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Original Paper

Which Investments Improve Student Performance? The Impact of Extracurricular Activities, Paid Classes, and At-Home Internet Use on Student Performance in Secondary School

Xin Gu[1], Sarah E. Pepin[2] & Paul D. Berger[1*]

[1] Marketing Department, Bentley University, Waltham, MA, USA

[2] GE Aviation, 100 Western Avenue, Lynn, MA, USA

* Paul D. Berger, Marketing Department, Bentley University, Waltham, MA, USA

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Abstract

The importance of education is acknowledged by modern society. As more and more people are willing to invest in education to improve students' performance, the question of which areas of investment contribute most strongly to better academic performance arises. Parents can choose to involve their children in extracurricular activities, or they can choose to pay for additional classes outside of regular schooling. In addition, the use of technology, or, more specifically, access to the Internet at home, is becoming more and more common, and its influence on student performance is a popular topic of study. In this paper, we use two experiments to uncover the factors that influence students' performance in Math and Portuguese Language and to support strategies for investment in education.

Keywords

education, paid classes, extracurricular activities, Internet, experimental design, ANOVA, Yates' Algorithm

1. Introduction

Due to limited resources, in many situations, we make choices. When it comes to educating children, parents want to invest in things which will positively affect their children's academic performance. If you only want to, or are only able to, pay for a few items to improve students' overall achievement in secondary education, which options should you choose? There are many factors that may influence student performance, such as family-related factors, demographics, personal ambitions of the student, etc.; however, we tend to have less ability to change these types of factors. Other factors, such as participating in extracurricular activities, attending extra classes, or deciding whether to have Internet at home, tend to be more choice-related. We want to explore these three factors to determine which investments are more effective in improving student performance in secondary school.

In order to estimate the effects of the aforementioned items, we designed two experiments (one for each of two dependent variables) and analyzed the results from the experiments. The data used in the experiments were collected in the 2005/2006 academic year, although the data were not entered onto a public website until 2014. The data include information on student achievement in secondary education in two Portuguese schools. Datasets are provided regarding student performance in two distinct subjects: Mathematics and Portuguese language. The data attributes include student grades, demographics, social and school-related features (Cortez & Silva, 2008).

2. Literature Review

An abundance of research has been conducted on the topic of how to improve students' performance. Shulruf (2011) analyzed whether extracurricular activities in secondary school can improve educational outcomes. The result of his analysis shows that, although there are associations between participation in extracurricular activities and educational outcomes, causal effects could not be confirmed.

Beuermann, Cristia, Cueto, Malamud, and Cruz-Aguayo (2015) conducted an experiment to test the short-term impacts of providing laptops to students for home use. Laptops were given randomly to 1000 students in 14 primary schools (with 14 control schools) in Lima, Peru. The results of this study indicated that there was no impact on academic achievement among the students who had received the laptops, although the teachers of these students reported that students with laptops put forth less effort (to achieve a similar result) than the other students. The study also noted that much of the home use was spent playing computer games; however, it is reported in the study that the games were educational in nature.

Huang (2013) studied the impact of after-school tutoring on student performance in both primary and secondary schools and across multiple countries. The focus of the tutoring was specifically in the subjects of math and science and performance was viewed from the national average. It was found in this experiment that after-school tutoring did improve the national average; interestingly, low performing students had a larger benefit from science tutoring, while high performing students saw a larger benefit from math tutoring.

In this paper, we concentrate on students' performance in secondary education and we focus on the factors in which people can invest and make a change quickly and easily; in this study, those factors are: (1) paid classes regarding a particular subject, (2) participation in extracurricular activities, and (3) Internet access at home (whether or not to pay for Internet service/home computer).

3. Method

There are two datasets in our analysis regarding the performance in two distinct subjects: Mathematics and Portuguese Language. We designed two three-factor experiments (i.e., two 2^3 experiments, one for each dependent variable/subject) to analyze the effects of the three factors on the performances in the two subjects.

3.1 Variables in the Experiments

3.1.1 Independent Variables

The independent variables we investigate for both subjects are listed below:

Factor A=Extracurricular Activities (Binary: Yes or No)

Factor B=Internet Access at Home (Binary: Yes or No)

Factor C=Paid Portuguese/Math Class (Binary: Yes or No)

3.1.2 Dependent Variables

Dependent Variable 1=Performance in Portuguese Language (scale: 0-20)

Dependent Variable 2=Performance of Math (scale: 0-20)

3.2 Analysis Process

3.2.1 Portuguese Language Grade

The first experiment was conducted on Portuguese Language Grade, which included 649 students. Plot 1 and Plot 2 in Figure 1 show the mean grades for students with or without extracurricular activities and the mean grades for students with or without internet access at home. On average, students with extracurricular activities performed better than those without it; students with internet access at home performed better than those without it. In addition, students without internet access at home had lower average grades than students without extracurricular activities.

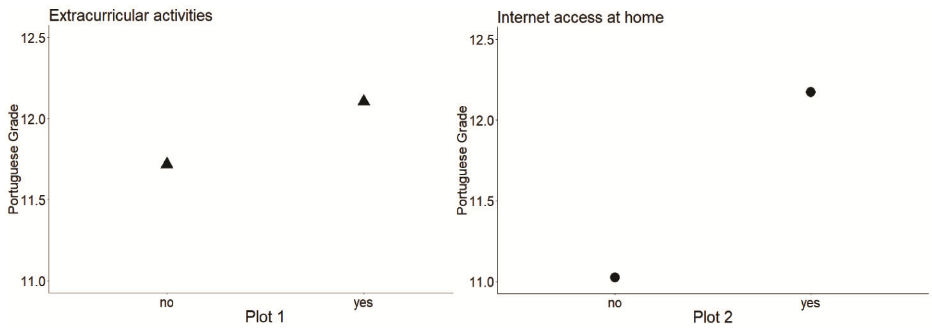

Figure 1. Plots of Portuguese Language Performance, with and without Extracurricular Activities and Internet Access at Home

Plot 3 in Figure 2 shows the mean grades for students with or without paid Portuguese Language classes. On average, students who attended paid Portuguese Language classes had lower grades than those who did not do so. This result does not necessarily mean that paid classes do not improve students' performance or, indeed, make performance even worse. It is also possible, indeed *likely*, that only those students with poor performance in Portuguese Language paid for additional Portuguese classes. We will discuss this further in the section on limitations of our study.

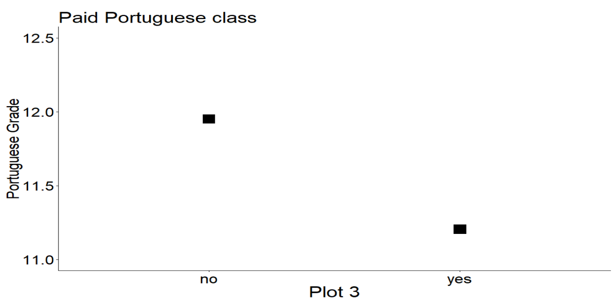

Figure 2. Plot of Portuguese Language Performance, with and without Paid Portuguese Classes

From the exploratory data analysis above, we can see that students' performance is potentially affected by all three factors. In order to uncover which factors are statistically significant for Portuguese Language achievement, we conducted a two-level, three-factor (i.e., 2^3) experiment.

The frequency of students in each treatment combination is shown in Table 1.

Table 1. Frequencies of Levels of Factors

		Factor A-Extra Curricular Activities			
		No		Yes	
		Factor B-Internet		Factor B-Internet	
		No	Yes	No	Yes
Factor C:	No	85	234	59	232
Paid Classes	Yes	4	11	3	21

The mean grades for each treatment combination are shown in Table 2:

Table 2. Mean Grade for Different Levels of the Factors

		Factor A- Extra Curricular Activities			
		No		Yes	
		Factor B-Internet		Factor B-Internet	
		No	Yes	No	Yes
Factor C:	No	11.09	12.03	11.19	12.38
paid classes	Yes	7.00	11.64	11.33	11.76

With the mean grade value for each treatment combination available, we can use Yates' Algorithm to calculate the main effect estimates and the interaction effect estimates from the data (Berger, Maurer, & Celli, 2018). The calculation process is displayed in Table 3. We also conducted a three-way ANOVA to test which effects are statistically significant; the results are shown in Table 4.

Table 3. Estimates of Effects—Yates' Algorithm

	yields	1st	2nd	3rd		
1	11.09	22.28	46.69	88.42	μ estimate	11.05
a	11.19	24.41	41.73	4.89	A Effect estimate	1.22
b	12.03	18.33	0.44	7.20	B Effect estimate	1.80
ab	12.38	23.40	4.45	-3.95	AB Effect estimate	-0.98
c	7.00	0.09	2.13	-4.96	C Effect estimate	-1.24
ac	11.33	0.35	5.07	4.01	AC Effect estimate	1.00
bc	11.64	4.33	0.26	2.94	BC Effect estimate	0.74
abc	11.76	0.12	-4.21	-4.47	ABC Effect estimate	-1.12

Table 4. Three-Way ANOVA

Tests of Between-Subjects Effects

Dependent Variable: PorGrade

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	240.637[a]	7	34.377	3.378	.002
Intercept	10298.685	1	10298.685	1012.085	.000
paid	32.383	1	32.383	3.182	.075
activities	31.635	1	31.635	3.109	.078
internet	68.165	1	68.165	6.699	.010
paid * activities	21.257	1	21.257	2.089	.149
paid * internet	11.357	1	11.357	1.116	.291
activities * internet	20.560	1	20.560	2.020	.156
paid * activities * internet	26.259	1	26.259	2.581	.109
Error	6522.629	641	10.176		
Total	98761.000	649			
Corrected Total	6763.267	648			

a. R Squared = .036 (Adjusted R Squared = .025)

The analysis results above show that when the significance level is set at 0.05 (Type I error rate is 5%, as is traditional), Internet access at home is significant (p-value is 0.010, less than 0.05), which means there is sufficient evidence to conclude that the students' performance in Portuguese Language is different due to having Internet access at home or not. The effect of internet access at home is estimated at +1.80, which means this factor has a positive impact on the students' performance in Portuguese Language. That the effect is positive was also seen earlier in Plot 2. The other factors are not "officially" significant at =.05, but are quite close to significant, at values of .075 and .078. Indeed, we often think of p-values between .05 and .10 as close enough to significant as to view the results as providing enough evidence perhaps to "reserve judgment", or collect more data. The effects are +1.22 for the extra-curricular activities, and –1.24 for the paid classes, neither value *that much* below (in magnitude) the 1.80 for the Internet.

3.2.2 Math Grade

The second experiment was conducted on Math Grade, which included 395 students. Plot 4 and Plot 5 show the mean grades for students with or without extracurricular activities and the mean grades for students with or without internet access at home. On average, students who participated in extracurricular activities performed better than students who did not participate in extracurricular activities. On average, students with internet access at home performed better than those without it. In addition, students without internet access at home have lower average grades than students who do not participate in extracurricular activities.

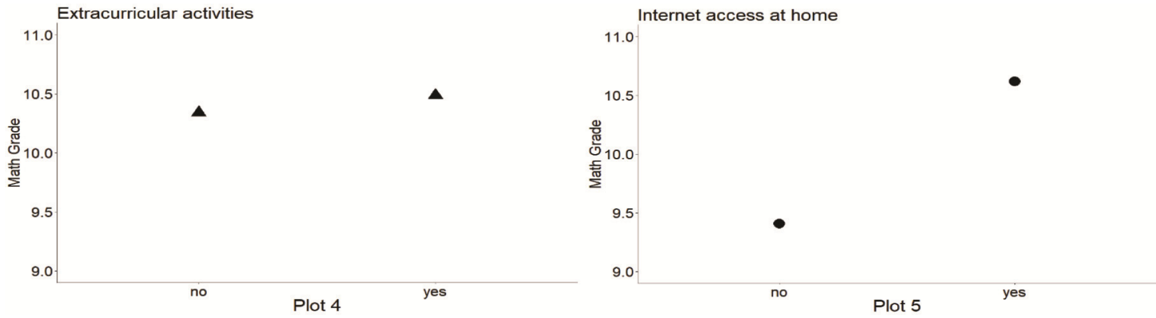

Figure 3. Plot of Math Performance, with and without Extracurricular Activities and Internet Access at Home

Plot 6 in Figure 4 shows the mean grades for students with or without paid math classes in our sample data. On average, students who attended paid math classes have higher grades than those who did not attend such classes.

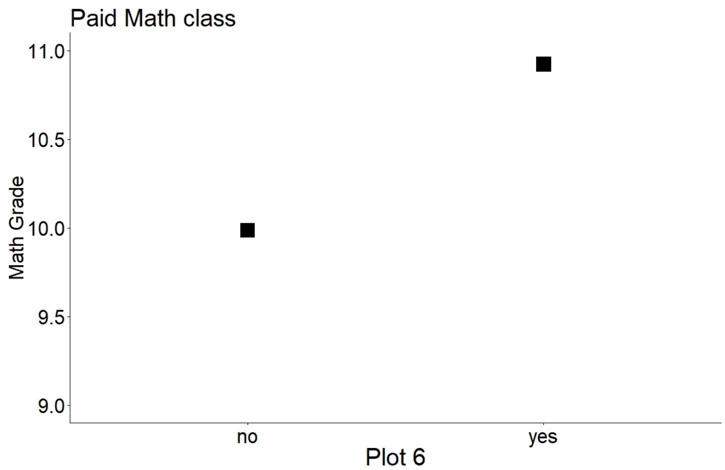

Figure 4. Plot of Math Performance, with and without Paid Math Classes

Similar to the Portuguese Language grade analysis, from the exploratory data analysis above, we can see students' performance is potentially affected by all three factors, although, indeed, Plot 4 in Figure 3 would indicate that there is *likely* not a significant difference associated with extra-curricular activities. To identify which factors are statistically significant with respect to math achievement, we conducted a similar 2^3 experiment.

The frequency of students in each treatment combination is shown in Table 5.

Table 5. Frequencies of Levels of Factors

		Factor A- Extra Curricular Activities			
		No		Yes	
		Factor B- Internet		Factor B- Intenet	
		No	Yes	No	Yes
Factor C: Paid Classes	No	22	81	25	86
	Yes	14	77	5	85

The mean grades for each treatment combination are shown in Table 6:

Table 6. Mean Grade for Different Levels of the Factors

		Factor A- Extra Curricular Activities			
		No		Yes	
		Factor B- Internet		Factor B- Internet	
		No	Yes	No	Yes
Factor C: Paid	No	8.36	10.41	9.28	10.21
Classes	Yes	10.57	10.79	11.4	11.07

Again, with the mean grade for each treatment combination available, we can use Yates' Algorithm to calculate the main effect estimates and the interaction effect estimates in the sample. The calculation process is displayed in Table 7. As earlier, we also conducted a three-way ANOVA to test which effects are statistically significant; the results are shown in Table 8.

Table 7. Estimates of Effects—Yates Algorithm

	yields	1st	2nd	3rd		
1	8.36	17.64	38.26	82.09	μ estimate	10.21
a	9.28	20.62	43.83	1.83	A Effect estimate	0.46
b	10.41	21.97	0.72	2.87	B Effect estimate	0.72
ab	10.21	21.86	1.11	-1.67	AB Effect estimate	-0.42
c	10.57	0.92	2.98	5.57	C Effect estimate	1.40
ac	11.40	-0.20	-0.11	0.39	AC Effect estimate	0.10
bc	10.79	0.83	-1.12	-3.09	BC Effect estimate	-0.77
abc	11.07	0.28	-0.55	0.57	ABC Effect estimate	0.14

Table 8. Three-Way ANOVA

Tests of Between-Subjects Effects

Dependent Variable: matGrade

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	181.109[a]	7	25.873	1.238	.281
Intercept	16615.825	1	16615.825	794.966	.000
paid	76.596	1	76.596	3.665	.056
activities	8.213	1	8.213	.393	.531
internet	20.229	1	20.229	.968	.326
paid * activities	.372	1	.372	.018	.894
paid * internet	23.414	1	23.414	1.120	.291
activities * internet	6.832	1	6.832	.327	.568
paid * activities * internet	.785	1	.785	.038	.846
Error	8088.799	387	20.901		
Total	51118.000	395			
Corrected Total	8269.909	394			

a. R Squared = .022 (Adjusted R Squared = .004)

The analysis results above show that when the significance level is set at 0.05 (Type I error rate is 5%), no factors are "technically" significant. The p-values for Internet access at home and extracurricular activities are much greater than 0.05, so there is no basis to conclude that students' performance in math is different due to these two factors.

However, we notice that, for paid math classes, the p-value is 0.056, only slightly greater than 0.05; therefore, this factor is at the margin of statistical significance. Since it is so close to being statistically significant at 5% significance level, based on the effect estimate (1.40) and the ANOVA result, we are comfortable suggesting that paid math classes may well have a *positive* impact on the students' performance in math.

4. Analysis and Discussion of the Results

The results of our analysis indicate that Internet access at home is significant at the .05 significance level for performance in Portuguese Language (p-value=.01), but not significant for performance in math (p-value=.326). We should give consideration to this difference to determine whether the results make sense. We could reasonably conclude, based on empirical evidence, that it is more likely that students in secondary school who have access to the Internet at home are not using the Internet to improve their math skills; we could also reasonably conclude that high school students are more likely to use the Internet for things like social media, computer games (Beuermann, Cristia, Cueto, Malamud, & Cruz-Aguayo, 2015), or for typing homework assignments. The nature of activities such as engaging in social media and typing homework assignments may contribute to improving students' performance in their Portuguese Language classes; if they are continuously reading and writing Portuguese, then we could reasonably argue that this continuous "practice" of reading and writing (albeit perhaps unintentional practice) could contribute to better performance in students' Portuguese Language classes. Since math and Portuguese Language are very different subjects, and it is less likely that students would take the initiative to use their home Internet access for improving their math skills, we can again reasonably conclude that the lack of impact of home Internet access on math grades makes sense.

We should also discuss the difference between our results and the results from the study done by Beuermann, Cristia, Cueto, Malamud, and Cruz-Aguayo (2015). In their research, a random sample of students were given laptops for home use; the results indicated the impact of the laptops on student performance was not significant. The laptops did not come with Internet access, so we cannot determine from the results of their study whether the students who were given laptops for home use had Internet access at home. We also cannot determine whether the students who were not given laptops had Internet access at home. Since our study is specific to the Internet and not to the presence/absence of computers in the home, we believe that our findings of significance for improvement in Portuguese Language not only make sense, but do not necessarily conflict with the findings of Beuermann, Cristia, Cueto, Malamud, and Cruz-Aguayo (2015), as the focus of the two studies differed. Indeed, our analysis shows that Internet access at home is significantly beneficial for Portuguese Language, but not for math. This difference could be due to the nature of the two subjects. So, our findings uncovered the impact of Internet access for improvement in one particular subject, versus improvement in overall academic performance.

Our results indicate that paying for additional math classes is close to significant at a significance level of .05 (p-value=.056). Given our results, we cannot technically say that paying for additional math classes is significant at the .05 level; however, since the purpose of our analysis is to determine where we should invest our resources to improve student performance, we do not believe we should discard these results as unimportant from a practical standpoint. Compared with the other two factors, there is a relatively greater positive impact on students' performance in their math grades when we invest in additional math classes outside of regular schooling. The result we obtained for additional paid classes in

Portuguese Language was also close to significant at p=.05, but not as close as for math grades.

Further, in the research done by Huang (2013), the results indicated that after school tutoring in different subjects had different impacts, depending on whether the student was a high performer or a low performer in the particular subject. The study found that science tutoring had a larger impact for students who struggled in science and that math tutoring had a larger impact for students who were already strong performers in their math classes. Our analysis does not explore this type of difference; however, we do not believe that it would be unreasonable for us to discover similar results-that tutoring in certain classes has a larger impact for higher/lower performing students in those subjects. For the scope of our analysis, we believe that the marginal significance for paying for additional math classes is practically significant, and that there is merit to investing in additional paid math classes to improve student performance in math grades; this may also be the case for the Portuguese Language, but the evidence is not quite as convincing as it is for math.

Lastly, for performance in both Portuguese and math, the results of extracurricular activities are not significant at .05 significance level (the p-value is .078 and .531, respectively); as we noted earlier, the p-value for the Portuguese Language is not too far from .05, which indicates that generally speaking, the students' performance is not different due to having extracurricular activities for math grades, but may well have an impact on Portuguese Language grades. We will further explore the analysis on extracurricular activities in next section.

5. Limitations and Directions for Further Research

We acknowledge some of the limitations of our paper. First, the data used in our analysis is secondary data; thus, the data was not collected to answer our specific research questions. Correspondingly, perhaps the most limiting aspect of the paper is that the data are not randomized. That is, whoever chose to pay for classes, indeed, paid for classes; whoever engaged in extra-curricular activities, indeed, did so; etc. Obviously, the ideal case, if it is possible, is to *randomly assign* students to each of the eight treatment combinations, rather than the data generation being consummated by self-selection. We do not believe that random assignment was feasible at the time of the data generation. We briefly discussed this issue earlier in the paper when examining the results depicted in Plot 3, in Figure 2, concerning paid Portuguese Language classes. However, we believe that the data are sufficient for our current analyses, and our results and findings are valid, as long as we acknowledge that this limitation exists.

In future research, we would like to collect randomly assigned primary data to customize our experiment, along with a larger sample size, and additional independent variables (factors) to enhance and refine the results of our current analysis.

Second, as mentioned in our discussion of the results, let us consider the factor, extracurricular activities. Our measure for engagement in extracurricular activities is strictly binary. We do not have knowledge of whether the student participated in one activity or in multiple activities, nor do we know the type of activity/activities in which the student participated. We believe that knowledge of both of these factors would better explain the impact of participation in extra-curricular activities (if any) on student performance. For example, we believe it could be reasonably argued that a student who participated in a math club is more likely to see a positive impact on his/her math grade than is a student who plays on the high-school football (soccer) team. It could also be reasonably argued that a student who engages in multiple extracurricular activities would have less time to focus on his/her studies and may thus see a decline in performance/grades.

We believe that it is reasonable to suggest the knowledge of the number and type(s) of activities in which students participate may better explain the relationship between extracurricular activities and performance; we would like to explore the impact of the number and type of extracurricular activities in future research in order to perform an analysis with increased granularity.

In addition, we are interested in studying the level of the impact in student performance before and after participating in additional paid classes. For example, is a student with a C average in math able to obtain an A or a B after he/she attends math tutoring, or is the impact marginal (say, a C+)? We are also curious about the impact of additional paid tutoring on performance when the student attends a public school versus a private school. These questions can be addressed by examining interaction effects in a designed experiment, possibly a *fractional*-factorial experiment.

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