Proud, S. (2018). You've got mail: The impact of online message-boards on performance in first year undergraduate mathematics and statistical methods units. *International Review of Economics Education*, *28*, 49-57. https://doi.org/10.1016/j.iree.2018.05.003

1. Introduction

In England, the de-regulation of fees and student numbers has meant a growth in cohort sizes for subjects such as economics, with cohort sizes of 600 not uncommon. These large cohorts bring many opportunities for pedagogical innovation, but also bring in significant costs. Students, on arrival at University, are often very happy to send questions to their lecturers via e-mail, often leading to the same (or at least similar) questions being sent, and replied to, multiple times, in large courses incurring significant time costs to the instructor.

Questions asked during lectures, and other forms of face-to-face teaching create the potential for positive externalities, in that in providing an answer for one student's question, the instructor can also provide more clarity of understanding for other students within the room. However, anecdotally, questions during face-to-face teaching can cause negative externalities, in that spending time answering many questions can lead to instructors not having the time to cover content which much of the class would find useful. As such, instructors often encourage students to ask the question via e-mail, or during office hours.

Whilst the receipt of e-mails provides a signal to the instructor about areas, and topics, which students have not understood well, the positive externalities of further clarity for other students is lost. Further, if several students have the same question, it can be very time consuming to reply to them all. As such, it is possible to appeal to technology to try to maintain the positive spillover effects of answering questions to groups of students, whilst also providing the opportunity for students to engage in peer instruction, and to further debate the topics, online, between themselves.

One such technology is asynchronous message board technology. Whilst asynchronous online message boards are not a new technology, to the author's knowledge, there is little *experimental* data about the efficacy and impact 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.

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, I 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. Background and methodology

In this study, I examine the introduction of a message board into a core, first year Mathematics and Statistics unit for 286 Economics students within a UK, Russell Group[1] University.

At the subject University, all students in BSc Economics (and equivalent) programmes must study four, core, units in their first year; Mathematics and Statistical Methods 1 (MSM1), Mathematics and Statistical Methods 2 (MSM2), Economic Principles 1 (EP1) and Economic Principles 2 (EP2). In addition to these, students also register for two, additional, units. The teaching and assessment for these units is split by semester, with MSM1 and EP1 taught in semester 1, and MSM2 and EP2 taught in semester 2. Each of these units are assessed through 100% examination. The overall structure of the first year is illustrated in Table *1*.

[Insert Table *1* about here]

Both MSM1 and MSM2 consist of 50% mathematics, and 50% statistics; the statistical focus in MSM2 is on introductory econometrics. The mathematics and statistics core material is delivered by separate lecturers, but the lecturer for statistics remains constant across the academic year. The assessment for both of these units consists of a 3 hour examination; in both cases, section A of the examination consists of 50 marks worth of mathematics, and section B consists of 50 marks worth of statistics.

In semester 2, it was decided to introduce message board software to the Mathematics and Statistics 2 unit (only) to enable positive externalities for students from being able

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

to observe other students' questions (and answers) to problems, and to encourage peer to peer learning. In the first semester, no message board technology was available, but students could ask questions of their lecturers via e-mail, or in office hours.

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 anonymity worked by not allowing other students to view who had posted the messages, but system administrators were able to view who had been submitting messages (although the administrators could not always link up which message was sent by which student)

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.

Prior to the start of semester two, Piazza message boards were set up, with separate areas for mathematics and statistical questions. For the statistical side of the unit, students were instructed that they should not send questions via e-mail, and should only ask questions via the Piazza message boards, and that questions via e-mail would not be answered; as such, the message boards were intended as a substitute for e-mail communications. The statistics lecturer provided full answers to any questions students asked on the message boards.

For the mathematical side of the unit, students were allowed to ask questions on the message boards, but the unit lecturer continued to answer questions via e-mail, and no answers were provided from academic staff to mathematics questions on the message boards.

No other changes were made to the resources available in semester 2; in both semesters, academic staff provided drop-in office hours; the main delivery method of teaching was a traditional method of lectures supported by small group classes.

Following the structure set out in Mazzolini and Maddison (2003), there are effectively two strategies employed here; in statistics, the lecturer took a “sage on the stage” role, by directly answering all questions, whilst for mathematics, the lecturer adopted a “ghost in the wings” role, by allowing students ask and answer all questions.

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. The message board software was repeatedly advertised via e-mail, in lectures, and on the Online Learning Environment (Blackboard). 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, this is 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, since sign up is non-random, it is important to explore whether this affects the causality of the results; I discuss how I control for this non-randomness in section 5.

The treatment effect is also different for mathematics and statistics. In statistics, the message board software was fully supported by the unit lecturer, with all answers posed by students given full, explanatory, answers; students also understood that no answers would be given to questions via e-mail. For mathematics, students could pose questions, but these questions were only answered by peers; staff continued to answer e-mails (as they had in the first semester). As such, it is possible to observe two different treatment effects.

3. Data

The data was collected from students who were registered on the first year of degree programmes in economics (and related subjects) at a UK Russell Group university in 2015/16. All of the students in the study studied two mathematics and statistical methods units, and two economic principles units. (Mathematics and Statistical Methods 1, Mathematics and Statistical Methods 2, Economic Principles 1, Economic Principles 2).

Table 2 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, who are omitted from the dataset. Further, any students who reported experiencing extenuating circumstances, which may have affected their performance in *any* of their examinations are omitted from the data. This leaves 253 students in the dataset.

[Insert *Table 2* about here]

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' educational outcomes (Y_{it}) at time *t* are also likely to be a function of (unobserved) individual characteristics (X_{it}), along with teaching (T_{it}) and effort (E_{it}) 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, the students are observed in two time periods; during both time periods, they study cognate subjects; in both time periods, they study mathematics, statistics, and economics. In period 1, no individuals receive the treatment of message board software, whilst in period 2, only a subset of students receive the treatment. As such, it is possible to 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, it will be possible to 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.

There are two potential threats to the internal validity of this analysis; firstly students who sign up for the message boards have different rates of progress *ex-ante* than those who do not sign up for the message boards. Secondly, students who sign up for the message-boards may have changed their study habits between semester 1 and semester 2. In either case, if significant results are simply the result of bias, the same results would be observed in the Economic Principles unit as observed in the mathematics and statistical methods units.

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 one 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 it could be concluded that there is likely little problem with not observing the student ethos, or equivalent variables.

Table 3 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 *3*, there is no difference in mathematical attainment prior to the treatment being introduced between the treated and untreated group ($p=0.7481$). However, students who sign up for the treatment of message boards have a statistically significantly higher grade in statistics (*p=0.0006)* in the untreated examination (MSM1).

[Insert Table *3* about here]

The marks that students can achieve in the mathematics and statistics examinations are censored above (at 50) and below (at 0); as such, a student who gained a relatively low mark in the first teaching block has limited scope for a reduction in grade in the second teaching block, but a significant scope for an increase in grade. Similarly, students who gain a high mark in the first teaching block have much more scope for reducing their mark than increasing.

As seen in Table *3* , the students who sign up for message boards are significantly higher performers in statistics than those who do not sign up. As such, due to the limited opportunities to improve their scores, in the absence of any causal effect from message boards, a negative impact would be predicted.

As a robustness check, in order to control for 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 the subset for mathematics (statistics), the students with the lowest 10% of mathematics (statistics) marks are dropped from the sample. Table *4* shows the distribution of test scores for students in the middle 80% of the distribution, again broken down by piazza usage. By omitting the lowest and highest 10% of students, the performances in mathematics (P=0.7168) and statistics (P=0.1662 are not statistically significantly different from each other. By omitting the highest and lowest performers, it should be possible to avoid bias caused by the censoring of the data, and will reduce any selection bias by matching students on prior attainment.

[Insert Table *4* about here]

As a further test of robustness, and to take account of possible problems due to the censoring of data, a second specification can be considered; using a Tobit regression. In UK University examinations, students are rarely awarded marks of *either* close to zero, or close to full marks; as such, it is likely that marks are *partially censored* above and below. The mathematics and statistics sections of the examinations are marked out of 50 marks each, whilst the Economic Principles examinations are marked out of 100. As such, I consider the possibility that in the mathematics and statistics sections students who gained less than 10 (out of 50) and more than 40 (out of 50) had their marks *artificially* censored, and they should have received lower (or higher) marks, if there had been no external constraint. Similarly, for the Economic Principles examination, I treat the marks as *artificially censored* if the marks are lower than 20, or higher than 80. The range of possible censoring creates a relatively conservative estimate of where marks may have been censored, so should provide a good robustness check for the original results.

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, the same results would be expected 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.

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.

[Insert Figure 1 about here]

Table *5* 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).

[Insert Table *5* about here]

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 *5* 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 statistics. In statistics, 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 statistics, 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 statistics. Of all the answers provided, 67% were provided by the statistics lecturer; all of the mathematics questions, however, were answered by active students.

6. Results

Table *6* 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 individuals are observed twice in the data, and I 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.

[Insert Table *6* about here]

The coefficient, represented by treatment on the treated in Table *6* shows the difference-in-difference estimate. Beginning with the economic principles estimates; this result provides a test of the common trend assumption. If there are differences in progress, either due to prior differences, or differences in student study pattern which are correlated with student sign-up for the message boards, then the results for the treated subjects would be expected to be matched by those in the untreated subject. The estimates effect, whilst small and positive is not statistically significant at *any* reasonable level of significance (*p=0.906*). This suggests that the expected level of progress for students who sign-up for the message boards is zero, absent of the message board technology; any significant results found for mathematics and/or statistics can thus be seen as causal.

Moving onto the treated subjects. 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, *Table 6* 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 6* provides us with a test of the common trend assumption; 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 7* shows the results from the specification, omitting the highest and lowest performers.

[Insert Table *7* about here]

For mathematics, the results are largely unchanged, with a large, significant, positive effect, but for statistics, the magnitude of the negative result is reduced, and becomes insignificant.

[Insert Table 8 about here]

As a further test of robustness for these results, I consider the possibility that there is partial censoring for students with marks close to the maxima and minima for each exam (section). To allow for this Table 8 shows the results of a Tobit analysis, with censoring below beginning at 10 marks and above at 40 marks for mathematics and for statistics, and for Economic Principles, censoring below beginning at 20 marks and above beginning at 80 marks. (In each specification, this relates to censoring below 20% and above 80%). The results presented are not quantitatively different from the results of Table *6*, suggesting that censoring of the data may not be a significant issue[2].

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 I can investigate the causal impact of different forms of engagement with online message boards. Table 9 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.

[Insert Table *9* about here]

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,

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[2] The magnitude of effect is replicated if we use censoring at 30% and 70%, although the statistical significance disappears for the negative impact in statistics. Table available on request.

p=0.014). Thus, in both mathematics and statistics there is a between 2 and 3 mark difference between the passive and active users of Piazza.

As such, this indicates that whilst the pooled regressions, illustrated in *Table 6*, the negative results for statistics are being driven by students who sign up for message boards, but do not actively engage.

7. Concluding Remarks and 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, I have found similar, striking results.

The mathematics results provide encouragement about the usage of online message-boards; students who actively engaged with the message boards significantly improved their outcomes, compared with both students who did not engage, and students who signed up, but did not, actively engage with the message boards. This distinction should not be surprising, as numerous studies have suggested that *active learning* improves student outcomes over and above passive learning (e.g. Dorestani (2005), Michel et al (2009)).

Within the results for statistics, 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.

Anecdotally, a secondary change also occurred with the introduction of the message boards; attendance at office hours was significantly reduced, which may *partially* explain the negative impact on inactive statistics students. Students may be, inappropriately, substituting one measure of contact (office hours) for another (message boards). Whilst this is not having any detrimental effect on the students who actively engage in the message boards, the substitution proves less than effective for the passive users. Thus, in order to ensure that message boards are not detrimental, it is important to ensure that any substitutions of effort are productive substitutions.

Even though the results suggest little positive impact of the message boards for statistics, if all students could be encouraged to be *active* participants in the message board software (and thus not suffering from the negative impact), this could still be a Pareto improvement. In many courses, staff spend significant time answering student queries via e-mail, with often queries being repeated by multiple students; answering questions via a message board only requires an answer to be provided once, and would thus require less time to answer questions, freeing up time to produce additional material for students.

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.

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Tables and Figures

Table 1 Structure of teaching

Semester 1 (September – January) (Examinations in January)	Semester 2 (January – May) (Examinations in May/June)
Economic Principles 1 Mathematics and Statistical Methods 1 Option	Economic Principles 2 Mathematics and Statistical Methods 2 Option

Table 2 Summary statistics

	MSM1	MSM2	EP1	EP2
Mean	59.264	59.502	59.265	62.897
Standard deviation	15.156	15.105	9.342	11.385
Number of observations	253	253	253	253

Table 3 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**	**Test of equality of means**
Mathematics			
Mean	30.134	30.398	$P = 0.7481$
Standard Deviation	6.555	6.489	
Number of observations	127	126	
Statistics			
Mean	24.524	29.266	$P = 0.0006$
Standard Deviation	11.398	10.215	
Number of observations	127	126	
Economic Principles			
Mean	57.799	60.742	$P = 0.0119$
Standard Deviation	9.342	9.291	
Number of observations	127	126	

Notes: Students are omitted if they have extenuating circumstances affecting their performance in either TB1 or TB2 examinations, only students who are examined in both MSM1, MSM2, and EP1 and EP2 are considered.

Table 4 Summary statistics for semester 1 units, broken down by students' subscription to Piazza, omitting the lowest and highest performers in TB1 examinations

	Did not sign up to message boards	**Signed up to message boards**	**Test of equality of means**
Mathematics			
Mean	30.390	30.183	$P = 0.7168$
Standard Deviation	4.307	3.779	
Number of observations	102	101	
Statistics			
Mean	26.485	28.071	$P = 0.1662$
Standard Deviation	8.635	7.739	
Number of observations	102	105	

Notes: Students are omitted if they have extenuating circumstances affecting their performance in either TB1 or TB2 examinations, only students who are examined in both MSM1 and MSM2 are considered. The sample sizes are marginally different as the lowest and highest performers are determined based on marks in mathematics, and in statistics, separately.

Table 5 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 6 OLS results for the standard difference in difference specification

		Mathematics and Statistical Methods	
	Economic Principles	Mathematics	Statistics
Treated	3.219***	0.291	4.587***
	(1.151)	(0.829)	(1.374)
Semester	3.547***	-0.382	2.378**
	(0.992)	(0.603)	(0.987)
Treatment on the treated	0.171	2.965***	-2.437*
	(1.449)	(0.861)	(1.318)
R^2	0.08	0.04	0.04
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. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for. **p<0.1, **p<0.05, ***p<0.01*

Table 7 Difference in difference results, omitting the highest and lowest performers.

	Mathematics and Statistical Methods	
	Mathematics	Statistics
Treated	-0.251	1.209
	(0.569)	(1.153)
Semester	-0.140	1.946*
	(0.653)	(0.991)
Treatment on the treated	2.645***	-0.865
	(0.947)	(1.322)
R^2	0.06	0.05
Number of students	203	206

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. Quantiles for mathematics(statistics) are constructed based on performance in the mathematics(statistics) section of the MSM1 examination. Standard errors, clustered by student are reported in parentheses. %. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for. **p<0.1, **p<0.05, ***p<0.01*

Table 8 Robustness check using Tobit analysis

	Economic Principles	Mathematics	Statistics
Treated	3.286***	0.217	4.617***
	(1.156)	(0.821)	(1.470)
Semester	3.601***	-0.115	2.594**
	(0.993)	(0.597)	(1.088)
Treatment on the treated	0.222	3.143***	-2.609*
	(1.456)	(0.894)	(1.459)
Number of students	253	253	253

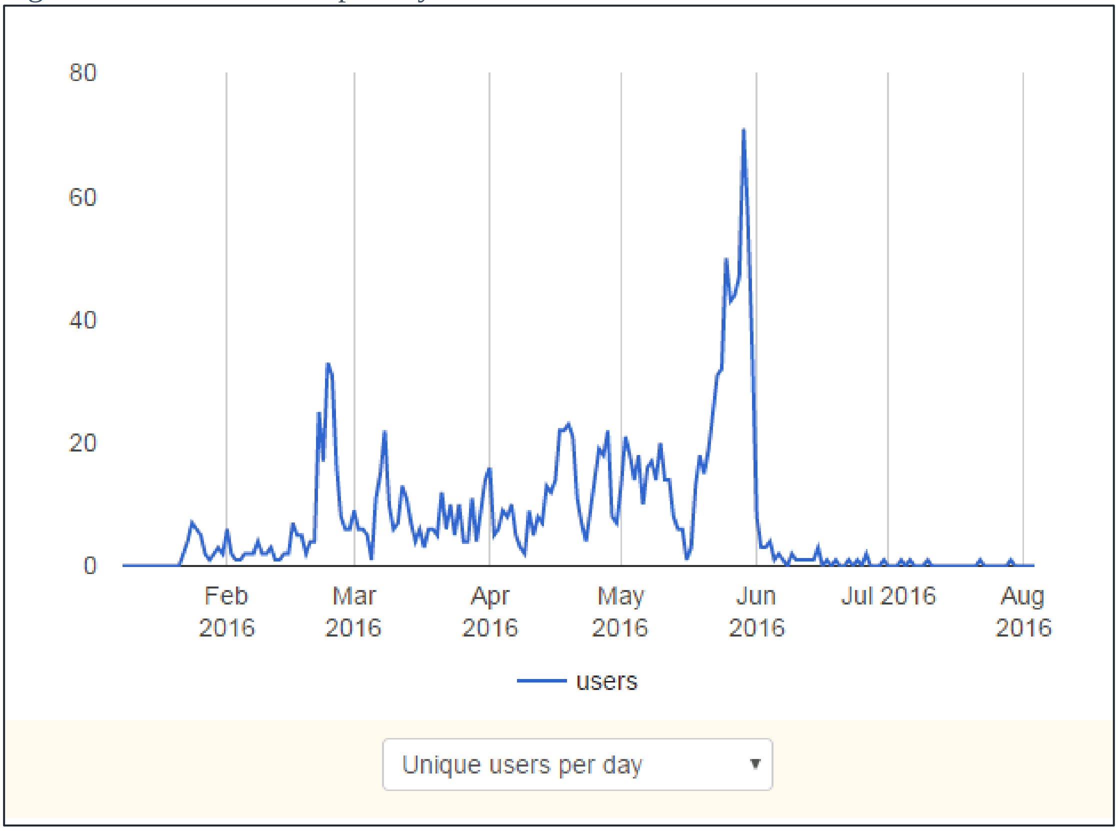
Notes: Dependent variable is the examination mark. For Mathematics and Statistical Methods, each section is marked out of 50. Data is treated as partially censored at marks of 10 and 40 for mathematics and statistical methods. Data is treated as partially censored at marks of 20 and 80 for economic principles. 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. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for. **p<0.1, **p<0.05, ***p<0.01*

Table 9 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. Student with extenuating circumstances are omitted from the analysis. Students' programme of study is controlled for. **p<0.1, **p<0.05, ***p<0.01*

Figure 1 Number of users per day



Notes: Figure constructed from data held by Piazza.