The Impact of Online Message-Boards on Performance in First Year Econometrics Units

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Abstract

As a supplement to face-to-face lectures and classes, message board software was introduced in a first year mathematics and statistical methods unit in a UK Russell Group University. Fifty percent of students signed up to this unit, so when combined with a further first-year mathematics and statistical methods unit, without message board software, this enabled the opportunity to use a difference in difference methodology to find the *causal* impact of message board software on student examination performance. The results suggest that students who actively engage with message boards perform significantly better than students who sign up for the message boards, but neither ask, nor answer, questions. However, the results for the impact compared to non-participants is mixed, and may be related to behavioural change in students.

1. Introduction[1]

In the UK, the de-regulation of fees and student numbers has meant a growth in cohort sizes for subjects such as economics. As a result, these large cohorts often mean that new technologies need to be utilised to support student learning, and respond to queries, rather than relying on a more traditional method of professors simply answering questions via e-mail.

One such technology is message board technology. Message boards allow students to ask questions of both lecturers and their peers when there are concepts, or problems that they do not understand.

1.1 Discussion of literature on message boards

To the author's knowledge, there is little *experimental* data about the efficacy of online message boards as a supplement to traditional person-to-person teaching. One notable exception is Althaus (1997), which suggested that students who actively engaged in online discussions boosted their grades and their perceived engagement with the unit. However, the results may well suffer from bias, as the authors found significant difference between participants and non-participants along the dimensions of their experience of e-mail, which could be correlated with their ability. The increased perception of learning is further emphasised by Wu and Hiltz (2004)

Much of the literature of online bulletin boards relates to a supplement to online delivered courses, and how an instructor might interact with students. Mazzolini and Maddison (2003) identify three separate forms of instructor-student interaction; the "sage on the stage", "guide on the side", or the "ghost in the wings". Their results suggest that students perceive instructors who post regularly to possess expertise and show enthusiasm, **but**, the more regular posting may have a negative impact on discussion length. However, Mazzolini and Maddison (2007) further note that discussion length in itself is not necessarily a good guide to the health of a discussion; an instructor answer might prevent fruitless searching by students through discussion to a correct answer.

[1] Abbreviations: MSM – Mathematics and Statistical Methods, EP – Economic Principles.

Maor (2003) further suggests that whilst online and peer learning environments might create the environment to enable collaborative learning, it is important for instructors provide a framework to enable students to participate in online discussions. Whilst there have been a number of papers examining the role of asynchronous online discussions, to the author's knowledge, none of the papers have produced convincing, unbiased, estimates of the impact of the message boards on individual examination outcomes.

In this paper, we examine the impact of the introduction of a message board to a first year mathematics and statistics unit within Economics related programmes at a UK university. Within the unit, mathematics and statistics are led by two different members of academic staff, who used two different models of management of the online message boards were used; for statistics, the unit lead endeavoured to answer all questions that were asked by students, whilst for mathematics, staff did not answer any questions, but students were encouraged to ask questions. Students also self-select into types of message board users; non-users, passive users and active users. The results suggest that active users perform, at worst, on a level with their non-user peers, but passive users perform strictly worse than their active user peers. The results differ according to subject and online tutor style.

2. Experimental design

In this study, I examine the introduction of a message board into a core, first year Mathematics and Statistics unit for Economics students within a UK, Russell Group[2] University. At the subject University, in first year economics programmes, students are registered for four, compulsory units, and are able to choose two optional units. These units are split across two semesters, with the majority of students studying 50% of the units in semester 1, and 50% in semester 2. The teaching for semester 1 runs over 12 weeks between September and December, with examinations in January, whilst the teaching for semester 2 begins following the January examination period, and involves 12 weeks of teaching between January and April, with a three-week break included for Easter.

[2] The Russell Group is a group of 24 research intensive, traditional Universities. More information is available from http://russellgroup.ac.uk/

In semester 1, it is compulsory for students on economics programmes to study mathematics and statistical methods 1 (MSM1), and economic principles 1 (EP1). MSM1 consists of 50% mathematics and 50% statistics (including a brief introduction into econometrics). In semester 2, it is compulsory for economics students to study mathematics and statistical methods 2 (MSM2) and economic principles 2. As with MSM1, MSM2 consists of 50% mathematics and 50% statistics (focussing on econometrics). The assessment for MSM1 and MSM2 are both equally split between mathematics and statistics, with mathematics included in section A of the examination, and statistics in section B for both units.

In semester 2, it was decided to introduce message board software to enable positive externalities for students from being able to observe other students' questions (and answers) to problems, and to encourage peer to peer learning.

The Piazza message board allows students to ask questions and collaborate. As discussed in Kang et al (2013), anonymity is likely to reduce inhibition, but runs the risk that participants may take advantage of anonymity. Hence, to try and maximise participation, students were allowed to post anonymously to the message board, but with the knowledge that the message board was being monitored by academics, and was reactively moderated. The choice of the Piazza message board was also motivated by the fact that equations could be included using a simple LaTeX equation editor, which enabled students to ask questions, and to view answers with more precision than was possible with simple, text-based e-mails or message boards.

The message board was introduced so that students could ask questions relating to the unit. Academic support was provided only for the statistics side of the unit. Students were advised to sign up for the Piazza message boards to ask questions relating to the statistics part of the unit.

No other changes were made to the teaching of the statistics part of the course. Students were also told that they could ask questions on the message boards about the mathematics part of the unit, but there would be no staff engagement with the questions; any questions thus had to be answered through peer instruction. In the first semester, the message board software was not available.

Whilst the message board software was made available to all students, students had to opt in to the software by voluntarily setting up an account and signing in. Despite the fact that the software was made available to all students, only 50% of students registered on the unit signed up for the message board.

As such, we have a pseudo-natural experiment. In semester 1, all students are untreated in mathematics and statistics. In semester two, students who signed up for the message board software receive the treatment of the message board, and those who do not sign up are the untreated. However, there is a different treatment for mathematics and statistics, in that for statistics, the treatment is through a message board with answers from an instructor, while for mathematics, any questions that are asked must be answered by the students.

3. Data

The data was collected from students who were registered on Mathematics and Statistical Methods 1 and 2, and Economic Principles 1 and 2 at a UK Russell Group university in 2015/16.

All of the units are assessed using a three-hour, terminal examination at the end of the teaching. For both mathematics and statistical methods units, the maximum mark available for the unit is 100, with 50 marks available for mathematics questions and 50 marks available for statistics questions.

Table 1 provides summary statistics for these examinations (and sub-parts of examinations). The data is restricted to students on programmes with mathematics and statistical methods 2 as a core, compulsory unit. For these programmes, it is also compulsory for students to study mathematics and statistical methods 1, economic principles 1, and economic principles 2. However, there are a number of students who do not complete all of the units, either as they are repeating years to pick up credit points for failed units, or due to illness, they miss one or more of the examinations.

4. Controlling for unobserved heterogeneity

Since students are not randomly assigned to the treatment of message boards, as they choose to sign up (or not), there will be unobserved heterogeneity between individuals who are treated and untreated in this model. Individuals' (unobserved) characteristics, X, are thus likely to determine whether they receive the treatment, or not

$$treatment_i = f(X_i) \qquad (1)$$

Students outcomes at time t are determined by their individual characteristics, along with educational inputs. However, individuals outcomes at time t are also likely to be a function of unobserved characteristics, along with teaching and effort input.

$$Y_{it} = g(X_i, T_{it}, E_{it}) \qquad (2)$$

It is conceivable that the unobserved characteristics that determine the likelihood to sign up for the treatment are the same as the unobserved characteristics which determine outcomes; for instance, a student who is a very hard worker may be expected to gain good grades in their exams, but may also want to take advantage of all opportunities to ask questions of instructors. As such, this individual would be more likely to sign up to the message board system.

A naïve OLS estimate of the impact of exam scores against whether a student has signed up for a message board would, thus, suffer from omitted variables bias; however, since we observe individuals in two time periods; in period 1, no individuals are treated, whilst in period 2, only a subgroup of students received the treatment. As such, it is possible that we can eliminate the impact of the unobserved heterogeneity by considering first differences, and compare the *change* in test scores between the *treated* and the *untreated* groups. However, this difference-in-difference specification will only be valid if the unobserved heterogeneity *only* affects the level of the exam score, and not the progression rate of the students.

Provided the trends between the treated and the untreated groups are the same, we can thus assess the efficacy of message board software, and different strategies using a *difference in difference* specification, as discussed in Card and Krueger (1994) and Meyer (1995)

$$Y_{it} = \beta_0 + \beta_1 treat_i + \beta_2 semester_{it} + \beta_3 treat_i \times semester_{it} + u_{it} \qquad (3)$$

Treat is a dummy variable that takes the value 1 if an individual, *i*, signs up to the message boards in semester 2, *semester* is a dummy variable that takes the value 1 in semester 2, and *u* is assumed to be a random error term. As such, β_3 is our causal treatment term; this represents how much more (or less) students who sign up for the message boards improve compared with their peers who did not sign up.

The difference in difference methodology will provide a *causal* estimate of the impact of online message boards on examination outcomes, provided that the pre-treatment trend is the same for both treated and untreated groups. In the case of random allocation to treatment, this would not create a problem. However, in this experimental design, students opt in to the treatment, and so care needs to be taken in ensuring that unobserved heterogeneity is not a cause of bias in the estimates.

Table 2 shows the performance of students in their semester 1 units, broken down by whether they have signed up for the message boards or not. As shown in Table 2, there is no difference in mathematical attainment prior to the treatment being introduced between the treated and untreated group (*p=0.477*). However, students who sign up for the treatment of message boards have a statistically significantly higher grade in statistics (*p=0.001)* in the untreated examination (MSM1).

The grade that an individual student gains in an exam is likely to consist of a component determined by their ability, the amount of work that they have exerted in preparing for the exam, and an error term. In *extremis*, let us suppose that students' grades are entirely composed of a random error term. We have seen above that students who signed up for the message boards gained higher marks in statistics than those who did not; as such, we might expect a negative coefficient to be merely evidence of mean reversion. Similarly, since grades are censored above, students with high scores in statistics in MSM1 will be less likely to be able to improve their scores. As such, the treated group have a lower likelihood of improving their scores in statistics than the non-treated group.

In order to investigate this possibility, I consider a refinement to the difference in difference strategy, by only considering a subset of students, with matched attainment in the *untreated* teaching block 1. To create this subset, the students are split into three quantiles. As discussed above, when the highest (or lowest) scoring students are included, there is the possibility of bias, due to censoring of the data, and potentially due to mean-reversion. To avoid these, I consider a specification with only the middle tertile included.

A second, potential, issue relating to trend assumption is that the ethos of students may be correlated with their likelihood to sign up for the message board software. For example, it may be the case that students who are hard-working are more likely to sign up for the message board software, **and** these students are also more likely to make better progress than lower-effort peers. Contemporaneously to their MSM1 and MSM2 units, students are also studying Economic Principles 1 and Economic Principles 2, which were not provided with similar opt-in message boards. If there is a difference in motivation for students who opt in to the message boards, we would expect to see the same results for changes in Economic Principles marks as seen in Mathematics and Statistical Methods. If the estimated impact for economic principles is equal to zero, then this suggests that there is little problem due to the self-selection of students.

To test whether omitting ethos causes bias to the estimates of the impact of message boards on exam scores, I consider a further specification; I re-estimate **equation (3)** using the scores from economic principles (where no such treatment was included) as the dependent variable, and the treatment variables left unchanged. If the ethos of students is a causal factor in signing up for the online message boards **and** a determinant of the *progression* of students (and not just the level) of students, then we would expect any results for the impact of message board software to be replicated in both mathematics and statistical methods **and** economic principles. However, if zero impact is seen in the specification using economic principles, then we can conclude that there is likely little problem with not observing the student ethos, or equivalent variables.

5. Student usage of Piazza

In order for online resources to be most efficacious, students need to be engaged and participatory; for example, Beaudoin (2002) identifies that whilst students who are appear inactive learners in online education courses believe that they are engaged in productive learning activities, their mean grades are lower than their more visibly active peers. Figure 1 shows a time series indicating the number of students who access Piazza per day; teaching began at the end of January, and between February and May, approximately 20 students were accessing per day. Prior to the exam period (the final week of May and first week of June), the number of students accessing Piazza increased.

Table *3* shows summary statistics for student engagement with the Piazza message board. In total, 141 students signed up for the Piazza service (from 284 total students registered for the unit). Whilst there were 141 students enrolled, only 45 posed questions, and 19 offered answers. The average student who was registered viewed 51 questions (interquartile range 9-92, median 27).

However, the students can be split into active and passive users; only 31.9% of students who registered for Piazza use asked questions, whilst only 13.5% answered questions. Table *4* shows the mean engagement by students, splitting them into *active* students who either asked or answered questions, and *passive* students who did not provides more insight into student engagement. In the active group, students viewed an average of 80.85 questions, compared with 36.45 for inactive students. On average, active students asked 3.2 questions and answered 1.87.

There were differences in engagement between mathematics and econometrics. In econometrics, 136 student questions were asked, whilst for mathematics only 21 questions asked. This difference is partly explained by the engagement of staff; students knew that the unit lecturer was willing to answer questions for econometrics, but for the mathematics section (lectured by a different instructor) no such support was offered.

157 questions in total were asked during the teaching, 21 for mathematics and 136 for econometrics. Of all the answers provided, 67% were provided by the econometrics lecturer; all of the mathematics questions, however, were answered by active students.

6. Results

Table *5* shows the OLS results of the difference in difference specification, as shown in equation (3)

$$Y_{it} = \beta_0 + \beta_1 treat_i + \beta_2 semester_{it} + \beta_3 treat_i \times semester_{it} + u_{it} \qquad (3)$$

Since we observe individuals twice in the data, and can only control for a limited amount of heterogeneity, it is likely that there is significant residual correlation. To mitigate against this, I use standard errors, clustered at the student level.

The coefficient, represented by treatment on the treated in Table *5* shows the difference-in-difference estimate. Beginning with the mathematics part of mathematics and statistical methods, as discussed earlier, students who sign up for the message board software are not significantly different in scores from those who do not, in semester 1. However, the causal estimate suggests that those who sign up for the message boards increase their mathematics score by 2.965 points (or 0.36 standard deviations) compared with those who do not sign up.

Conversely, in statistics/econometrics, *Table 5* shows that those who sign up for message boards perform 2.437 marks (or 0.26 standard deviations) worse than those who did not. It should be noted that this result is significant at the 10% significance level (p=0.066).

However, this result is somewhat counterintuitive, as it suggests that using the message board software, when provided with academic support leads to worse grades than either no message board software (control), or message board software with no support (mathematics).

Column 3 of *Table 5* provides us with a test of the common trend assumption; if there are differences in ethos of student, affecting student progress and correlated with student sign-up for the message boards, then we would expect the results shown in columns 1 (or 2) to be replicated for other subjects. The estimates effect, whilst small and positive is not statistically significant at *any* reasonable level of significance ($p=0.906$). This suggests that there is little problem of student ethos causing bias in our results; as such, we can have confidence that the results presented do not suffer from this sort of bias.

The second form of bias that we may be worried about is the possibility that due to censoring of exam marks (to a maximum of 50 and a minimum of 0) for each section. *Table 6* shows the results from the specification, broken down by tertile of performance in semester 1. The most *reliable* estimate is that from tertile 2; this tertile is unlikely to suffer from mean reversion, and any unobserved heterogeneity between the treated and untreated group is likely to be less important, as there is a closer match in terms of prior attainment in this group.

For mathematics, the strong, statistically significant, positive impact observed above remains present; in the second tertile, the effect is estimated as 3.521 grades. Similarly, the estimated effect in statistics remains negative, indicating that message boards, with significant tutor input have a negative impact on outcomes; as before, the estimate is only significant at the 10% significance level ($p=0.056$).

6.1 Active versus passive users

As discussed above, students who sign up for the online message boards are split into two types; active participants who actively ask and answer questions, and passive participants, who only sign up to view questions; thus we can investigate the causal impact of different forms of engagement with online message boards. Table 7 shows the results of the difference in difference specifications for two sub-samples. Subsample 1 uses only students who actively asked and/or answered questions on Piazza as the treatment group, whilst subsample 2 uses only students who signed up for Piazza, but did not ask or answer any questions as the treatment group. In both cases, the control group consists of students who did not sign up to use Piazza.

In specification (1), the treatment group are students who actively participated in the Piazza message boards; the estimated impact for mathematics is 4.444 marks (or 0.54 standard deviations). For statistics, the impact is not significantly different from zero. Specification (2) uses students who passively participate in the message boards. There is a smaller, positive estimated impact for mathematics (2.143 marks), but for statistics, there is a large, statistically significant, negative impact on the treated (3.650 marks, p=0.014).

As such, this indicates that whilst the pooled regressions, illustrated in *Table 5*, the negative results for statistics are being driven by students who sign up for message boards, but do not actively engage.

7. Discussion

Beaudoin (2002) makes the observation that in online classes, whilst low visibility learners may be engaged in study, they perform worse in terms of exam grades than more visible students who engage with the online material. In this paper, we have found similar, striking results.

Within the results for statistics, we can see that using the online message boards has no significant impact on students who actively engage with the material, although students who passively engage with the material perform markedly worse than students who do not use the system.

On the face of it, this does not look like a promising result; however, if the message boards can be managed with strictly less inputs than a traditional system, then this could still lead to a Pareto improvement. Anecdotally, within the teaching, lecturers reported that students were less likely to send questions via e-mail, and attendance at office hours was markedly reduced.

The anecdotal evidence of a reduction in engagement via e-mail and via office hours suggests that students are, often inappropriately, substituting one measure of contact (office hours) for another (message boards). However, the students who passively engage with the message boards are not sufficiently engaged with the learning technology, and as such, may perform worse.

For the mathematics results, the passive learners suffer a similar a similar deficit to their peers who actively engage with the message board software, although both the passive and active learners perform better than their peers.

The differential results for mathematics and statistics could be down to two factors; either students respond differently to online message boards in mathematics teaching compared with statistics teaching, or alternatively, the peer instruction mechanism is a more effective teaching mechanism than a mechanism where instructors actively engage. In this paper, it is impossible to identify the mechanism, raising questions for further work.

However, the observed behaviour of students does suggest that the impact of a completely peer led discussion board is limited; in contrast to the results of Mazzolini and Maddison (2003), engagement with the discussion board was much greater for statistics-related questions than for mathematics related questions, in spite of the greater level of tutor engagement in the statistics message boards.

Tables and figures

Table 1 Summary statistics

	MSM1	MSM2	EP1	EP2
Mean	56.861	59.020	59.464	63.0
Standard deviation	15.333	15.349	9.429	11.216
Number of observations	276	276	276	276

Table 2 Summary statistics for semester 1 units, broken down by students' subscription to Piazza

	Did not sign up to message boards	Signed up to message boards
Mathematics		
Mean	29.832	30.391
Standard Deviation	6.690	6.325
Number of observations	138	138
Statistics		
Mean	24.458	29.040
Standard Deviation	11.406	10.412
Number of observations	138	138
Economic Principles		
Mean	57.967	60.960
Standard Deviation	9.364	9.288
Number of observations	138	138

Table 3 Student engagement with message boards

	Mean	SD	P25	P50	P75	N
Views	51.25	50.037	9	27	92	141
Questions asked	1.07	2.51	0	0	1	141
Questions answered	0.62	3.30	0	0	0	141

Table 4 Mean engagement, by student activity

	Views	Questions asked	Questions answered
Students who either asked or answered questions	80.85	3.21	1.87
Students who did not ask or answer questions	36.45	0	0

Table 5 OLS results for the standard difference in difference specification

	Mathematics and Statistical Methods		
	Mathematics	Statistics	Economic Principles
Treated	0.291	4.587***	3.219***
	(0.829)	(1.374)	(1.151)
Semester	-0.382	2.378**	3.547***
	(0.603)	(0.987)	(0.992)
Treatment on the treated	2.965***	-2.437*	0.171
	(0.861)	(1.318)	(1.449)
R^2	0.04	0.04	0.08
Number of students	253	253	253

Notes: Dependent variable is the examination mark. For Mathematics and Statistical Methods, each section is marked out of 50. Students are only included if they have marks for both semesters. For Economic Principles, the examination is marked out of 100. Standard errors, clustered by student are reported in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for.

Table 6 Difference in difference results, broken down by tertile.

	Mathematics	Statistics
Tertile 1	4.482***	0.904
	(1.556)	(2.079)
R^2	0.07	0.17
Number of treated students	51	51
Number of untreated students	27	27
Tertile 2	3.521**	-3.645*
	(1.595)	(1.879)
R^2	0.04	0.11
Number of treated students	38	38
Number of untreated students	48	48
Tertile 3	1.865	0.885
	(1.351)	(1.901)
R^2	0.02	0.20
Number of treated students	38	38
Number of untreated students	51	51

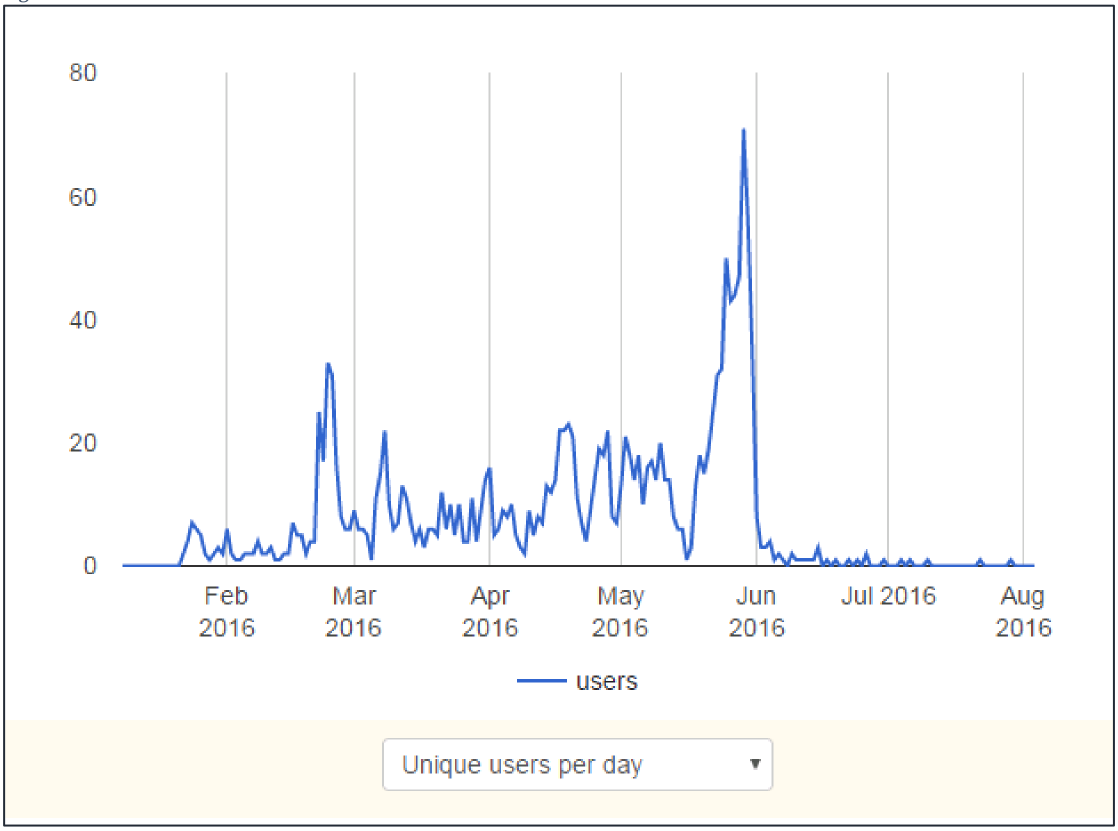
Notes: Dependent variable is the examination mark. For Mathematics and Statistical Methods, each section is marked out of 50. Students are only included if they have marks for both semesters. Tertiles are defined by the grade in mathematics and statistical methods in semester 1. Standard errors, clustered by student are reported in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for.

Table 7 Comparing active and passive students.

	Treatment group – Active students (1)		Treatment group – Passive students (2)	
	Mathematics	Statistics	Mathematics	Statistics
Treated	0.187	5.214***	0.375	4.351***
	(1.087)	(1.650)	(0.958)	(1.601)
Semester	-0.382	2.378**	-0.382	2.378**
	(0.604)	(0.990)	(0.604)	(0.989)
Treatment on treated	4.444***	-0.256	2.143**	-3.650**
	(1.130)	(1.710)	(0.989)	(1.476)
R^2	0.05	0.06	0.03	0.03
Number of students	172	172	208	208
Treated students	45	45	81	81
Untreated students	127	127	127	127

Notes: Dependent variable is the examination mark. For Mathematics and Statistical Methods, each section is marked out of 50. Students are only included if they have marks for both semesters. Standard errors, clustered by student are reported in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for.

Figure 1


80
60
40
20
0
Feb 2016
Mar 2016
Apr 2016
May 2016
Jun 2016
Jul 2016
Aug 2016
users
Unique users per day

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