Is there an Inverse Relationship Between Study Time and Final Exam Scores? Evidence from Principles of Economics

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In this paper, we examine how well the number of hours spent studying per week, and ability - math ability as measured by scores on an formative Algebra I assessment and students' SAT Math scores, and study skills - predict students' final exam scores in a Principles of Economics class. We first evaluate the effect of number of study hours on final exam scores in a Principles of Economics class in the Fall of 2014 with a sample of 694 students. Other studies have used self-reports to evaluate students' study time. However, self-reports may be exaggerated as a student may not want to admit that she/he does not study sufficiently. To avoid inflated self-reports of number of hours spent studying, we asked students to report both their own study time as well as their estimate of the number of hours they thought their classmates would spend studying for the course in the coming semester. Since this question was asked at the end of the Fall semester of freshman year, we thought students would base their estimate of their classmates' study time on their own actual study hours during the semester.

Controlling for student ability using SAT Math and SAT Verbal scores, our initial results for the Fall semester show a strong negative relationship between hours of study and the student's final exam score. The magnitude is larger for study hours during non-exam weeks than it is during exam weeks. One interpretation of the results might be that students who have lower math ability and/or poor study skills perceive they are in need of studying more. Both SAT Math and Verbal scores have a significant positive effect on students' final exam performance. An extra point increase in a student's SAT Math score increases the student's final exam score by 0.08 which is about 0.05 larger than the increase from the SAT Verbal score. The results are robust given gender, ethnicity, class standing and students' performance on a formative Algebra I Assessment given at the start of the semester.

One interpretation of the results might be that those who report higher study times for others, themselves actually put in more hours of study or perceive they are in need of studying more. This may be true of learners with lower math ability and weak study skills. Can students compensating with time for lower math ability? Our results indicate that in general they cannot. Further, we evaluate if high ability and low ability students choose different study methods. Are low ability students spending time studying effectively? We see there is a distinct difference in the study methods that high ability vs. low-ability students choose and that attendance at lectures or discusion sections is, in fact, a study strategy used by high-ability students. In fact, low-ability students may not fully understand what "studying" is. Can low ability students compesnsate by studying much more during exam weeks? Our results show that they cannot.

Previous Work in this Area

Prior studies have found it difficult to establish a positive relationship between study time and students' grades in a class. Over the course of a 10-year period, Schuman et al. (1985) used four different measurement approaches at the University of Michigan and found that none of the approaches were successful at producing the desired result. Studies at other universities by Hill (1991) and Rau and Durand (2000) produced similar results.

Some studies have found no significant effects of study time on students' grades in a class. Plant et al (2005) posit that the amount of study by college students is a poor predictor of academic performance. The amount of study emerges as a predictor of cumulative GPA only when *both* the quantity and quality of study and prior knowledge and skills are taken into consideration.

Stinebricker & Stinebrickner (2005) found it may be difficult to establish the relationship since many confounding factors such as race, friends, roommates with video games, class attendance, work etc play a role in the relationship between studying and course grade. Stinebrickner and Stinebrickner (2008) estimated the causal effect of studying on the GPA of two groups of freshmen using data obtained from a diary kept by the students. They found no important differences in class attendance or study efficiency between the two groups of students (identical except for the fact that one group had roommates who had brought a video game to college), but did find that study time mattered. Their instrumental variable estimate showed that one additional study hour increased GPA by 0.36 points.

In another study of student test scores in macro principles, Bonesrønning and Opstad (2012) found that increased study effort improves test scores but the study time effect was smaller than that reported by Stinebrickner and Stinebricker (2008). This was attributed to the fact that this study looks at test scores in a specific class rather than GPA measured across several classes.

This paper differs from previous research by looking at cumulative final exam scores rather than cumulative GPAs or course grades. A cumulative final exam score may the best measure of how much student has learned in the course as it does not incorporate any homework, extra credit or other types of grades that may not fully reflect the student's knowledge of the course material. For example, the students may be working on homework assignments with large groups of friends who give him/her the solutions.

Besides SAT Math and Verbal scores to identify innate student ability, we have a specific measure of prior knowledge and abilities needed to succeed in the course - scores on the Algebra I Assessment as well as whether students have had AP Economics. None of the other studies has looked at the effect of this measure of performance on final exam scores in comparison to study time.

Although we did not ask for daily logs of time consumption, we asked for self-reports of their own study time as well as a proxy measure - an estimate of how much their friends in the class studied. Other papers cited the difficulty of getting students to complete these daily logs.

Our results are quite different from results of previous research.

Methodology

I. Data

Data was collected from students in three large sections of Principles of Economics, which included 694 students in total. All students were required to take a formative Algebra I Assessment at the beginning of the Fall semester. Algebra I is a prerequisite for the course. The assessment is a simple 45-minute test which covers four topics: arithmetic, algebra, geometry and graphing. All questions are open response and students are not allowed to use calculators. To Pass (show proficiency in Algebra I), students needed to score at least 80% (get 16 out of 20 questions correct). Students have three opportunities to pass the assessment between August and September. Students who cannot pass the assessment even after three attempts lose roughly 10% of their course grade. We use the number of attempts needed to pass the assessment and students' scores on their first attempt as measures of their learning ability. Gender information was collected from a questionnaire on the front page of the assessment.

In December 2014, 686 students from our sample took the final exam in Principles of Economics while 684 students participated in a survey of their study hours. We administered the survey at the beginning of the final exam. Students were informed that their answers to the survey questions would not be related to their final exam score. The survey was collected in the classroom and contained information on students' own study hours during weeks with and without exams, their estimate of their classmates' study hours during weeks with and without exams, their expected grade in the course and their ranking of different modes of study used (i.e., group study, study alone, tutoring, Teaching Assistants or Professor's office hours and others). Teaching Assistants in the course recorded student's attendance at discussion sections. This is used as another measurement of students' study time.

The university provided data on students' class levels and ethnicity as well as students' SAT Math and Verbal scores. We introduce them as control variables, since they could also affect students' learning results. The summary of the data is attached in the Appendix.

II. Estimation

We first want to estimate the effect of individuals' study hours on their final exam scores. The following is the simple ordinary least squares (OLS) equation we used for the initial estimation. We control for students' study ability in the regression using their SAT Math and Verbal scores. Our main interest is the coefficient of students' self study hours.

$$FinalScore_i = \alpha + \beta SelfStudyHours_i + \psi X_i + \varepsilon_i \quad (1)$$

$$E(SelfStudyHours_i \varepsilon_i) = 0 \quad (2)$$

Equation (1) would estimate the effect of students' hours of study on their final exam results correctly only if there are no measurement errors in the self-reported hours. That is, if equation 2 holds. However, we expect students who are less qualified for the course to report higher hours of self-study because they want to make a good impression on instructors. On the other hand, students might also have a propensity to report lower hours than actual due to some insensitivity to the passage of time. Either situation will cause a bias in the OLS estimation. To address this problem, we asked students to evaluate their classmates' study hours. We then use it as an instrumental variable (IV) for students' self-reported study hours.

$$SelfStudyHours_i = \rho + \pi OtherStudyHours_i + \kappa X_i + \xi_i \quad (3)$$

$$FinalScore_i = \gamma + \delta SelfStudyHours_i + \gamma X_i + \eta_i \quad (4)$$

Equation 3 is the first-stage estimation where we show the relationship between students' own study hours and their reports of classmates' study hours. Equation 4 is the main estimation in this study. The variable of students' self study hours is instrumented by their reports of classmates' study hours in the estimation. Our assumption is that students' report of classmates' study hours is highly correlated with their own study hours and satisfies the exclusion restriction.

III. Results

Table 1 shows the initial OLS estimation results based on students' self-reported study hours. Since 88% of students taking Principle of Economics are freshmen, we use their SAT Math and Verbal scores as a measure of their pre-college study abilities. Hours of study, either during the non-exam or exam weeks, do not have a significant effect on final exam grades. The sign of the effect, however, is consistently negative even when we control for pre-college study ability. We interpret this initial result with caution. It shows that an extra self-study hour reported by students is negatively correlated with their final exam scores. Due to the existence of measurement error as discussed earlier, the OLS estimated coefficient of study hours is biased towards zero.

Table 1: Students' Self-Reported Own Study Hours
Dependent Variable: Final Exam Scores

	(1)	(2)	(3)	(4)	(5)	(6)
Study Hours	-0.4369*	-0.1144	-0.0565			
	(0.1811)	(0.2134)	(0.2122)			

	(1)	(2)	(3)	(4)	(5)	(6)
Study Hours (Exam Week)				-0.1934* (0.0765)	-0.0865 (0.0866)	-0.0977 (0.0859)
SAT Math		0.0822*** (0.0087)	0.0813*** (0.0087)		0.0832*** (0.0087)	0.0815*** (0.0087)
SAT Verbal			0.0245** (0.0076)			0.0243** (0.0075)
_cons	72.6279*** (0.8877)	17.0267** (6.0040)	1.7643 (7.5970)	72.8647*** (0.9349)	16.7947** (6.0169)	2.5399 (7.4275)
N	680	517	517	678	515	515

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

We use students' reports of classmates' hours of study in Principles of Economics as an instrumental variable (IV) for their own study hours. Students' report of others' hours of study is positively correlated with their own study hours as shown in Table 2. The effect is significant and the magnitude is around 0.8.

Table 2: Correlation Between Self and Others' Study Hours
Dependent Variable: Self Study Hours

	Non Exam Week			Exam Week		
	(1)	(2)	(3)	(4)	(5)	(6)
OtherStudyHours	0.8076*** (0.0277)	0.7491*** (0.0338)	0.7470*** (0.0338)			
OtherStudyHours (Exam Week)				0.8669*** (0.0290)	0.8160*** (0.0327)	0.8155*** (0.0328)
SAT Math		-0.0033* (0.0013)	-0.0032* (0.0013)		-0.0068* (0.0031)	-0.0069* (0.0031)
SAT Verbal			-0.0013 (0.0012)			0.0007 (0.0027)
_cons	0.7386*** (0.1343)	3.0554*** (0.8979)	3.8277*** (1.1421)	1.7952*** (0.3341)	6.6855** (2.1073)	6.2741* (2.6421)
N	631	481	481	619	474	474

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

Table 3 shows the result of the IV estimation. Hours of study have a consistently negative effect on the final exam score.The magnitude is larger for study hours during non-exam weeks than it is during exam weeks. One interpretation of the results might be that students who have lower

math ability perceive they are in need of studying more. This can be seen when we use the SAT score as a measure of students' ability. Both SAT Math and Verbal scores have a significant positive effect on students' final exam performance. In addition, an extra point increase in a student's SAT Math score increases the student's final exam score by 0.08 which is about 0.05 larger than the increase from the SAT Verbal score. Another reason may be students' weak study skills. We will explore students' methods of study in the Discussion section.

Table 3: IV Estimation: Student Reported Classmates' Study Hours
Dependent Variable: Final Exam Score

	(1)	(2)	(3)	(4)	(5)	(6)
Study Hours	-0.7463**	-0.6266*	-0.5685			
	(0.2520)	(0.3124)	(0.3099)			
Study Hours (Exam Week)				-0.2650*	-0.2148	-0.2439*
				(0.1045)	(0.1190)	(0.1178)
SAT Math		0.0816***	0.0804***		0.0835***	0.0811***
		(0.0093)	(0.0092)		(0.0093)	(0.0092)
SAT Verbal			0.0265***			0.0298***
			(0.0079)			(0.0080)
_cons	73.7268***	19.4664**	3.1308	73.4783***	17.9372**	0.7503
	(1.1466)	(6.5554)	(8.1997)	(1.2078)	(6.5377)	(7.9147)
N	631	481	481	619	474	474

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

IV. Robustness Check

We next show evidence that the results are robust. Because of the measurement errors discussed earlier, we will use IV estimation.

In Table 4 , we include gender in our regression. Male students and female students may have different levels of efficiency in managing their time. After controlling for gender, our results are still robust. Both students' reported study hours during non-exam weeks and during exam weeks are negatively correlated with their final exam scores, although only the result for exam weeks is statistically significant. The results show that when reported study time during the exam week is increased by one hour, a student's final exam score will decrease by 0.25 points controlling for gender. We also find that, on average, female students get a higher score on the final exams compared to male students, although this result is not statistically significant.

Table 4: Robustness Check: Gender
Dependent Variable: Final Exam Score

	(1)	(2)
Study Hours	-0.559	
	(-1.81)	
Study Hours (Exam Week)		-0.247*
		(-2.11)
SAT Math	0.0821***	0.0826***
	(8.94)	(8.95)
SAT Verbal	0.0271***	0.0304***
	(3.42)	(3.81)
Female	2.211	2.109
	(1.88)	(1.80)
_cons	0.532	-1.519
	(0.06)	(-0.19)
N	481	474

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

We also consider whether a student's year in college (freshman, sophomore, junior or senior) will affect their ability to manage their time. Do students with higher class standing tend to use their time more efficiently as they are more used to college life? Table 5 shows that when we include students' class levels in our regression our results still do not change. Their study hours during the non-exam weeks and exam weeks are both negatively correlated with their final exam scores. Also only students' study hours during exam weeks are statistically significant. Our result shows that each additional hour they spent in study during an exam week is correlated with a 0.24 point decrease in their final exam score when we control for class standing. We also find that, on average, higher class level students tend to have higher final exam scores than lower class level students, although the result is not statistically significant.

Table 5: Robustness Check: Class Standing
Dependent Variable: Final Exam Score

	(1)	(2)
Study Hours	-0.570	
	(-1.84)	
Study Hours (Exam Week)		-0.244*
		(-2.07)
SAT Math	0.0804***	0.0811***
	(8.74)	(8.80)

SAT Verbal	0.0261**	0.0295***
	(3.28)	(3.68)
Sophomore	1.171	0.928
	(0.56)	(0.44)
Junior	3.456	1.556
	(0.46)	(0.24)
Senior	4.150	3.539
	(0.56)	(0.48)
_cons	3.244	0.850
	(0.39)	(0.11)
N	481	474

Standard errors in parentheses

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Next, we want to test whether ethnicity will change our result. From our pilot interviews with some Principles faculty, we learned that Asian students tend to spend more time on study than other students. After taking the ethnicity into consideration, our results remain the same as seen in Table 6 - students' reported study hours are negatively correlated with their final exam scores. This is true for both non-exam week and exam week, while both results are not statistically significant.

Table 6: Robustness Check: Ethnicity

Dependent Variable: Final Exam Score

	(1)	(2)
Study Hours	-0.551	
	(-1.79)	
Study Hours (Exam Week)		-0.197
		(-1.65)
SAT Math	0.0781***	0.0799***
	(7.73)	(8.04)
SAT Verbal	0.0369***	0.0393***
	(3.89)	(4.09)
Asian	1.743	0.922
	(0.55)	(0.29)
Black or African American	5.131	4.121
	(1.21)	(0.96)

Hispanic or Latino	5.974	5.209
	(1.78)	(1.53)
Nonresident alien	7.699*	6.752*
	(2.43)	(2.10)
Two or More Race Codes	5.357	4.228
	(1.45)	(1.14)
White	4.774	4.032
	(1.76)	(1.46)
_cons	-6.923	-9.045
	(-0.77)	(-1.03)
N	481	474

Standard errors in parentheses

* p<0.05 ** p<0.01 *** p<0.001

Besides SAT scores, we also include students' scores on their first attempt of the Algebra I assessment and the number of attempts they needed to pass the assessment as measurements of their ability. In Table 7, our results are still the same as before. Study hours are negatively correlated with their final exam scores and students' ability are positively correlated with them. Our result shows that one point increase in their score on their first attempt of the math assessment is correlated with 1.83-1.79 points increase in their final exam score. Also, compared to the students who pass the assessment in their first attempt, students who passed the assessment in the second attempt will. on average, have a lower final score by 5.79-6.15 points, while a student passed in the third attempt will have a lower score by 4.57-4.75 points, and students who failed assessment will have a lower score by 13.67-13.21 points.

Table 7: Robustness Check: Measurement of Ability
Dependent Variable: Final Exam Score

	(1)	(2)	(3)	(4)
Study Hours	-0.320		-0.430	
	(-1.07)		(-1.41)	
Study Hours (Exam Week)		-0.132		-0.194
		(-1.16)		(-1.67)
SAT Math	0.0410***	0.0430***	0.0613***	0.0632***
	(3.92)	(4.10)	(6.05)	(6.22)
SAT Verbal	0.0233**	0.0256***	0.0256**	0.0282***
	(3.08)	(3.34)	(3.28)	(3.57)

Score on the First Attempt	1.832***	1.794***		
	(6.76)	(6.66)		
Pass in the Second Attempt			-6.150*	-5.792*
			(-2.53)	(-2.43)
Pass in the Third Attempt			-4.738**	-4.567**
			(-2.94)	(-2.85)
Fail			-13.67**	-13.21**
			(-3.05)	(-2.81)
_cons	-0.751	-2.701	17.32*	14.64
	(-0.10)	(-0.36)	(1.99)	(1.72)
N	481	474	481	474

Standard errors in parentheses

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Finally, we expand our sample by including the outliers. Some students answered the survey questions with extremely high study hours, for example, 100 hours per week and 200 hours per week. In our baseline regression, we exclude these observations since we think that these answers are not quite reliable. Just in case their answers reflect their real own approximation, we include these observations in our robustness check. Table 8 shows that our results still hold. Students' reported study hours are negatively correlated with their final exam scores both during non-exam weeks and exam weeks. The result is statistically significant only for exam weeks. A one hour increase in a student's reported study hours during an exam week is correlated with a 0.15 point decrease in their final exam score.

Table 8: Robustness Check: Outliers
Dependent Variable: Final Exam Score

	(1)	(2)
Study Hours	-0.0322	
	(0.1232)	
Study Hours (Exam Week)		-0.1532**
		(0.0545)
SAT Math	0.0843***	0.0820***
	(0.0090)	(0.0091)
SAT Verbal	0.0273***	0.0289***
	(0.0079)	(0.0080)
_cons	-2.1175	-0.0732

	(7.7393)	(7.7015)
N	483	476

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

Discussion

Non-Linear Relationship

Our main results are based on the linear regression. To better understand the effect of study time on final exam scores, we examine the possibility of a non-linear relationship between them. We add the squared term of students' own study hours and their reports of classmates' study hours into the IV estimation. The result is shown in Table 9.

Table 9: Non-Linear Relationship of Study Hours and Final Exam Score

Dependent Variable: Final Exam Score

	(1)	(2)	(3)	(4)
Self Study Hours (Exam Week)	-0.106 (-0.24)		-0.460 (-0.95)	
Sq. Self Study Hours (Exam Week)	-0.00490 (-0.36)		0.00666 (0.45)	
Self Study Hours		-2.265*** (-3.50)		-2.306** (-2.90)
Sq. Self Study Hours		0.0696** (2.67)		0.0824* (2.50)
SAT Math			0.0805*** (8.60)	0.0753*** (7.80)
SAT Verbal			0.0303*** (3.73)	0.0234** (2.84)
_cons	72.59*** (27.39)	78.12*** (37.25)	2.101 (0.25)	13.46 (1.42)
N	619	631	474	481

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

There is no significant non-linear relationship between students' study hours during an exam week and their final exam score. The effect of squared study hours during a non-exam week on the final exam score is significantly positive. The final exam score decreases as students' regular study hours increase but starts to increase afterward. Regular study time (during a non-exam week) for high ability students is not higher than for other students. They can get good grades

with about the same amount of study time. On the other hand, students who are behind others in terms of ability, are in need of much more study time in an average week in order to obtain better grades.

Compensating with Time for Low Ability

Can students compensate for lower ability with time? Are the magnitudes of these two effects the same? Since study time and ability are measured using different scales, we transform all the variables in our regression into z-scores using the following formula to run the regression again.

$$Z = \frac{x - \mu}{\sigma}$$

Here Z is the z-score, x is the variable of interest, μ is the mean of the population, and σ is the standard deviation of the population.

Results in Table 10 show that study time is negatively correlated with students' final exam scores while math ability is positively correlated with them. Comparing the coefficients before explanatory variables, we can see that the effect of SAT Math on the final exam score is greater than that of study hours, while the effect of SAT Verbal on the final exam score is smaller than that of study hours. This is true in both the non-exam week and the exam week. Students' first attempt score on the math assessment also has a strong positive effect on their final exam score. And this effect is greater than that of their study time. So the answer to the question that we asked earlier seems to be no - in general, students cannot compensate for low ability with time.

Table 10: Discussion Magnitudes of Different Effects (Z-Score)

Dependent Variable: Final Exam Score

	(1)	(2)	(3)	(4)
Study Hours	-0.1817		-0.1023	
	(0.0990)		(0.0952)	
Study Hours (Exam Week)		-0.1745*		-0.0945
		(0.0843)		(0.0813)
SAT Math	0.3598***	0.3630***	0.1835***	0.1922***

	(0.0411)	(0.0412)	(0.0468)	(0.0468)
SAT Verbal	0.1324***	0.1493***	0.1165**	0.1280***
	(0.0397)	(0.0401)	(0.0378)	(0.0383)
Score on the First Attempt			0.3219***	0.3154***
			(0.0476)	(0.0473)
_cons	0.0250	0.0264	0.0129	0.0197
	(0.0400)	(0.0400)	(0.0380)	(0.0381)
N	481	474	481	474

Standard errors in parentheses

* p<0.05 ** p<0.01 *** p<0.001

Do Study Methods Matter?

Often, students seem to spend a lot of time studying without getting the good grades they desire. One reason may be the inefficiency of their study methods. We asked students to rank their methods of study for the course from the most used to the least used. We select the one that students report as the most used to test the correlation with their final exam scores.

Table 11 shows that compared to students who usually prefer to study by themselves, students who choose to study with others, go to professor's or teaching assistants' office hours or working with tutors tend to have lower final exam scores. The result is not statistically significant. We interpret it here as a tendency.

Table 11: IV Estimation: Study Method on Final Exam Score

Dependent Variable: Final Exam Score

	Non Exam Week	Exam Week
	(1)	(2)
Study Hours	-0.5639	
	(0.3109)	
Study Hours (Exam Week)		-0.2523*
		(0.1199)
SAT Math	0.0796***	0.0795***
	(0.0093)	(0.0094)
SAT Verb	0.0267**	0.0291***
	(0.0082)	(0.0083)
Study Method (Base: Study Alone)		
Group Study	-2.4284	-1.7452
	(1.5033)	(1.5186)
Office Hours	-4.9001	-5.2010
	(4.3272)	(4.3145)
Tutor	-2.7368	-1.8826
	(3.3178)	(3.5362)
_cons	4.1384	2.8207
	(8.3765)	(8.1011)
N	462	456

Standard errors in parentheses

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Table 12 shows that students spend more time studying when they join a study group or meet with a tutor than when they study by themselves. Firstly, they may be chatting during the group meeting. Secondly, students might not be well prepared for meetings with tutors. As a result, tutors need to go over questions on exercises one by one which takes a much longer time than students who are self-motivated and study by themselves. Students who like to go to office hours, are less likely to spend more time on self-study. It might be either because they learn materials very fast from the instructor's explanation or they do not perform well in the class but keep showing up during the office hour in order to make a good impression on the professor. It may also be because they believe that meeting with a tutor or professor is in and of itself an adequate form of study. The estimation of students' expected levels of grades based on their

methods of learning shows that students who rank TA and Professor's office hours as the most used way of study tends to have lower expectation on their final course grades than students who study alone. The result is not statistically significant and is not shown here.

Students who are most likely to study alone use less time in studying and get higher exam scores. This is probably because they use studying hours more efficiently than others.

Table 12: Correlation between Study Hours and Ways of Study

Dependent Variable: Self-Reported Study Hours

	Non-Exam	Exam	Non-Exam	Exam
	(1)	(2)	(3)	(4)
Study Method (Base: Study Alone)				
Group Study	0.2042	1.3830	0.1483	1.0095*
	(0.3122)	(0.7596)	(0.2225)	(0.5066)
Office Hours	-0.0528	-1.6275	-0.0286	-1.8728
	(0.9056)	(2.1930)	(0.6408)	(1.4451)
Tutor	1.1707	4.0440**	0.9756*	2.2481
	(0.6042)	(1.4634)	(0.4876)	(1.1744)
SAT Math	-0.0073***	-0.0197***	-0.0030*	-0.0065*
	(0.0018)	(0.0045)	(0.0014)	(0.0031)
SAT Verb	-0.0031	0.0042	-0.0011	0.0007
	(0.0017)	(0.0040)	(0.0012)	(0.0028)
Other Study Hours			0.7475***	
			(0.0344)	
Other Study Hours (Exam Week)				0.8113***
				(0.0326)
_cons	10.6385***	19.8407***	3.5388**	5.8570*
	(1.5748)	(3.8167)	(1.1906)	(2.6649)
N	496	494	462	456

Standard errors in parentheses
* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Working Much Harder During Exam Weeks

As shown in Appendix Table 1, there exists a discrepancy in students' hours of study between non-exam weeks and exam weeks. It is quite usual for students to work more or even just start studying right before exams in the hope of getting better grades. We study the effect of the increase in learning hours between two periods on students' final exam grades. However, our study shows that the larger the discrepancy of learning hours between non-exam weeks and exam weeks, the lower students' final exam scores will be. Results are not significant. Under the

significant positive correlation of difference in classmates' study hours and students' own study hours, we interpret this result as students who work much harder during exam weeks than regular weeks are those who have lower math or study abilities or who were not taking coursework seriously.

Table 12: Effect of Increased Amount of Study Hours on Final Exam Scores

Dependent Variable: Final Exam Score		
	(1)	(2)
Difference in Self Study Hours	-0.1674	-0.2010
	(0.1227)	(0.1367)
SAT Math		0.0838***
		(0.0091)
SAT Verbal		0.0305***
		(0.0081)
_cons	71.8375***	-2.6347
	(0.9512)	(7.7008)
N	615	471

Dependent Variable: Difference in Self Study Hours		
	(1)	(2)
Difference in Others' Study Hours	0.8248***	0.7869***
	(0.0288)	(0.0329)
SAT Math		-0.0046
		(0.0028)
SAT Verbal		0.0025
		(0.0025)
_cons	1.5469***	3.1944
	(0.2293)	(2.3414)
N	615	471

Standard errors in parentheses
* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Discussion Section Attendance

Students are required to register for a 50-minute discussion session held once every week. During the discussion section, teaching assistants go over problems applying the concepts learned over the course of the previous week. Discussion section attendance is not required but highly recommended. To encourage students to attend, students receive a point of extra credit if they stay and actively participate during the discussion section. We use the total number of discussion attendance extra credit points earned through the semester as a measure of students' study hours.

Table 13 shows the effect of discussion section attendance on students' final exam scores. Students who attend an extra discussion section have final exam scores 1.8 point higher. However, students who attend most discussion sections might be those who have strong self-motivations and study abilities. They can efficiently use or even out-of-class study time by reviewing weekly materials in the discussion section. In fact, we find that the higher the attendance of discussion sections the higher hours of study students have during the regular week. On the contrary, the attendance of discussion sections is negatively correlated with students' self study hours during the exam week (shown in Appendix Table 2). Hence, we conclude this estimated effect as a correlation between the discussion attendance and the final exam score rather than the causal effect. On the other hand, it indicates that hours of study is helpful in improving the course's grade as long as study time is used wisely.

Table 13: Discussion Attendance Effect on Final Exam Score

Dependent Variable: Final Exam Score

	(1)	(2)	(3)	(4)
Attendance	1.7927***	1.8278***	1.8354***	1.8354***
	(0.2971)	(0.3136)	(0.3106)	(0.3501)
SAT Math		0.0841***	0.0829***	0.0829***
		(0.0083)	(0.0082)	(0.0092)
SAT Verb			0.0243**	0.0243**
			(0.0074)	(0.0085)
_cons	53.1382***	-2.7853	-17.5087*	-17.5087*
	(2.9652)	(6.3073)	(7.6778)	(7.9096)
Cluster-Robust	No	No	No	Yes
N	686	522	522	522

Standard errors in parentheses

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Conclusion

Most faculty teaching large Principles of Economics classes filled with predominantly freshman struggle with the fact that there is so much diversity among students and that given the challenges of their first year in college, students have difficulty figuring out how to study for a hard subject like Economics. By the time faculty figure out who in the class is weak and how to help them, it may already be too late. This problem results in large numbers of freshmen doing poorly on final exams and not learning the foundational material so important for upper level coursework.

This research aims to provide give faculty the tools with which to identify weaker students early in the semester, to suggest to students study methods appropriate for the class and perhaps even provide students with data on what study methods top students use.

Some areas for future research include looking at time spent on online homework as another measure of study time and tracking number of visits to TA and faculty office hours. We did not ask questions on the actual quality of study time. It could be that some students study together very efficiently and help each other greatly while other students may use the time for socializing and not actually do any studying. We plan to ask questions on exactly what students do when they say they are studying. We also did not ask questions about the length of study sessions when studying alone versus with friends.

One important factor in looking at study time and its impact on final exam scores is dynamic selection. Research (Babcock 2010) has shown that a tougher grading standard leads higher-ability students to increase study effort to meet the higher standard whereas lower-ability students deem the higher standard unattainable and give up, creating an ambiguous net effect on grades. It is important for faculty to understand the conditions under which we can motivate all students to change their study behavior early in the course given their performance on early assignments and tests. We hope to study this in the future.

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Appendix

Appendix Table 1: Data Description

Variable	Observation	Mean	Standard Deviation	Min	Max
Exam Score					
Final Exam Score (out of 100)	686	70.76	13.69	11.25	99.50
Study Hours					
Self Study Hours (Regular Week)	680	3.97	2.87	0.00	30.00
Self Study Hours (Exam Week)	678	10.16	6.81	1.00	45.00
Classmate Study Hours (Regular Week)	631	4.04	2.69	0.00	35.00
Classmate Study Hours (Exam Week)	619	9.79	6.10	0.00	50.00
Discussion Attendance (out of 11)	686	9.83	1.72	0.00	11.00
Ability					
SAT Math (out of 800)	525	659.35	65.89	430.00	800.00
SAT Verbal (out of 800)	525	638.27	73.76	430.00	800.00
Pass Assessment in the First Attempt	686	0.73	0.44	0	1
Pass Assessment in the Second Attempt	686	0.06	0.24	0	1
Pass Assessment in the Third Attempt	686	0.21	0.41	0	1
Fail	686	0.02	0.13	0	1
Attempt 1 Assessment Score (out of 20)	686	16.75	2.58	5.00	20.00
Demographic Characteristics					
Gender (Female)	686	0.49	0.50	0	1
American Indian or Alaska Nati	686	0.00	0.04	0	1
Asian	686	0.10	0.30	0	1
Black or African American	686	0.04	0.19	0	1
Hispanic or Latino	686	0.07	0.26	0	1
Nonresident alien	686	0.16	0.37	0	1
Race/ethnicity unknown	686	0.05	0.22	0	1

Two or More Race Codes	686	0.05	0.21	0	1
White	686	0.52	0.50	0	1
Study Method					
Group Study	651	2.37	1.10	1	5
Study Alone	676	1.42	0.88	1	5
Tutor	573	3.76	1.14	1	5
TA/Professor Office Hours	615	3.31	0.95	1	5
Others	314	4.13	1.13	1	5
Z-Score					
Final Exam Score	686	0.03	0.93	-4.01	1.98
Self Study Hours (Regular Week)	680	-0.03	0.61	-0.88	5.50
Self Study Hours (Exam Week)	678	-0.04	0.65	-0.91	3.27
Other Study Hours (Regular Week)	631	-0.04	0.57	-0.90	6.54
Other Study Hours (Exam Week)	631	-0.04	0.57	-0.90	6.54
SAT Math	522	0.00	1.00	-3.48	2.14
SAT Verbal	522	0.00	1.00	-2.83	2.20
Attempt 1 Assessment Score	686	0.00	1.00	-4.54	1.26

Appendix Table 2: Correlation Between Self Study Hours and Discussion Attendance

Dependent Variable: Self Study Hours

	Non-Exam Week (1)	Exam Week (2)
Attendance	0.0831	-0.0404
	(0.0644)	(0.1527)
_cons	3.1549***	10.5530***
	(0.6428)	(1.5257)
N	680	678

Standard errors in parentheses

* p<0.05 ** p<0.01 *** p<0.001

The following questions are NOT related to your final exam score.

l. During a regular week without any major exam (Midterm/Final) in this course

    1. What is the number of hours per week ***you*** typically spent outside of class doing reading the textbook, reviewing lecture notes/powerpoints, listening to lecture recordings, doing the online homework or solving workbook problems for this course?

                                            _____hours per week

    2. What is the number of hours per week ***your classmates*** typically spent outside of class doing reading the textbook, reviewing lecture notes/powerpoints, listening to lecture recordings, doing the online homework or solving workbook problems for this course?

                                            _____hours per week

ll. During a week with a major exam (Midterm/Final) in this course

    3. What is the number of hours per week ***you*** typically spent outside of class doing reading the textbook, reviewing lecture notes/powerpoints, listening to lecture recordings, doing the online homework or solving workbook problems for this course?

                                            _____hours per week

    4. What is the number of hours per week ***your classmates*** typically spent outside of class doing reading the textbook, reviewing lecture notes/powerpoints, listening to lecture recordings, doing the online homework or solving workbook problems for this course?

                                            _____hours per week

5. Which of the following grades do you expect you will receive in this course?
                       A.   B.   C.   D.   F.

6. Please **<u>rank the methods</u>** you used to study for this course from **1: Most used to 5: Least used**

_____group study (number of group members _____)
_____ study alone
_____tutor
_____attend Professor/TA office hours
_____others(please specify):_____