Student Effort and Learning Outcomes in Principles of Microeconomics courses

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Abstract

Students maximize their utility very well when it comes to how much time to spend in one activity vs. the other. The purpose of this study is to examine a controversial debate whether students who spend more time on completing the assignments perform better. More specifically, the study investigates the relationship between the time spent [as a measure of students' efforts] on an assignment and students' learning outcomes. The study uses a unique dataset with the students' out-of-class activities in Principles of Microeconomics courses between Fall 2012 and Spring 2013 downloaded from Aplia, an online learning environment.

Introduction

Even though thousands of instructors and millions of students use Aplia throughout the U.S., studies on its effectiveness are limited. Aplia is an online teaching and learning solution which gives students great flexibility because it encourages more effort (Vaugh, 2005) and it offers a tailored approach. When submitting homework assignments on Aplia, students receive an instant feedback on each question and have an option to try it again up to three times before they move on to a next question. Each student can spend as much or as little time as they want on a question or an assignment.

Aplia also saves a lot of time for instructors because of its instant feedback feature. Instead of grading assignments, instructors can spend more time on designing class activities based on students' performances which can be monitored using its analytical tools. In addition, instructors can integrate other features of Aplia in their classrooms such as news analysis, class discussions, and online experiments to engage with students and to help them be prepared for the class. When students are more prepared and more engaged, instructors can use valuable classroom times more effectively, which enhances students learning and success in the course.

Aplia is one of the most widely used online learning tools in Introductory Economics courses although other similar online packages exist in the market (for example, MyEconLab, LaunchPad, EconPortal, SaplingLearning, etc.), each offering different types of question sets and features. Currently, Aplia has been used in more than 1700 institutions (mostly in the U.S. but 12 other countries) and served 4.9 million students[1]. One important feature that Aplia offers for instructors is its ability to track students' activities (such as when they logged in, when they submitted each question, how many times they tried each question, etc.). To my knowledge, this feature is not available in other online packages. Instructors can use this feature to analyze not only overall class performance but also study habits of certain students who may be struggling with the homework assignments, or to handle specific questions that a student may have. Currently, there is no study that uses Aplia's detailed student activities records except Kauper's work (2011) which uses login and logout times to examine whether students minimize their costs (study time) or maximize their outcome.

[1] This information is obtained Dec. 1, 2014 from Aplia's website http://www.aplia.com/company/.

Existing literature on effectiveness of Aplia and other online learning environments focus on whether the online homework assignments affect students' performances measured by the final exam score or the course grade (Kassis, Boldt, & Lopez, 2008; Mijid & Liard-Muriente, 2012; Nguyen & Trimarchi, 2010; Pace, 2010). However, one way to measure the effectiveness of Apia is how much time students spend in completing assignments and its relationship with the student's performance. Time is a valuable resource. The purpose of this study is to investigate how students' efforts on a particular question and/or an assignment affect the students' learning in Principles of Microeconomics course in a mid-size, 4-year university located in New England. We use 124 students' records from Fall 2012 to Spring 2013 downloaded from Aplia and combined them with students' demographic information and their final grades.

On one hand, students who spend more time and start their assignments early perform better not only on that assignment but also over time in the course. On the other hand, although some students delay their homework assignments until the last minute (Caplan & Gilbert, 2008), others have better background than others even though they spend less time on homework assignments. Still some students simply don't have enough time to study (they work full-time besides being a full-time student). As a result, not all students who spend more time completing assignments earn a good grade. Thus we use several ways to measure students' efforts in this study such as time spent on a question and an assignment, number of attempts on each question, number of questions and assignments completed. Next section reviews existing literature on effectiveness of Aplia and highlights how this study contributes to the current knowledge of effectiveness of online teaching and learning tools.

Literature review

Existing literature on Aplia finds positive impacts of its effectiveness on student learning in Principles of Economics courses. For example, Pace (2010) argues that Aplia engages students early in the term and gives each student individualized questions. As a result, it improves the student's exam performance between 5 and 7 percent. Lee Courtney, and Balassi (2010) found that 90% of students reported that Aplia significantly improved their understanding of Microeconomics Principles over the course of the semester. Nguyen and Trimarchi (2010) also claim that about 2 percent increase in their course grade is attributable to Aplia. Ball and Eckel (2004) found that Aplia experiments facilitate active learning in large classrooms and improves students' understanding of core economic concepts because it provides a pathway for students to apply their understanding. Collins Deck, and McCrickard (2008) compared the effectiveness of Aplia in a Principles of Microeconomics course with another homework management system such as Homework Manager and argue that Aplia is as effective as Homework Manager in a Principles of Accounting course. Lastly, Alpert, Harmon, and Lambrinos (2013) examined two types of problem sets on Aplia across three different delivery modes and found that practice problem sets reinforce students' learning in high-stake exams.

In addition, the studies that investigate Aplia's impact on student learning in other subjects show similar results. For example, Cutshall, Mollick, and Bland (2009) examined an undergraduate business statistics course. They argue that students find Aplia homework assignments to be very useful as well as the ability to get immediate feedback. In their follow up study, Mollick and Cutshall (2013) suggest that Aplia's

usefulness is positively correlated with students' level of introversion but negatively correlated with the level of thinking. Williams (2012) used a dataset of four sections of a graduate level introductory educational statistics course and found that Aplia affected only homework grades but not the other grades.

However, Aplia also has an element that could potentially diminish student-teacher interactions and could result to a detrimental outcome for student learning (Oppenheimer, 2003). Kassis, Boldt, and Lopez (2008) found a negative but insignificant impact of Aplia on average test scores, when comparing two classes that use online textbooks and Aplia with two classes that use a standard textbook without any online components. Mijid and Liard-Muriente (2012) analyzed the effect of Aplia on the likelihood of passing the introductory economics courses with a "C" or above. They also found negative but statistically insignificant effect of Aplia on a passing grade. Flannery Kennelly, and Considine (2013) compared the effectiveness of paper-based and online assignments and found that paper assignments were more effective on test scores than the Aplia homework assignments.

While most studies in the above show the positive effects of Aplia on student learning and their course performance (Ball & Eckel, 2004; Collins et al., 2008; Cutshall et al., 2009; Lee et al., 2010; Nguyen & Trimarchi, 2010; Pace, 2010), others find no negative effect (Kassis et al., 2008; Mijid & Liard-Muriente, 2012; Mollick & Cutshall, 2013; Williams, 2012). However, the above studies use either binary variable whether Aplia is used in a course when measuring its effectiveness or survey data. The current study differs from the previous literature on Aplia because it uses actual time spent on an assignment as a measure of students' effort.

There are three studies on Aplia that are closely related to this paper. First, Caplan and Gilbert (2008) claim that students who procrastinate have a lower performance relative to students who do not delay their work and argue that students' study habits are a complement to Aplia. Second, Kennelly, Considine, & Flanner (2011) analyzed whether Aplia affects specific sets of questions on the exam. They argue that students are more likely to complete assignments that use Aplia but found little evidence that Aplia is beneficial on exam scores. Third, Kauper (2011) used students' login and logout records and found that students rather minimize their study hours instead of maximizing their outcome (the course grade). Although none of these studies used actual time each student spent on each question or assignment, these findings led us to interesting questions: if students do not perform well because they procrastinate, if they minimize their study hours but they are more likely to complete the assignments on Aplia, what is the payoff for their study time? Does completing assignments help them earn better grade? Or does spending more time on each question or an assignment have a better outcome? Do number of attempts matter at all? We will try to answer these questions using students' activity records which capture actual time submitted for each question. Next section describes data used in this study.

Data and Summary Statistics

In this study, we use retrospective data on student performance and student activities on homework assignments in Principles of Microeconomics courses taught by one instructor between Fall 2012 and Spring 2013. There were seven sections during

this period (1 fully online section in Fall 2012, Winter 2013 and Spring 2013, 2 hybrid[2] sections in Fall 2012 and Spring 2013). Class sizes were small with 15-25 students.

In the Fall and Spring terms, students submitted mandatory weekly assignments on Aplia, which consist of about 10 questions. In these assignments, they had an option of up to three attempts for each question (aka GradeItNow or GIN problem sets). The GIN problem sets give students detailed feedback on each question when they submit the question and are automatically graded by taking the average of the three attempts. In addition, students were given an option to complete one (or two) news analysis a week as an extra credit assignment. Students read a short news article (usually one or two pages long) on Aplia and answered questions related to the article. News analyses are not GIN problem sets; students' answers are graded at the deadline (aka GradedAtDeadline or GAD problem sets). During the Fall and Spring, they also participated in three (or four) experiments on Aplia that demonstrate how competitive markets work. Each experiment requires them to complete "Preparing an Experiment" before the experiment and "Analyzing an Experiment" after the experiment. Besides these three types of problems completed on Aplia (graded problem sets, news analysis and preparing/analyzing experiments), students participated in weekly online discussions and took a midterm and final exam. The total Aplia scores as a percentage of a final course score ranged from 43% to 60% in the Fall and Spring.

For the Winter term, assignments were longer with about 20-25 questions although the Winter course was much shorter (three weeks) than the Fall and Spring terms. There were only four GIN assignments on Aplia in addition to online discussions

[2] Hybrid classes met face-to-face and online once a week (50-50).

and a final exam. Given the Winter term was too short, the news analysis and experiments were not assigned[3]. The total Aplia score made up to 60% of the final course grade.

The data on student activities reports are downloaded from Aplia website for each student. Each downloaded excel file consists of two sheets with Login History sheet, (where login and logout dates and times are recorded), and Answer Submissions sheet, (where assignment name, question number with the date and time of submission for each question are recorded). All assignments on Aplia were posted one week before the due date. Students were encouraged to start their assignments as early as possible and to ask questions during the week.

For each student record, we calculated the following variables: time spent on each attempt, a number of attempts on each question, total time spent on a question and an assignment, and a number of times a student logged in to complete an assignment. Then we computed the average values of these variables, and total number of questions and assignments completed for each student. We combined this dataset with student demographic information and course grades obtained from our Office of Institutional Research[4]. Table 1 shows the descriptive statistics of student demographic information - the course grade, cumulative GPA, SAT scores, number of credits earned, class standing, gender, race, age, and school - and the average time spent on assignments, questions, and attempts.

[3] All students were required to complete "Introduction to Aplia Tools" and "Graphing Exercise with Tutorials" assessment at the beginning of the term. Both of these assignments were GIN problem sets.
[4] We obtained an exempt letter for this study approved by the Human Studies Council at our institution.

Table 1: Summary Statistics

Variable Name	Description	Obs.	Mean	St.dev	Min	Max
CourseGrade	Final course grade	124	2.842	1.017	0	4
GPA	Cumulative GPA before taking the course	103	2.921	0.624	1	4
SATM	SAT Math Score	89	522	78	340	720
SATV	SAT Verbal Score	89	494	65	280	660
SATW	SAT Writing Score	87	502	71	310	680
AllCredits	Total credits completed before taking the course	124	54	30	9	152
FirstYear	Class standing - first year	124	0.145	0.354	0	1
Sophomore	Class standing – sophomore	124	0.379	0.487	0	1
Junior	Class standing – junior	124	0.298	0.459	0	1
Senior	Class standing - first senior	124	0.169	0.377	0	1
Female	Gender – Female	124	0.435	0.498	0	1
White	Race – White	124	0.782	0.414	0	1
Black	Race - Black	124	0.113	0.318	0	1
Hispanic	Race - Hispanic	124	0.065	0.247	0	1
Asian	Race - Asian	124	0.040	0.198	0	1
Online	Fully online course	124	0.347	0.478	0	1
Age	Age of a student	124	22.1	5.8	18	57
SBusiness	School of Business	124	0.532	0.501	0	1
ScArtsSciences	School of Arts and Sciences	124	0.323	0.469	0	1
SET	School of Engineering & Technology	124	0.145	0.354	0	1
Fall	Fall 2012	124	0.435	0.498	0	1
Winter	Winter 2013	124	0.056	0.232	0	1
Spring	Spring 2013	124	0.508	0.502	0	1
Attempt_time	Average time spent on attempts	124	5.005	2.653	1.4	24.02
N_attempts	Average number of attempts	124	1.344	0.194	1.03	2.58
Question_time	Average time spent on questions	124	7.512	5.489	1.82	44.82
N_questions	Total number of questions	124	208	64.6	37	355
Assignment _time	Average time spent on assignments (minutes)	124	72.0	61.2	14.27	467.38
N_assignments	Total number of completed assignments	124	24	7.7	3	37
N_logins	Average number of logins for completing assignments	124	1.338	0.415	1	3.25

We received 124 records[5] with student demographic information. There were 21 transfer students' records with 0 cumulative GPA, which is replaced by a missing value.

[5] We excluded from our analysis students who earned "F" because he/she failed to complete significant portion of homework assignments or who withdrew from the course.

Most of them were sophomore, junior and first-year students. Also, there were many observations with missing SAT scores (international students, for example). Fourteen percent of our sample is first-year students, 38% is sophomore, 30% is junior and the remaining 17% is senior. Forty three percent of the sample is female students and 78% is white. The average age is 22 years (but the median is 20 years old). The three online sections made up to 35% of our sample. More than 53% of the sample is in business related majors (and business majors are required to take both Principles of Microeconomics and Macroeconomics as prerequisites). The three sections in the Fall 2012 made up to 43%, the winter section was only 6% and the remaining 51% was Spring 2013.

On average, students spent 5 minutes per attempt and tried 1.3 times per question[6]. The average time spent on a question was 7.5 minutes. Students completed 208 questions throughout the term, on average. They spent 72 minutes on an assignment and the total number of assignments completed was 24. Students logged in 1.3 times in order to complete an assignment. As shown in Table 1, there are big variations in these variables, especially the number of questions and assignments, due to the winter term which was quite different than the Fall and Spring terms.

Empirical Model

In order to examine how students' effort is paid off, we use the following simple OLS model:

$$Y = \beta_0 + \beta_1 X_{effort} + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon \qquad (1)$$

[6] Only GIN problem sets gave students an option of up to three attempts per question. The GAD problem sets did not have such option. However, for the GAD problems, students can change their answers as many times as they wanted before the deadline.

Y – course grade (standard grade: A to F with +/- converted into 0 to 4 scale)

X_{effort} – variables that measure students' effort. We used the following specifications.

Specification 1: the average time spent on attempts and the average number of attempts per question (each submission is an attempt to answer a question)

Specification 2: the average time spent on questions and total number of questions

Specification 3: the average time spent on assignments and the total number of assignments completed.

X_i – control variables. We used the following six categories of controls

student's ability (cumulative GPA and SAT scores), demographic information (gender, race and age), school (School of Business, or School of Arts and Sciences, or School of Engineering and Technology), class standing (number of credits completed and first-year/sophomore/junior/senior), course delivery mode (online or hybrid), and term (Fall or Winter or Spring).

ε is a random error term.

We run equation (1) using OLS regression model. We would expect the sign for the X_{effort} be a positive and significant.

Results

The regression results of the OLS estimates of coefficients are shown in Table 2. In Specification 1, we examined the effect of the average time spent on an attempt and the number of attempts per question on student's course grade. Although we found a

positive and significant coefficient for the average time spent on an attempt, the estimate is sensitive to the model. The number of attempts has no effect on student's performance (although positive but it was insignificant). This can be explained by the fact that students who just followed Aplia's instant feedback in a next attempt in order to get a higher score may not recall information in the exam. Other factors that positively affect students' course grade include the cumulative GPA, or being in a business major or liberal arts and social sciences major. While white students are more likely to get a better grade, female students are less likely to perform well in the course.

Since the time spent on an attempt is correlated with the time spent on a question and on an assignment, we include the time spent on a question only in Specification 2. In Specification 3, we include the time spent on an assignment only.

Table 2: The OLS Results of Student Efforts on Course Grade

	Specification 1		Specification 2		Specification 3	
attempt_time	0.106	0.146**				
	(0.066)	(0.063)				
num_attempts	0.402	0.342				
	(0.552)	(0.519)				
question_time			0.040	0.052*		
			(0.028)	(0.027)		
num_questions			0.006***	0.005***		
			(0.002)	(0.002)		
assignment_time					0.002	0.003
					(0.003)	(0.003)
num_assignments					0.052***	0.048***
					(0.017)	(0.016)
cumgpa1	0.720***	0.741***	0.589***	0.621***	0.571***	0.607***
	(0.196)	(0.184)	(0.189)	(0.180)	(0.194)	(0.187)
SATM	0.001	0.003	0.001	0.002	0.001	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
SATV	-0.003	-0.003	-0.002	-0.003	-0.002	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)

Table 2: The OLS Results of Student Efforts on Course Grade (cont.)

	Specification 1		Specification 2		Specification 3	
SATW	0.002	0.002	0.002	0.002	0.003	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
female	-0.396*	-0.547**	-0.479**	-0.629***	-0.465**	-0.608***
	(0.228)	(0.219)	(0.209)	(0.205)	(0.212)	(0.211)
white	0.461	0.516*	0.482*	0.538*	0.410	0.452*
	(0.305)	(0.287)	(0.289)	(0.275)	(0.286)	(0.275)
age	-0.026	-0.051	0.027	0.003	0.023	-0.002
	(0.111)	(0.105)	(0.105)	(0.100)	(0.107)	(0.103)
SchBus	0.322	1.019***	0.218	0.839***	0.287	0.877***
	(0.217)	(0.304)	(0.203)	(0.292)	(0.206)	(0.302)
SchArts&Sciences		0.986***		0.856***		0.807**
		(0.320)		(0.303)		(0.313)
credits	0.012	0.009	0.021*	0.016	0.022*	0.018
	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
sophomore	0.150	0.415	-0.274	-0.016	-0.384	-0.136
	(0.410)	(0.395)	(0.388)	(0.379)	(0.391)	(0.387)
junior	0.190	0.587	-0.512	-0.092	-0.647	-0.239
	(0.731)	(0.699)	(0.700)	(0.681)	(0.706)	(0.694)
senior	-0.167	0.449	-1.273	-0.593	-1.401	-0.730
	(1.170)	(1.117)	(1.131)	(1.101)	(1.143)	(1.126)
online	0.256	0.251	0.052	0.043	0.067	0.061
	(0.305)	(0.287)	(0.295)	(0.280)	(0.301)	(0.289)
winter	-0.145	-0.169	0.632	0.523	0.985	0.654
	(0.545)	(0.512)	(0.593)	(0.565)	(0.861)	(0.835)
_cons	-1.718	-2.142	-2.794	-3.022	-2.564	-2.660
	(2.749)	(2.587)	(2.456)	(2.334)	(2.494)	(2.391)
F statistics	3.640	4.440	4.660	5.330	4.390	4.890
R-square	0.477	0.545	0.538	0.590	0.523	0.569
Number of obs.	81	81	81	81	81	81

Note: *, **, or *** indicate significant level at 10%, 5% and 1%.

As shown in Specification 2, the coefficients for the time spent on a question are statistically significant and positive but it is again sensitive to the model specifications. However, we found the statistically significant (at 1%) and positive coefficient for the number of questions submitted. In other words, one more question submitted would

increase the course grade by 0.005 points. The rest of the coefficients in Speciation 2 were the same as in Specification 1.

Lastly in Specification 3, we found that the number of assignments completed has significant impact on course grade but not the time spent on an assignment. One more assignment completed would impact the course grade by 0.048 (or 0.052) points. These findings in Specifications 2 and 3 are contrary to what we expected but are consistent with the previous research that found students who complete assignment more likely to perform better.

Conclusions

In this study, we examined the effect of students' effort on their course performance and found that number of questions or assignments completed has more impact than the time spent on these questions or assignment. In today's digital world, the way students use Aplia greatly affects and influences their learning. Sure, all students have a busy life nowadays: they spend endless hours for studying, reading/reviewing course materials, going to classes, completing assignments, in addition to working (part-time or full-time), socializing, staying fit, enjoying their favorite sports, shows, movies, etc. If used incorrectly, their time spent on Aplia assignments can be useless instead of saving the time for them. Thus instructors make it aware to students and tell them when to start the assignments, how to use the tools, feedback, and multiple attempts features effectively.

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