, & Valkenburg, 2015). Controlled experiments show that actual performance may be the same, but the time to achieve it is longer (Bowman, Levine, Waite, & Gendron, 2010; Rubinstein, Meyer, & Evans, 2001). While some studies fail to demonstrate differences between performance of cognitive tasks with and without distraction, they do show decreased efficiency of information processing (End, Worthman, Mathews, & Wetterau, 2010) and increased memory errors (Rubinstein et al., 2001).

**Use of Videoconferencing Software**

Recorded lectures and posting notes online only may not meet students' needs (Gysbers et al., 2011). All modern Learning Management Systems (LMS) include some form of videoconferencing to enable virtual class meetings. Moodle has a Videoconference Edition (Moodle, Inc., 2019). Blackboard offers the Blackboard Collaborate module (BlackBoard Inc, 2019). Canvas includes the Conferences tool (Canvas LMS Community, 2019). Each have their strengths and weaknesses, and those will not be addressed here.

In addition to discussions via video conferencing, Zoom meeting features include presentation and collaboration features. Pure presentation can be done with desktop sharing, application sharing, whiteboards, slideshows, and sharing of online videos. Collaboration features like Instant Messaging, annotation and drawing tools, and remote desktop control transform the shared view into two-way communication between instructor and students (SJSU, 2018).

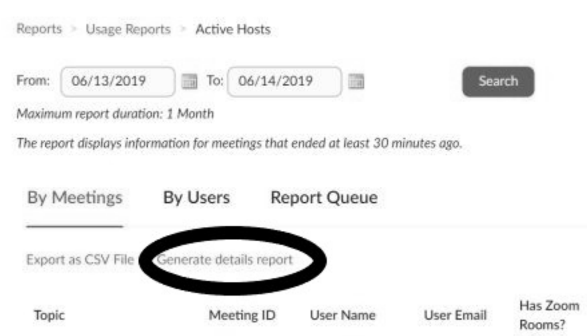



Figure 1- Details Report

Zoom comes in different versions. The free version is limited to 40-minute sessions and is not suitable for teaching full class sessions. Zoom for Education allows each host to teach full class sessions but has limited administrative tools for faculty. The Zoom Pro version is relatively inexpensive and offers extra administrative controls and reports. Join time, leave time, student name, and attentiveness score can all be found in the Details report (Figure 1).

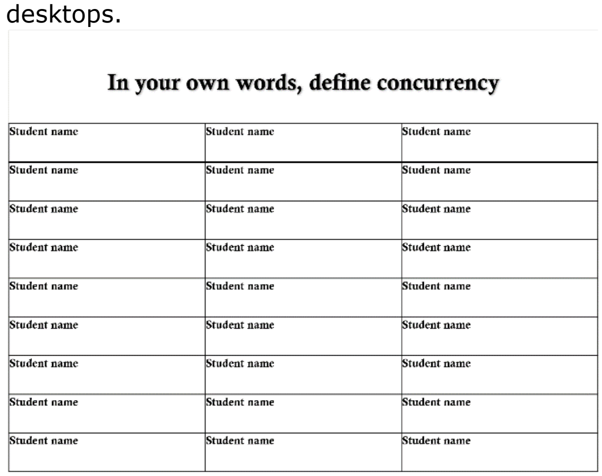
## 3.METHODOLOGY

This research project involves using data automatically recorded by Zoom Pro. We analyzed data for two classes in the Mathematics and Computer Science department taught by the primary author. The first course, CS2014 or Computer Science I, is the introductory programming course with C++. The course consists of three lecture hours and one lab hour each week. Twenty-five students started the class, and 20 students took the final exam. The second course, CS3343 or Operating Systems, consists of three lecture hours only. Twenty-five students started the class, and 23 took the final exam. Both classes were taught as F2F classes in the same computer lab, and students were not allowed to participate remotely by college policy.

In the lecture sessions, students viewed the shared desktop of the instructor. All applications, whether PowerPoint, system utilities, virtual machines, or the C++ compiler, were used from the instructor's desktop. The syllabus instructed students to maximize the Zoom window, and to use pen and paper for any note taking. All lectures were automatically recorded and generally available after two hours.

In both classes, a variety of Zoom features were used to encourage or force students to be active participants. Students could pose anonymous questions on the shared desktop using the annotation and drawing tools. They could use the chat box for less immediate questions and comments. Voice communications were hardly ever used by students. A grid with names was used to respond to questions to the whole class (Figure 2). Individual students would take over control of keyboard and mouse of the instructor to finish or edit program code. This could be done as volunteers, or as called on by the instructor.

Distraction from the class was also actively discouraged. Students were required to keep their desktop camera on and trained on their faces. The stated goal was increasing the feeling of belonging to the group (class), but it also allowed the instructor to call on students who appeared to be less than attentive. Some students trying to take the class from another location, or even from a car while driving, were identified and either told to leave the meeting or removed from the session by the instructor. Cell phone use was prohibited, and students could only answer calls after leaving the classroom. Finally, no interactive desktop sharing was used where students – not the instructor - shared their desktop. Having students share their work increases diversity of solutions but is somewhat time-consuming and depends on all other computers having software correctly installed. A fortunate side-effect of limited sharing is the accurate recording of focus of students' desktops.


In your own words, define concurrency

| | | |
|---|---|---|
| Student name | Student name | Student name |
| Student name | Student name | Student name |
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| Student name | Student name | Student name |

*Figure 2-answering grid*

Grades on the final exam were used as measures of student performance. The final exam was comprehensive and covered the whole course. For the CS2014 programming class, this is a natural choice. Declaration of variables is necessary for using loops, and repetition structures are needed for reading and writing files. Each skill builds on what was learned previously. The choice for a comprehensive final in the CS3343 Operating Systems class is more a philosophical one. Formative assessments like programming assignments and intermediate tests help identify where students need more help and instruction as the course continues, and summative assessments like course projects and final exams serve to evaluate how well student outcomes have been achieved. In each course, several intermediate tests were used. For each subsequent test (including the final), 50% of questions came from "old" material and the remainder from material covered since the last test. This allowed for checking if previously missed concepts were now understood.

For each final exam, students had a review session where they could ask questions. The final exams in both courses were in multiple choice (MC) format.

**Zoom Statistics**
Zoom Pro allows generation of comprehensive meeting reports in Excel format. Data include topic, join time, leave time, and the "attentiveness score." Attentiveness in this context is defined as the percent of time that the shared Zoom window is in focus. If a student is logged in but works with another application, the time does not contribute to attentiveness. If students are disconnected during class and reconnect, each part will have its own attentiveness score. It is important to note that attentiveness is recorded for each individual student, whereas other software may only report "engagement" for the group (Adobe.com, 2019)

Students were required to log in for each meeting. Many students use inconsistent login names, so the name used for the BlackBoard gradebook was looked up in an alias table. Students also tend to log in before the class starts and may stay until after the end of class. During class, they may occasionally be disconnected and need to reconnect. The exact time of participation was calculated in new columns. We provide the formulas in Appendix A, and a template with all formulas is available at https://1drv.ms/x/s!AnmVh-GZtTJyv4UyDwd7xAK0EDw7hg?e=I2CWsX
To protect student privacy, we replaced student names with random numbers between 1111 and 9999.

## 4. SAMPLE AND DATA COLLECTION

Both classes started with 25 students. As usual in CS, the majority of students were male (CS2014: 22 males, 3 females; CS3343: 20 males, 5 females). Most students were traditional full-time students in their late teens and early twenties (CS2014: 2 non-traditional students; CS3343: 1 non-traditional student).

Class attendance and attentiveness data were automatically recorded by Zoom, since students were required to log in to the class sessions. Participation scores were posted on the Blackboard gradebook every two weeks, and students who scored low on participation early in the course received an email with separate data for attendance and attentiveness to explain why their scores were low. Since we measured the influence of conditions in for each student in one course only, we used the final exam in the course to measure performance. The final MC exam was posted on BB and scores automatically calculated. Questions and answers were reviewed based on less than 50% correct answers, and no questions were found to be incorrectly stated.

## 5.ANALYSIS

Since both Zoom and Blackboard gradebook were already in Excel format, we used the Excel Analysis Toolpak to perform the linear regression. All absences received a participation score of zero as no time was spent in class. Absences were not corrected for excused absences, such as attendance of events sanctioned by Academic Affairs. Students who did not finish the class and did not take the final exam were included with a zero score for the final. Statistics for both courses are listed in Appendix B.

It is interesting to note that none of the students got a perfect 100% participation score (maximum scores of 98.4% and 93.6%). This truly is an effect of attendance alone, since attentiveness is only recorded when the desktop is shared, and the instructor did not start sharing until the class started.

Linear regression showed a statistically significant relationship between participation and grade on the final exam for CS3343 ($p = 0.01$) but not for CS2014 ($p = 0.25$). One explanation of the difference may lie with the type of the class. CS2014 is a skills class, and CS3343 is a concepts class. Concepts classes predominantly use a lecture format, and skills classes use more of a lab environment with individual instruction (Sinclaire, Simon, Campbell, & Brown, 2011). Indeed, the CS2014 class included a one-hour lab each week. The hands-on component may have superseded the effect of lecture participation.

The influence of hands-on work in the labs can also be seen when comparing lab attendance and final grades. During the lab, students were logged in to a separate Zoom session to record attendance, but no desktops were shared and therefore attentiveness was not relevant. We found a significant relationship between lab attendance (not participation) and score on the final exam ($p = 1.24E-8$). This is consistent with the findings of (Barrington & Johnson, 2006).

Another explanation of the absence of a relationship in CS2014 may lie with late withdrawals. Students who withdraw before week 12 are removed from the course management system, but some students need to stay in a class for Financial Aid reasons and drop a course shortly before the final exam. They would still be represented in the data. Three students in CS2014 struggled with significant health events but tried to finish the class right up to the final exam, when their position was hopeless. Where CS3343 only had 2/25 students not taking the final exam, CS2014 had 5/25 or 20% dropping the final. Analyzing the data without the five non-final takers still did not show any statistical significance ($p = 0.65$).

Maybe due to financial aid and health reasons, the average participation score of non-finishers of 87.9% is higher than the class as a whole with72.9% Furthermore, students in the front of the class were extremely active in volunteering for taking over control, which may have allowed students further back in the class to "log in, and tune out." They may have finished the course, but with lower grades. Seating location does affect student performance, whether through random assignment (Benedict & Hoag, 2004) or through students being forced forward when their preferred seats are not available (Perkins & Wieman, 2004). Since data had to be anonymized before analysis, and seating location was not included, this will have to remain an issue for future research.

## 6. CONCLUSIONS AND RECOMMENDATION

Participation in class, as a product of attendance and attentiveness, may be a valid objective measure to predict student performance. Since it can be monitored as semesters progress, it can also be used to identify students at risk of failing and underperforming. This is especially significant, because the data can be recorded automatically in Zoom and analyzed with minimal effort in Excel.

This does not mean that the combination of attendance and attentiveness is a perfect measure of participation. Time of entering and leaving the session is a perfect measure of attendance, but computer focus on the application is not a perfect measure of attentiveness. It is still possible to log in, keep the application in focus, and play on a cellphone – or sleep. We can consider using screen captures of the answer grids in the lecture recordings to monitor and measure actual responding. Additional attention-focusing tools like sending code snippets or answers through the chat box, which records name of respondents so they can be counted, should also be considered. Individual students can also be called to attention based on signs of disinterest on the video images of their webcams. All these measures take time, and one of the major benefits of automating recording attendance and attention is freeing up faculty from the chore of attendance recording.

The type of class may matter. Concept classes may benefit more because hands-on work in skills classes offers additional learning opportunities. The interactive tools in skills classes are more limited to single students. Taking over control of mouse and keyboard only involves a single student but using chat boxes and grids with answer boxes for all students forces the whole class to pay attention.

An area of concern may be student acceptance of what could be construed as an intrusive technology. The use of Zoom monitoring should be disclosed, preferably in writing in the syllabus. We did this, and there were no complaints interpersonally or in the course evaluations. Instructors should take care not to open the shared desktop before and after class, since focus of the students' computers would be monitored then too. If students are given a choice between attending locally and remotely in the same class session, it must be made clear that students cannot attend using cell phones or tablets. The interaction requires the use of full-fledged keyboards and mice. Use of wireless connections for remote students can result in poor video and audio quality, as well as the need to reconnect.

The positive results of this study warrant repetition and refinement in other CS courses and in other subject areas such as humanities, social sciences, and business in future semesters. Further opportunities for research include counting responses in the chat box or onscreen, monitoring seating and comparing the results of skills classes with and without associated labs.

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**Appendix A: Generating Data**

A simulated details report is shown below. The column "Name (Original Name)" holds the student name as provided during login. The column "User Email" holds the student email as provided during login. Students often provide inconsistent login information, but a simple table with variations of the name can be used to look up the name as used in the gradebook.

| Topic | Meeting ID | User Name | User Email | Has Zoom Rooms? | Creation Time | Start Time | End Time | Duration (Minutes) | Participants | Name (Original Name) | User Email | Join Time | Leave Time | Duration (Minutes) | Attentiveness Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CS2014 CS1 | 213-885-828 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 118 | 20 | (student name) | (student email) | 3/4/2019 11:54 | 3/4/2019 13:50 | 117 | 53.36% |
| CS2014 CS1 | 213-885-828 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 118 | 20 | (student name) | (student email) | 3/4/2019 12:44 | 3/4/2019 13:50 | 67 | 84.97% |
| CS2014 CS1 | 213-885-828 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 118 | 20 | (student name) | (student email) | 3/4/2019 12:50 | 3/4/2019 13:50 | 60 | 100.00% |
| CS2014 CS1 | 213-885-828 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 118 | 20 | (student name) | (student email) | 3/4/2019 12:51 | 3/4/2019 13:50 | 60 | 98.56% |
| CS2014 CS1 | 213-885-828 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 118 | 20 | (student name) | (student email) | 3/4/2019 12:51 | 3/4/2019 13:50 | 59 | 30.34% |
| | | | | | | | | | | | | | | | |
| CS3343 Operating Systems | 843-765-396 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 91 | 24 | (student name) | (student email) | 3/5/2019 9:19 | 3/5/2019 10:46 | 88 | 100.00% |
| CS3343 Operating Systems | 843-765-396 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 91 | 24 | (student name) | (student email) | 3/5/2019 9:20 | 3/5/2019 10:46 | 87 | 95.06% |
| CS3343 Operating Systems | 843-765-396 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 91 | 24 | (student name) | (student email) | 3/5/2019 9:21 | 3/5/2019 10:46 | 85 | 100.00% |
| CS3343 Operating Systems | 843-765-396 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 91 | 24 | (student name) | (student email) | 3/5/2019 9:21 | 3/5/2019 10:46 | 85 | 100.00% |
| CS3343 Operating Systems | 843-765-396 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 91 | 24 | (student name) | (student email) | 3/5/2019 9:26 | 3/5/2019 10:46 | 81 | 100.00% |
| | | | | | | | | | | | | | | | |
| CS2014 CS1 lab | 167-747-341 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 59 | 18 | (student name) | (student email) | 3/6/2019 13:53 | 3/6/2019 14:50 | 58 | 23.83% |
| CS2014 CS1 lab | 167-747-341 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 59 | 18 | (student name) | (student email) | 3/6/2019 13:53 | 3/6/2019 14:50 | 57 | 1.33% |
| CS2014 CS1 lab | 167-747-341 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 59 | 18 | (student name) | (student email) | 3/6/2019 13:53 | 3/6/2019 14:50 | 58 | 15.67% |
| CS2014 CS1 lab | 167-747-341 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 59 | 18 | (student name) | (student email) | 3/6/2019 13:53 | 3/6/2019 14:51 | 58 | 2.16% |
| CS2014 CS1 lab | 167-747-341 | (instructor name) | (instructor email) | No | (not relevant) | (first to enter) | (last to leave) | 59 | 18 | (student name) | (student email) | 3/6/2019 13:53 | 3/6/2019 14:51 | 58 | 17.56% |

Join Time and Leave Time for each entry are recorded in date + time format.

- Date can be extracted with the formula =INT([@[Join Time]])
- joined can be extracted with the formula =MOD([@[Join Time]],1)
- left can be extracted with the formula =MOD([@[Leave Time]],1)

Start and end times for the class can be looked up from a small table (named "classes") as follows:

- class_starts with the formula =VLOOKUP([@Topic], classes,2, FALSE)
- class_ends with the formula =VLOOKUP([@Topic], classes, 3, FALSE)

To accommodate for coming early, coming late, leaving early, and leaving late, we used the MAX and MIN formulas:

- start with the formula =MAX([@joined],[@[class_starts]])
- stop with the formula =MIN([@left],[@[class_ends]])

Next, the "real time" in class was calculated as the difference and percent in class as the fraction:

- real_time =[@stop]-[@start]
- percent_in_class =[@[real time]]/([@[class_ends]]-[@[class_starts]])

Attendance and attentiveness were multiplied and converted to percentages with two decimals:

- participation =ROUND([@[percent_in_class]]*[@attentiveness],4).

In the gradebook, participation scores were summed in case students were disconnected during class:

- session_participation=IFERROR(SUMIFS(ZoomData[participation], ZoomData[studentName],[@[full_name]],ZoomData[Topic],"CS2014_CS1",ZoomData[date],F$1),0)

## Appendix B: Statistical Output

CS3343 – Operating Systems

| *participation* | | *final* | |
|---|---|---|---|
| Mean | 76.2% | Mean | 157.6 |
| Standard Error | 3.2% | Standard Error | 10.8 |
| Median | 81.2% | Median | 176 |
| Mode | #N/A | Mode | 204 |
| Standard Deviation | 16.2% | Standard Deviation | 53.8 |
| Sample Variance | 2.6% | Sample Variance | 2890.7 |
| Kurtosis | 1.69925609 | Kurtosis | 4.7 |
| Skewness | -1.42638148 | Skewness | -2.2 |
| Range | 61.2% | Range | 204 |
| Minimum | 32.4% | Minimum | 0 |
| Maximum | 93.6% | Maximum | 204 |
| Sum | 1905.2% | Sum | 3940 |
| Count | 25 | Count | 25 |

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.502818411 |
| R Square | 0.252826354 |
| Adjusted R Square | 0.220340543 |
| Standard Error | 47.47352528 |
| Observations | 25 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 17540.08114 | 17540.08114 | 7.782670302 | 0.010412384 |
| Residual | 23 | 51835.91886 | 2253.735602 | | |
| Total | 24 | 69376 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 30.42582657 | 46.56460768 | 0.653410994 | 0.519970696 | -65.90040348 | 126.7520566 |
| participation | 166.8806288 | 59.81933918 | 2.78974377 | 0.010412384 | 43.13489756 | 290.6263601 |

CS2014 – Computer Science I

| *participation* | | *final* | |
|---|---|---|---|
| Mean | 72.9% | Mean | 108.32 |
| Standard Error | 4.8% | Standard Error | 12.45775796 |
| Median | 84.3% | Median | 124 |
| Mode | #N/A | Mode | 0 |
| Standard Deviation | 23.8% | Standard Deviation | 62.28878979 |
| Sample Variance | 5.7% | Sample Variance | 3879.893333 |
| Kurtosis | 0.89846521 | Kurtosis | -0.432090221 |
| Skewness | -1.2805363 | Skewness | -0.803775468 |
| Range | 90.4% | Range | 196 |
| Minimum | 8.0% | Minimum | 0 |
| Maximum | 98.4% | Maximum | 196 |
| Sum | 1823.2% | Sum | 2708 |
| Count | 25 | Count | 25 |

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.238435249 |
| R Square | 0.056851368 |
| Adjusted R Square | 0.015844906 |
| Standard Error | 61.79333936 |
| Observations | 25 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 5293.85386 | 5293.85386 | 1.386400216 | 0.251054931 |
| Residual | 23 | 87823.58614 | 3818.416789 | | |
| Total | 24 | 93117.44 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 153.8042887 | 40.55812226 | 3.792194514 | 0.000941171 | 69.90342045 | 237.705157 |
| participation | -62.3679229 | 52.96841434 | -1.177454974 | 0.251054931 | -171.9414364 | 47.2055905 |