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How Students' Efforts Outside of the Classroom Correlate to Their Learning Outcome in Both Online and Face to Face Classes

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ABSTRACT

Many studies have focused on improving students learning outcome in the classroom by applying different learning tools, approaches and modalities to teaching and learning in the classroom. This study seeks to investigate the correlation between students' efforts outside of the classroom and learning outcome in introductory physics courses for both online and face to face learners. The study looked into the effectiveness of efforts outside of the classroom, and examines the comparative effect of online learning versus face to face, and have the quest to answer the question: what factors hindered students learning in both modalities? The study also looked at other non-academic factors that students encountered outside of the classroom such as class attendance, engagement in full or part time job, on-campus or off-campus residence, family issues and if students took Physics in high school.

Four introductory Physics classes, which consist of two face to face and two online, were used as the platform for this study. In the face to face class, students were required to record the amount of time spent outside of the classroom studying, reviewing what was taught in class, and completing homework/assignment. For the online, students recorded the overall time devoted to the course online on a daily basis. The study was conducted in summer 2022 for the online classes and in fall 2022 for the face to face class. At the beginning of these classes, survey for study time was created for students to complete the amount of time they devoted each day to the class. Students performance outcome on examinations was assessed to see if there is correlation to their efforts and other non-academic triggers.

The study tends to find a threshold for impact based on efforts outside of the regular classroom activities and other non-academic factors.

INTRODUCTION

In higher education, efforts and resources are been put into best practices of teaching and learning in order to improve students' learning outcome. Such efforts include different teaching and learning tools, approaches and modalities [1 - 11]. Students' quality and instructor's teaching skills also play a role. However, studies have shown that students' motivation [12 - 16], class attendance and absences [17 - 26]; not completing work [27], and employment during school [28 - 35] are inevitable factors that affect students learning outcome. Studies on study time have been inconsistent [36 - 39]. The question remains if students are investing enough time studying outside of the classroom? And how much time is enough time? There is need for students' efforts outside of the classroom because retention of information in class generally elapses with time [40-47]. However, according to [45], there is no magic number for how many hours should be spent studying for each hour of classroom time. The needs of each student are different and different types of material require different types of reinforcement. It is important to spend some time outside the classroom reinforcing the material that was learned in the classroom.

Ebbinghaus's research [40, 41] dates back to the 1880s, but it is still widely used and highly regarded. Herman Ebbinghaus, wanted to understand more about why we forget things and how to prevent it. His research produced the Forgetting Curve [44], a visual representation of the way that learned information fades over time (see figure 1). Ebbinghaus experimented with his own ability to remember in which he attempted to recall after different lengths of time. The results reveal that memories weaken over time and that review is important for retention (figures 2 and 3). In 2015, Murre and Dros [42] successful replicated Ebbinghaus' classic forgetting curve. Another study on the relationship of time and learning retention by Kamuche and Ledman [47] produced similar result.

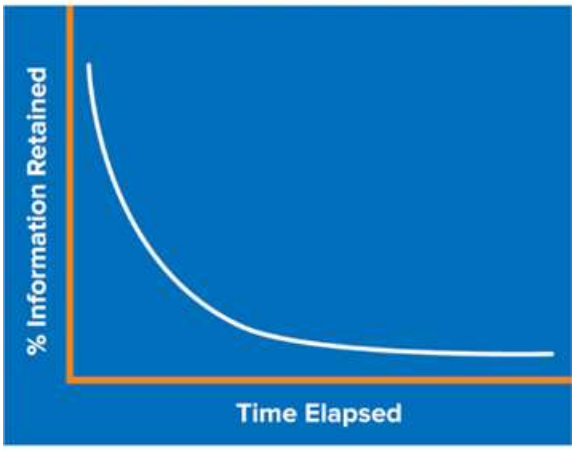

Figure 1 – The forgetting curve [44].

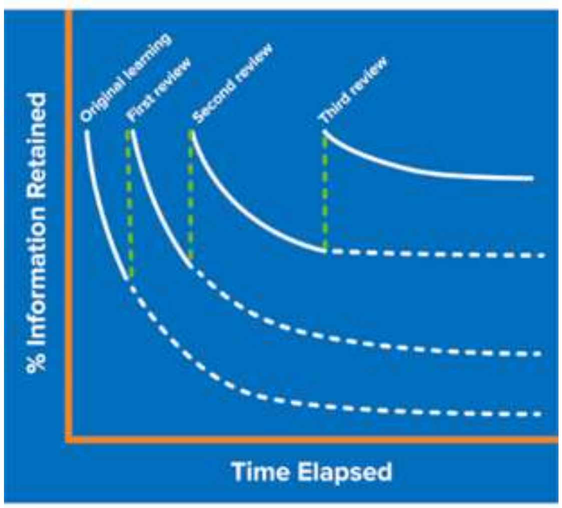

Figure 2: The forgetting curve and the effect of review [44].

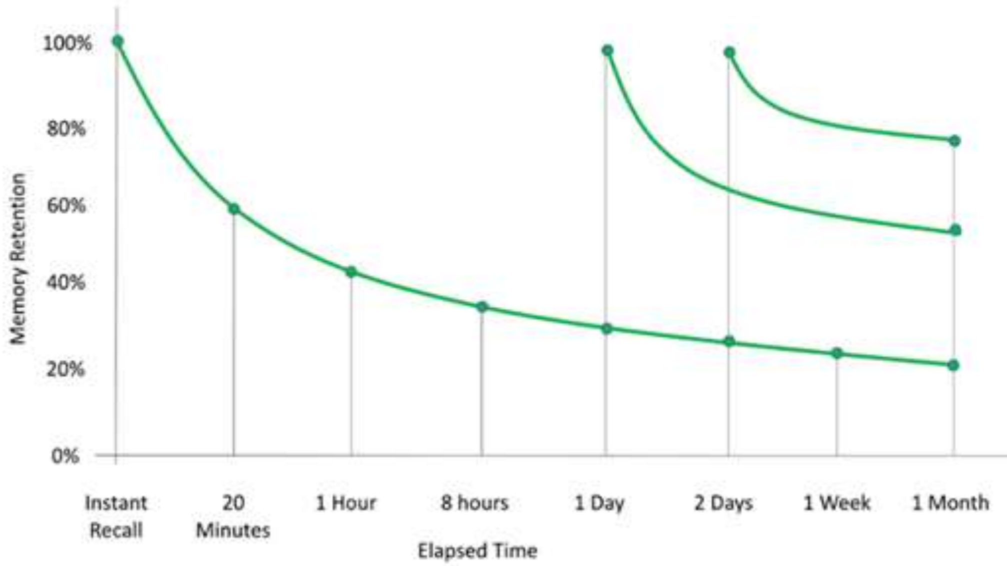

Figure 3: The forgetting curve, memory after different times has elapsed and review after day 1 and day 2 [45].

The effectiveness of students' efforts outside of the classroom, was studied, and the comparative effect of online learning versus face to face was examined with the quest to answer the question: what factors hindered students learning in both modalities? The study also looked at other non-academic factors that students encountered outside of the classroom such as class attendance, engagement in full or part time job, on-campus or off-campus residence, and if students took Physics in high school.

METHODOLOGY

This study focuses on how to improve students learning outcome by examining student's effort outside of the classroom in an introductory algebra-based college physics course (Mechanics). The study methodology centered on two face to face sections and two online asynchronous sections. The face to face classes were offered in the fall of 2022 for 15 weeks duration, the regular fall semester calendar. We do not offer introductory physics classes online in the fall and spring semesters. The two face to face classes had twenty (20) and twenty-one (21) students respectively for a total of forty-one (41) students. The face to face class met every Monday, Wednesday, and Friday for 50 minutes time duration. The online asynchronous classes were offered in the summer of 2022 for 8 weeks duration from 06/02/2022 to 07/29/2022. A total of 46 students were enrolled in the online sections. It is to be noted that both face to face and online sections for this study were taught by the same instructor (the author).

At the beginning of both the face to face and online classes, students were asked to complete a questionnaire. The questionnaire required them to tell the class about themselves, their background, interest and their concerns about the class. Their responses are presented in Tables 1 and 2, for face to face and online students, respectively.

In addition to the questionnaire of interest, background and concerns, students were asked to record how much time they invested in the course. Face to face students were asked to record on a daily basis the amount of time spent outside of the classroom studying, reviewing what was taught in class, and completing homework/assignments. The online students were asked to record the overall time devoted to the course on a daily basis. The recorded times for the online students included time reviewing the course materials, studying, completing homework, and taking quizzes and exams.

The instructor created the study time log survey on the State University of New York at Canton (SUNY Canton) online course platform (Brightspace) for both face for face and online classes. Students entered their survey on a daily basis, saved it and submitted their weekly record. As an incentive to motivate students to complete the survey, the instructor provided bonus points for every survey completed and submitted on a weekly basis.

Additional data were collected from the face to face class students at the end of the semester. The data collected include other non-academic factors that students encountered outside of the classroom such as class attendance, engagement in full or part time job, on-campus or off-campus residence, and if students took Physics in high school.

Table 1: Face to face students' questionnaire and responses.

Questionnaire	Students' Responses
Tell us about yourself, background, and your interests. What are your concerns about this class?	1. I graduated in 2021 and am currently a member of the army reserves. My interests for the most part consist of sports and firearms. One of my main concerns is my lack of background in math. My last math class was geometry in my sophomore year of high school so it'll be a challenge for me but nothing I can't handle. 2. I am looking forward to learning physics and getting to understand the basics of how they work. One thing I am worried about is that the exams will be tough and that I will struggle to pass the class. I think this year of classes will be fun and I hope it goes well. 3. l am taking this class because I want to go to vet school after I graduate from here. My biggest concern with this class is how I am going to fit it in with all my other classes, meaning I am taking many upper level classes and I'm worried I won't have enough time to put in a lot of effort into this one. 4. I've taken physics courses in the past and enjoyed them so I don't have any concerns at the moment about the course.

	5. I took physics in high school and did fairly well. I’m a little worried about keeping up with the assignments and quizzes because I’m really bad with technology. 6. My only concern with the class is the final but outside of that I believe this will be a good year. 7. My biggest concern about physics is that I haven't taken it since 2015, and I am a little rusty. 8. Am in the physical therapy assistant program. I play soccer for SUNY Canton, my favorite soccer team is Tottenham Hotspur, and I love reading. My only concern about physics 121 is math, it is not my strong suit. 9. I am a non-traditional student. I have a master's degree in forensic psychology, and am in the process of applying to schools for physical therapy. I don't really have any concerns about Phys 121 specifically. I am more concerned with time management because I work for SUNY Canton full time in addition to being a coach and an Academic Recovery Mentor. It can get difficult at times to balance everything time wise. 10. I major in HVAC engineering. My concerns about this class is mostly the equations and formulas that I'll have to remember.

Table 2: Online students’ questionnaire and responses.

Online	Students’ Responses
Tell us about yourself, background, and your interest. What are your concerns about this online class? Is this your first time taking online class?	1. I'm 23. I'm going to Queens College to become a Pre-K teacher and Physics is a requirement for the teaching program. I have taken online classes before and I love them way more than in person classes because I can still work. I am nervous about physics because I had to withdraw the first time but hopefully this time is better because I've been studying physics all summer to prepare for this class. 2. I am an Education Major at Canisius College, and I am taking this class because I am interested in Medical Sonography as well as this is a general ed course required that I need. I am a little nervous about this class just because this is my first-time taking physics and I struggle in math. I am going to be a junior and a fun fact about me is that I have dyslexia, so I'm looking forward to seeing how I do in this class. 3. I am taking this class since I had to withdrawal from the previous physics class I was taking at SUNY Cobleskill, which I can see that some other people

	are doing as well! I loved physics in high school but my previous teacher kind of ruined it for me so hopefully I will enjoy this class. 4. I have three kids and husband. I have worked full-time as a Registered Nurse for 14 years including some tough months in the Covid ICU's in Manhattan in the spring and summer of 2020. I decided I would like to go back to school for a Doctorate as a Nurse Anesthetist and have heard Physics will be very helpful in running the anesthesia machines. I took physics in high school but haven't since and really look forward to re-learning and learning even more! I'm getting the hang of the online courses as I've taken a couple this summer but I'm still working on getting the eBook and access codes. 5. I am taking this course to fulfill a Physics Lecture credit. I am a senior at SUNY Maritime college currently. This is my first time taking an online class and it is the last class I need to graduate from college thankfully! 6. I am a Long Island University student and I have been conditionally accepted to the professional phase of the Doctor of Pharmacy Program. I am taking a Physics course to complete my undergraduate program (prerequisite course). 7. I am an upcoming sophomore at the University at Buffalo for Environmental Design and Architecture. This is not my first online course, but is my first summer course. I love hiking, boating, camping, and doing all things out door. 8. I'm going into my freshman year at the University of New Haven for Civil Engineering with an environmental focus. I love to read romance novels and play music. 9. I am 27 years old, and this is not my first online class. I am the father of two beautiful girls, a 3-year-old, and a 5-month-old. I am a veteran of the Army and currently work for National Grid. I am taking physics to further my knowledge and be considered for a promotion at work. I am concerned about this online class because I have never taken a physics course before, and with it being the summer term, it will go by quickly. 10. I'm currently a senior at Brown University, concentrating in Computer Science. I'm taking this class since I've always wanted to take a physics course but with only one semester left in the fall before I graduate and there being required courses I need to take, I probably won't get to. I have one semester of experience with online classes (during the initial covid pandemic stage), so I don't have any concerns about it as of now. 11. I am a recent graduate of the University of Maryland and am taking this course to fill the requirements for PT grad school. I have taken online summer courses at UMD, but never at another school, so I am excited to see how they compare over this summer!

DISCUSSIONS AND RESULTS

Introductory college physics course was taught using two different modalities, face to face and online. The study looked into the effectiveness of efforts of students outside of the classroom for face to face, and the equivalent effect for those students who opted for the online version of the same course. It is important to note that in examining the comparative effect of online learning versus face to face, the methodology differences must be analyzed but should not be overemphasized. In both modalities, the same material content was covered, and similar weekly homework, quizzes and assignments were assigned. The online modality was fast paced requiring about half the time of the face to face mode. Weekly work for the face to face students was equivalent to 3 to 4 days work for the online students. Face to face students had three exams, plus the final exam; whereas, the online students had two exams, the midterm exam and the final exams. The reduced number of exams for online mode was due to time constraints. It was observed that the differences in methodology did not influence the outcome in any measurable way.

Tables 1 and 2, show students' responses to the questionnaire. The questionnaire was meant to gauge students' background, interest and concerns; and to understand the "whole" student beyond just a number in the classroom. The responses show diverse background of students. The summer online students were mostly students from other universities (not from the host institution, SUNY Canton). Specifically, only 9 percent (4 students) of the online students were from SUNY Canton.

The total study time in hours for the semester was computed for every student based on their record of daily study times. The face to face students attended lecture for a total time of 37.5 hours in the semester. This is in addition to their recorded study time. Figure 4 shows the average course study times for both modalities. On the average, face to face students studied for 30.7 hours outside of the classroom, while the average study times for the online students was 41.7 hours. Analysis of the data from Figure 4, shows that online students devoted more time. Figure 5 shows that the online students also have higher average course grade compare to face to face students.

Figures 6 and 7 show the graphs of quantitative data of course grades versus study times. Quantitative regression analysis of Figures 6 and 7 are shown in Tables 3 and 4. Multiple R in the regression statistics is the correlation coefficient that measures the strength of a linear relationship between the study time and the course grade. For these plots, Multiple R = 0.29 and 0.33 respectively, indication of weak correlation between the study time and course grade. R Square factor is another determinant, the coefficient of determination, which is used as an indicator of the goodness of fit. It shows how many points fall on the regression line. This R^2 value is calculated from the total sum of squares, more precisely, it is the sum of the squared deviations of the original data from the mean. The R square value here are 0.0858 and 0.11466, respectively for Tables 3 and 4; which means that only 8.58 % and 11.5 % of the data fit the regression analysis model. That is, 8.58 % of the dependent variable (course grades) are explained by the independent variables (course study times) of Figure 6. This is an indication of weak correlation between course grade and study time. One can deduce that students who put little or no time will fail and those who put a lot of time above average will succeed. However, students who are between these extremes, may have other non-academic factors that might require some attention.

To substantiate this correlation result analysis between grade and study time, the study futher looked at the weekly study time versus in class examination. Figure 8 shows the correlation between one-week of study time and exam #1. Students had one week to study for this exam and recorded their study times for the week following the exam day. A quantitative analysis using regression is shown in Table 5. The correlation shown in Figure 8 and Table 5 imply a much lesser correlation compared to Figure 6 and Table 3; an indication that other factors play a role. Comparable study for the online class using the midterm exam versus the study time for the midterm is shown in Figure 9 with the corresponding regression statistic shown in Table 6. Analysis of Figure 9 and Table 6 show the same weak correlation between study time and grade.

An interesting result is the correlation of other factors not related to academics. For face to face class, attendance seems to be an important factor. Figure 10 shows the semester class attendance correlation to course grade. It gives the number of absences versus course grade based on the factor of class attendance. The regression analysis is shown in Table 8. The analysis shows that Multiple R = 0.699. This is a quantitative analysis for strong correlation with R square = 0.489. This means that about 50 percent of the data fit the regression analysis model. That is, 50 % of the dependent variable (course grades) are explained by the independent variables (class attendance). This is an indication of strong correlation between course grade and attendance.

Figure 11 shows the bar chart of average course grades of students who lived off campus, students who did not take physics in high school and those that worked during the semester while in school. Data analysis showed that those who did not take physics in high school devoted more study time outside of the classroom. Students who did not take physics in high school have an average course grade of 80%, with minimum grade of 57 % and maximum grade of 99 %. For the students who worked during the semester, the number of hours they worked was not considered. This group have an average course grade of 71%; with minimum and maximum grades of 20 % and 99 % respectively. The off-campus students have an average course grade of 84 % with minimum and maximum grades of 67% and 99%. It is to be noted that the 99% grade maximum for all the categories was from the same student who happened to be in all categories (off-campus, worked and did not take physics in high school). This student maintained perfect attendance, talented, and put in about the average study time for the course.

CONCLUSIONS AND FURTHER WORK

The results from this study provide an insight as to how study times outside of the classroom affect students' performance outcome. The trend of the results of grades versus study times (Figures 6 and 7) show two extremes: (1) students who devoted little or no time, and (2) students who put in a lot of study times. The students who devoted little or no time outside of the classroom failed or drop out of the class at some point. However, the students who devoted a lot of study times above the average excelled in the class. The results also show that the majority of the students are somewhere in-between these two extremes. The course average study times for face to face students was 31 hours outside of the classroom. Hence, from this study, it is recommended that students put in at least 2 hours per week effort outside of the classroom for 3 credits hour course. This implies that students should devote a minimum of 50 minutes (actual from this study is 48 minutes) outside of the classroom for every 50 minutes lecture class. For online asynchronous class, the average course study times was 42 hours. It implies that online students should devote minimum of 5.25 hours a week. The study shows that methodology does not affect students' outcome. Also, the online students in this study have higher course grade average compare to the face to face students. This may be attributed to self-motivation and devotion.

It is conclusive from Figure 10, that attendance is a non-academic factor that contributes to students' learning outcome. Upon careful analysis of data from this study, it was observed that few students who missed class also did well if they return to campus and sought additional help to catch up on missed work. This is pro-active and a determining factor for those who must miss class because of unforeseen circumstances. Figure 11 presents the analysis of data of non-academic factors in correlation to course grade. The off-campus and high school physics did not have any influence on the outcome. However, data shows that students who did not take physics in high school devoted more study times. Engagement in an employment as a student was a factor that correlated to lower outcome in terms of course grade as seen in Figure 11.

It is recommended that more work be done to determine the threshold of failure due to non-academic factors.

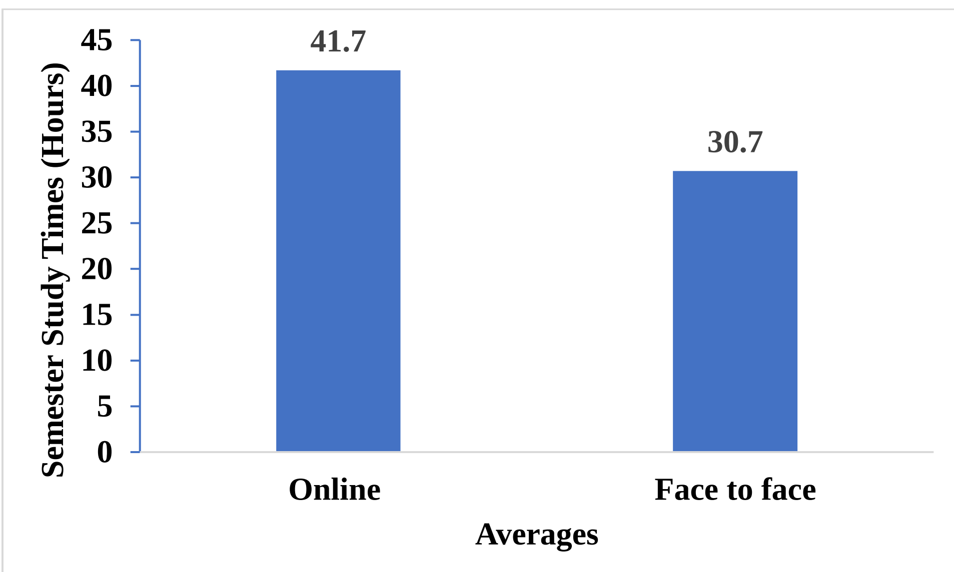

Figure 4: The average semester study times for online and face to face classes.

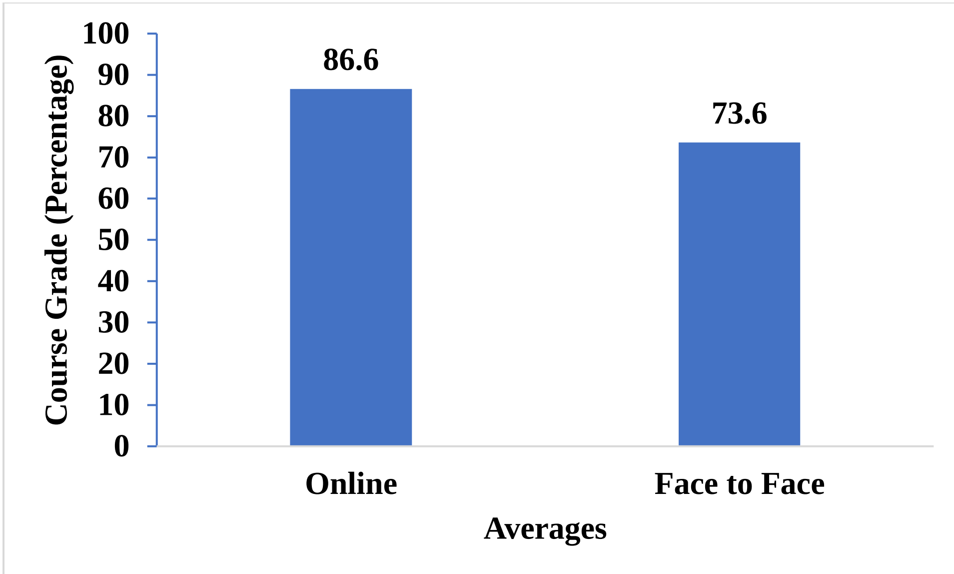

Figure 5: The average semester course grade for online and face to face classes.

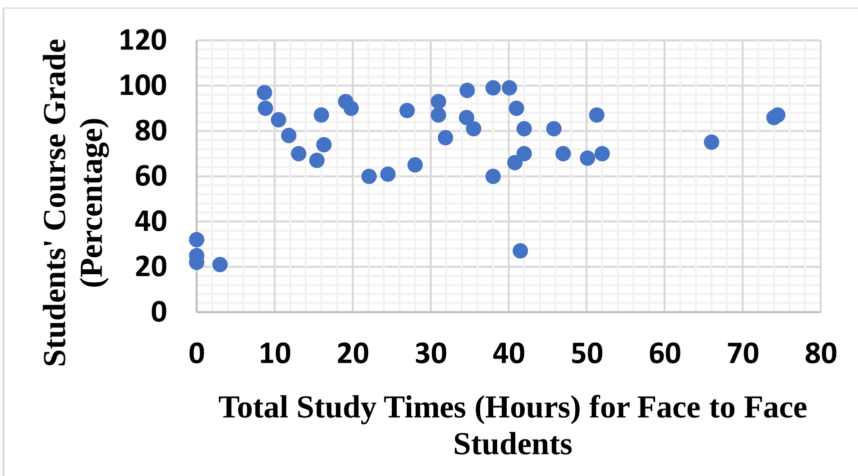

Figure 6: Plot of students' course grades in correlation with study time for face to face class.

Table 3: Regression analysis of figure 6.

Regression Statistics	
Multiple R	0.29292
R Square	0.085802
Adjusted R Square	0.061094
Standard Error	19.46388
Observations	39

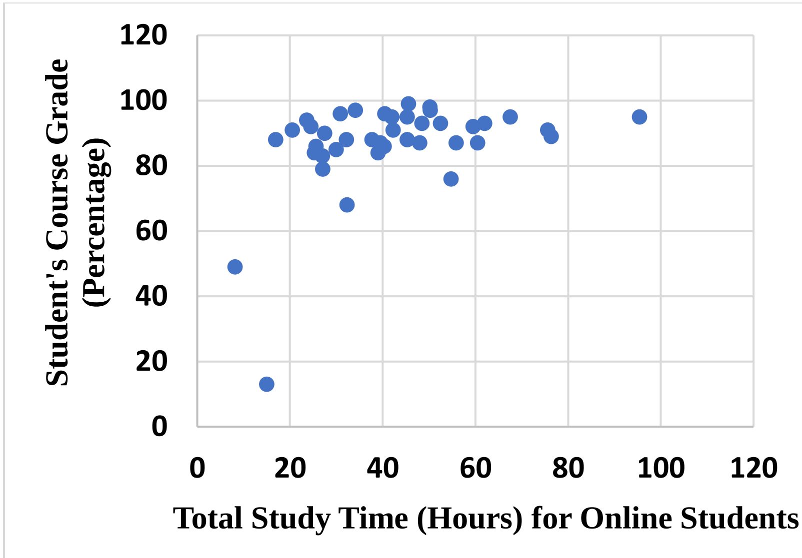

Figure 7: Plot of students' course grades in correlation with study time for online class.

Table 4: Regression analysis of figure 7.

Regression Statistics	
Multiple R	0.338475
R Square	0.114565
Adjusted R Square	0.090635
Standard Error	13.12947
Observations	39

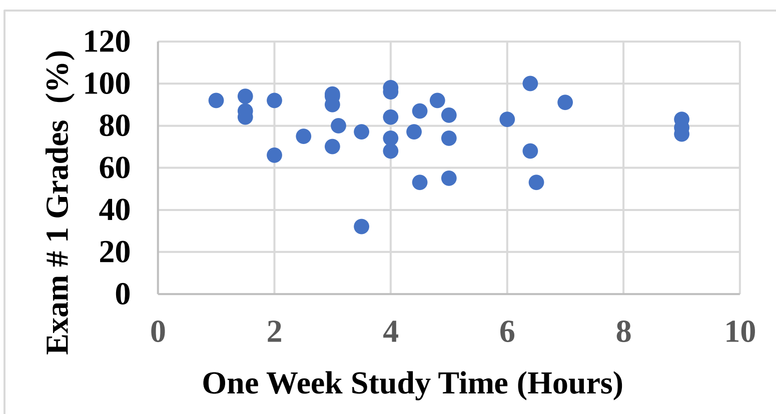

Figure 8: Plot of exam #1 grades in correlation with of one-week study time for this exam (face to face class).

Table 5: Regression analysis of figure 8.

Regression Statistics	
Multiple R	0.088926
R Square	0.007908
Adjusted R Square	-0.0241
Standard Error	15.34554
Observations	33

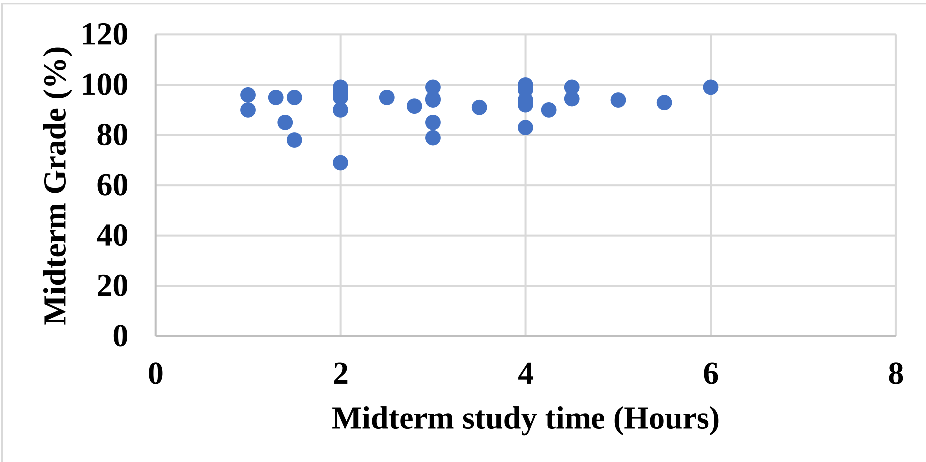

Figure 9: Plot of midterm grades in correlation with time devoted to studying for the midterm (online class).

Table 6: Regression analysis of figure 9.

Regression Statistics	
Multiple R	0.280896
R Square	0.078903
Adjusted R Square	0.04919
Standard Error	6.958752
Observations	33

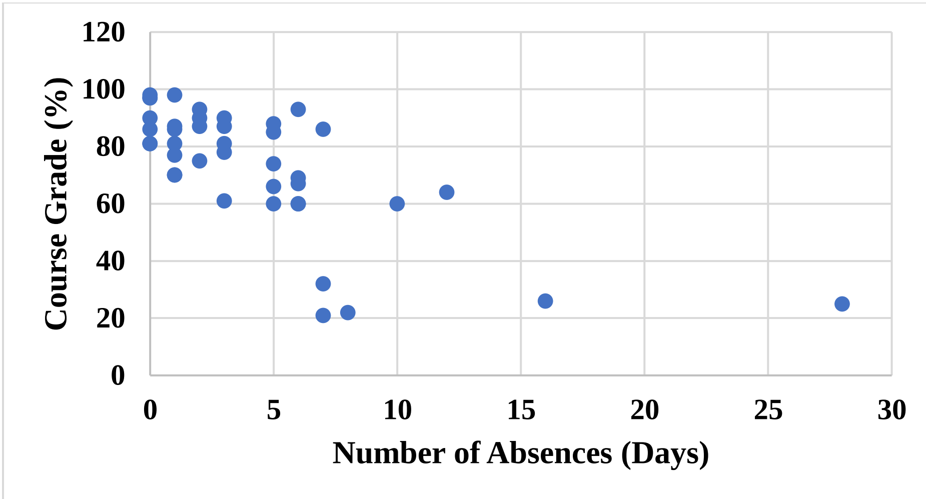

Figure 10: Semester class attendance correlation to course grade.

Table 7: Regression analysis of figure 10.

Regression Statistics	
Multiple R	0.69913
R Square	0.488783
Adjusted R Square	0.47533
Standard Error	3.772712
Observations	40

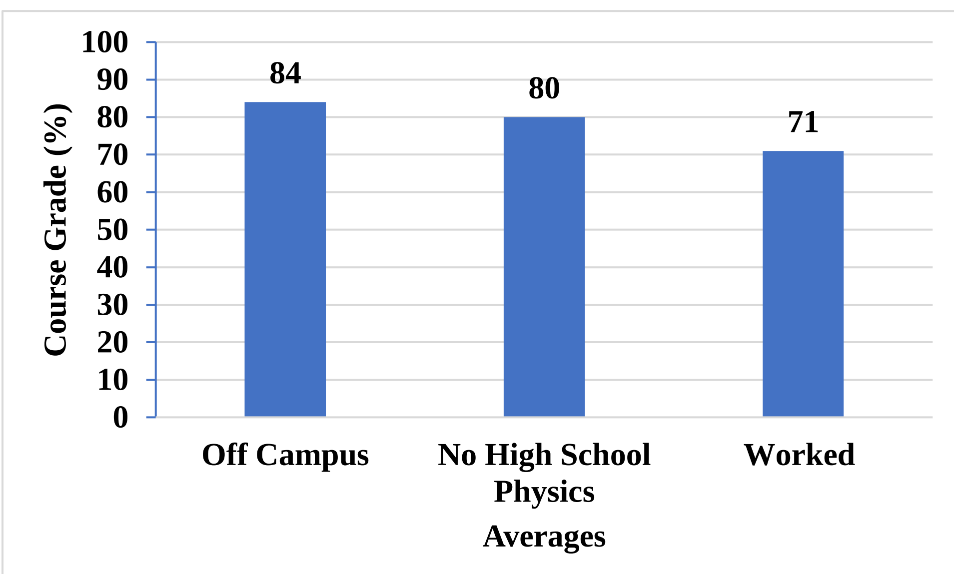

Figure 11: The average semester course grade for other non-academic factors, off campus students, students with no high school physics and students that worked during the fall semester.

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