Virtual Learning Environments: Linking participation to evaluation

ABSTRACT

This paper considers the role of online multiple choice revision quizzes within the Virtual Learning Environment as a means of improving learning outcomes. A quiz was offered to 1st year undergraduates. Results were analysed to consider whether student participation improved performance. The analysis reveals little or no direct association between exam performance and participation, both at the mean and throughout the performance distribution, suggesting that the benefits from participation in on-line revision aids are not large. The use of such material needs to be made available judiciously since it may encourage displacement activity and provide little material benefit to the student.

KEYWORDS: Virtual Learning Environment; revision preparation; student engagement

JEL CLASSIFICATION: A22

1. INTRODUCTION

Engaging with students on large undergraduate modules is a perennial problem. The lecture format, for all its strengths, can be perceived to be an impersonal and anonymous environment which does not encourage active participation in the teaching and learning process (Trowler 2010). However, it remains a convenient way of imparting information and explaining key concepts within the higher education sector and is unlikely to be replaced as the main form of contact between lecturer and student any time soon (Biggs 2006)[1]. The purpose of this paper is to explore additional ways to engage with students to complement large lectures.

Improving student engagement is essential if we are to encourage a more active learning approach within the undergraduate community. In order to evaluate the usefulness of both multiple choice quizzes as a revision aid and the effectiveness of VLEs (Virtual Learning Environments) as a means of engagement, this paper provides an evaluation of the impact of an online revision quiz on the final exam marks of a large, first year undergraduate module. The course was generalist in nature, split between two lecturers (the two authors) and covered two broad economic policy topics.

As a large first year core module with two hourly lectures per week, it was difficult to engage with the students on a small group basis. This was particularly frustrating given that the nature of the material delivered lent itself to in-class discussions. Moreover, because of regular changes to the material covered, past papers were of limited use for revision. The aim of the multiple choice quiz was therefore to improve student performance through:

1. Engaging with the students outside the lecture environment
2. Assisting with their revision

By collecting information on quiz uptake and marrying this up with information on subsequent exam performance, the pedagogic question this research is able to consider is whether engagement in multiple choice quizzes delivered via the VLE improves student performance. Existing evidence on the impact of additional online resources in economics is relatively thin on the ground despite their proliferation as add-ons to core text books. This paper goes some way in addressing the evidence gap. The paper is organized as follows: the following section discusses the recent literature in relation to student engagement and interactive learning environments. Section 3 outlines the data and section 4 discusses the nature of the intervention, the estimation strategy and ways of controlling for student heterogeneity for evaluation purposes. Section 5 presents the results and in section 6 we conclude and discuss the limitations and possible extensions for this research.

2. STUDENT ENGAGEMENT AND REVISION AIDS IN VIRTUAL LEARNING ENVIRONMENTS

There are two elements of pedagogic concern in this paper: firstly, the value of multiple-choice testing as a means of formative assessment and secondly, the impact of engagement (defined in terms of attendance at lectures and use of VLEs) on performance.

The value of multiple-choice testing for formative assessment

Dunn and Mulvenon (2009) offer a broad review of the available evidence on "formative assessments". They are unhappy with the vagueness of the term and are critical of the lack of empirical evidence. In a study by Sly (1999), the use of practice tests as a means of exam preparation was assessed. Her findings indicate that the weaker students who undertook the tests outperformed higher ranked students. However, her study does not appear to control for any

other student characteristics beyond whether they undertook the test. Clearly there are likely to be factors that determine both whether students engage in the test and performance in tests and this study is able to control for a range of these factors.

Multiple choice questions within the context of lectures have been seen to be useful in reviewing material covered in class (Salemi 2009) but concerns exist about their usefulness as a source of assessment at a time when they have become more abundant as teaching staff look for efficient ways to manage their workloads. Whilst they are viewed as a less subjective form of assessment (Becker and Johnston 1999), they have been criticised for having a number of pedagogic shortcomings (Douglas et al 2012). Most notably they are often accused of only dealing with surface rather than deep learning (Gibbs 1992). Within the context of Bloom's taxonomy, multiple-choice tests would therefore relate to the wider, lower part of the learning pyramid only – knowledge and comprehension. Indeed, Biggs (2006) cites Gardner (1993) as having declared them to be the 'enemy of understanding' (Biggs 2006, 181), because of the false perception of the level of understanding that may be conveyed to students who performed well in them.

The impact of engagement on performance

Our study also relates to the effects of engagement, either by attending lectures or using VLEs, on performance. Colby (2005) identifies 'trigger points' in absenteeism at which action should be taken. If students do not attend 70% of contact hours, they have a 2 in 3 chance of failing and a 4 in 5 chance of not getting a first/2:1. If they do not attend 80% of contact hours, they have an even chance of failing and a 2 in 3 chance of not getting a first/2:1. If students miss only one or two sessions during the first two weeks, this is cause for concern and should be acted upon to prevent deterioration in performance (Muir 2009, p53).

Within the economics discipline specifically, Romer (1993) looked at courses and found an average absentee rate of around 35% - the rate was markedly higher for large lecture groups (Romer, 1993; Table 1 p.169). Attempting to disentangle motivation from attendance, Romer (1993) includes only those students who were able to complete all tests and also controlled for the students' ability using their grade point average. He finds that in his most restrictive model, students that have a perfect attendance record are likely to achieve a B+, whilst those that attend only a quarter of the lectures are likely to achieve a C. He suggests that there might be a case for making some classes mandatory and proposed an experimental framework which Marburger (2006) went some way towards implementing. Marberger (2006) finds there is a statistically significant difference in the performance of students that had compulsory attendance classes compared to students who did not although the differences are not substantial. In an earlier paper, Marburger (2001) also found evidence to support the inverse relationship between attendance and performance.

In a study that has similarities with this analysis, Hoskins and van Hooff (2005) look at a range of online learning tools to consider the roles that motivation and ability play in influencing performance. They study a sample of 110 psychology undergraduates on a second year module and look at a suite of online activities, including WebCT (a VLE) site visits, participation in self-assessment (akin to ours) and engagement in an online forum.

Hoskins and van Hooff (2005) highlight a number of advantages to online interaction with students. From a lecturer's perspective, there is rapid feedback, it enables a more flexible pace of delivery and it is possible to reach and motivate a wide range of individuals, which is especially important in the climate of continual growth towards mass higher education. From a student's perspective, the online facilities offer greater anonymity and opportunities to practice a

range of generic skills, such as team working, time management, etc. In addition, greater online engagement enables students to develop their computer skills, something of a 'critical filter' (they argue), as students move into employment.

Their empirical analysis shows that age has a positive influence on web use (generally) and dialogue (mostly with reading rather than posting). However, when looking at online assessment, they find that no variables are significant. Turning to consider performance (such as exam outcome), they find that only the online forum (Bulletin board) has any significant effect on outcome – and this varied depending on whether the participation was active (posting) or passive (reading only).

Twigg (2003) refers to the finding of earlier papers that VLEs have failed to yield better student performance outcomes as the 'no significant difference' phenomenon and points to the need for university courses to be redesigned in order to see benefits. The process may therefore be regarded as a form of technology adoption following the s-curve model of technology adoption first put forward by Rogers (2010), according to which, in the early stages of its life-cycle, innovations are relatively slow to provide benefits.

3. DATA DESCRIPTION

The module analysed in our paper was a first year generalist course entitled 'The British Economy'. It focussed on applied economics and was delivered to 142 students in 2012 and 130 in 2013. This was a compulsory course and students required a grade of 40% to pass the module.[2] Students were required to sit a final examination that accounted for 45% of the overall module mark. Previous assessments comprised a first semester examination (also 45%) and an essay, submitted in the first teaching block (10%).[3] By the time of their final examination,

students had received feedback and their marks for the first semester material. This formative assessment should contribute to a higher overall attainment in the final piece of assessment and therefore, we would expect to see a positive and significant association with these elements.

The multiple-choice quiz was introduced as a revision aid, accessible to all students through the VLE. The quiz was launched in the final week of lectures and a little over a month before the examination. The students were alerted to its existence in the revision lecture at the end of the course and also by a notice on the VLE. The multiple-choice quiz comprised of 2 sections, with 10 questions on each part of the course, each of which had four possible answers. Students were able to take the test repeatedly, with no record of their answers being stored. Once each question was answered, feedback was provided. In the second year of the scheme, the feedback was extended to include more signposts as to where students could find more information. It was stressed in lectures and in accompanying guidelines that this was in no way complete preparation for the examination, but would give some guidance in relation to key concepts and issues that would be covered in the examination. The multiple choice approach offers a relatively simple way of ensuring that the breadth of material covered throughout the course was included in the revision material to prevent too much question-spotting. The VLE enabled statistics tracking to identify those who accessed the quiz, and when, over the revision period which could then be matched with data on the individual characteristics of the students and crucially their final exam mark.

Table 1 provides an overview of 2012, the first year of data, and table 2 contains similar data for 2013, the second year of analysis. Note there is a slight difference in the variables available. First semester marks and feedback highlighted students' lack of exam essay writing skills in general (although by no means in all cases), with the average marks being 63 per cent on the

coursework and 53 per cent for the first semester examination. We were therefore mindful of a need to encourage students to think about how to present the material and to consider how concepts and empirical evidence might be linked to their responses in exam conditions.

[Table 1 about here]

Overall, there are 138 observations for the 2012 cohort. On average, the students are a little over 19 years old; the relatively low standard deviation shows that the spread of age in the cohort is narrow, as one would typically expect in an undergraduate programme. Only 10 per cent of the population are resitting the module. 20 per cent of the population are female, so a large male bias is evident. Those undertaking the BSc stream as opposed to the BA stream account for 65 per cent of the population. It is surprising perhaps that the marks between the first semester and the second semester exam are relatively consistent. Worryingly, lecture attendance as a share of all possible lectures, lies at only 35% on average (with around 10% of students not registered as attending any lectures). This shows a significant problem with student engagement, which in part prompted the intervention analysed here.

Table 2 reveals there are a number of similarities between the two years, with shares of those repeating the level around 10 per cent and students with a disability accounting for 8 per cent of the population in 2013, which is broadly comparable with the corresponding figures for 2012. However, the number of overseas students on the course increased significantly and there is a reduction in the number of females on the programme. A slightly lower proportion of students are enrolled on the BSc in 2013, as opposed to the BA degree scheme compared to the previous year. Note that the share of those participating in the quiz falls in the second year, to only 62%, 10 percentage points lower than the first year of its introduction. Data on attendance was

unfortunately not available for this year. Overall however, the two years seem to be relatively comparable.

[Table 2 about here]

Figure 1 provides an overview of the distribution of marks from the final examination for those that participated in the quiz and those that did not (1 and 0 on the chart, respectively). It shows that the spread of achievements is smaller for those that participated and that the density peaks at a higher point in the distribution. Fewer of those that participated in the quiz achieved a mark below 40 and thus there appears to be some compression in the distribution and some grounds for testing statistically whether those that engaged with the quiz experienced higher exam marks.

[Figure 1 about here]

Partial correlations between the variables in our dataset are presented in tables 3 and 4 for both years of data. The most important result is that variables measuring participation in the quiz are positively correlated with the final exam mark. However, these correlations are not statistically significant but due to the existence of variables likely to impact both participation in the quiz and the exam mark, such a result cannot be regarded as conclusive and a multivariate regression approach is required.

[Table 3 and 4 about here]

Earlier research into the determinants of performance (Park and Kerr, 1990) looked specifically at grades and therefore adopted a multinomial logit approach to modelling. Here the dependent variable is continuous and therefore we use a standard OLS approach. In their early study, Park and Kerr (1990) focus analysis on a cohort of Money & Banking students over the period 1984-87, controlling for ability using the grade point average and for past performance using the

students' position on the American College Test (ACT), as well as student absence. They control for individual characteristics but report that these are largely insignificant in determining grades. Interestingly, they find that whilst relevant, attendance is a less important determinant of final grade than cumulative grade point average and ACT entry level, indicating that ability has a large impact on performance. The data available here allow for the inclusion of attendance for one year (2012). The results from the analysis of 2012 data are presented in the first section of the results below.

Analysis based on one year of data is somewhat limiting and a pooled cross section over a number of years is to be preferred wherever possible. What limits this approach are any changes that take place from one year to another, although the specification can be adjusted to take into account specific 'year' effects, be they improved cohorts or changes to the treatment (i.e. the revision quiz). In the case of this study, an additional year of data was available. For the second year of the quiz, slight changes were made to delivery and the level of detail in the feedback was substantially expanded upon (although the questions remained the same). The aim of this refinement was to improve the information students received from each of the questions, to build into the quiz additional reference signposts to additional relevant information, as well as to highlight that this was the starting point for gaining further insight. Another limitation with using the pooled data was that, attendance information was not available for 2013 and therefore could not be used. The model was therefore re-specified, although all other controls remain virtually the same. As with the single year of data, the pooled cross sectional analysis involved a number of alternative specifications which are discussed in the results section below.

4. METHODOLOGY: ASSESSING THE IMPACT

The challenge of establishing the contribution the quiz could make to overall attainment is hampered by our inability to truly identify the counterfactual, that is, what would the student have scored in the absence of the quiz? What is known is which students accessed the quiz, and their examination results may be compared with those students that did not participate in the quiz, after controlling for the influence of observed characteristics. It is also possible to test to see whether multiple uses make a difference to overall achievement. Whilst more sophisticated methods are available to explore the nature of the selection issue, a first step would be to establish that there is any sort of relationship before testing its robustness. In the initial year of data, those that did not participate in the revision quiz account for around 24 per cent of students. Of those that did participate, around a fifth carried out the quiz on one occasion. Over half the students on the course carried out the quiz more than once. As one would expect, the proportion of students that carry out the quiz dwindles as the frequency increases. A relatively small, but significant proportion (around 3.5%) of students carried out the quiz more than 10 times although the benefits to *multiple* attempts are likely to be questionable[4].

In the analysis, the dependent variable is the exam result for an individual at the end of the module. This is thought to be a function of ability (proxied by past performance), attendance and participation in the revision quiz. In more extensive specifications, controls were added to account for individual effects. More formally:

$$ex_i = f(ability; attendance; quiz; characteristics)$$

For the first year of analysis, the following model was estimated using standard OLS regression techniques for year 1 of the data (2012):

$$ex_i = \alpha + \beta_1 Attend_i + \beta_2 Quiz_i + \beta_2 Quiz^2{}_i + \beta_4 CW_i + \beta_5 ex\_1_i + X_i + e_i \quad (1)$$

The sample size was somewhat lower than the full student population for the module, a result of student withdrawal or incomplete information. Overall, there were 138 observations available for year 1 and 130 for year 2. These data include attendance shares for students (not available for year 2). *Ex_1* and *ex* are the examination results of the student from the end of semester 1 and semester 2, respectively. The variable of interest in this analysis is the second semester exam mark (*ex*). *Quiz* indicates participation in the quiz. In some specifications this is entered as a dummy variable that takes a value of one if the student accessed the online quiz; in other specifications, it is a continuous variable tallying the number of attempts at the quiz. When this definition is used, a squared term is also included to detect any non-linearity, since we would expect there to be diminishing benefits to successive attempts. *CW* is the coursework mark (%) achieved by the student and *X* is a vector of individual characteristics that includes age, the type of degree the student is studying, gender and whether or not the student is from overseas.

The richness of our control variables provides some confidence that the coefficient on $Quiz_i$ and $Quiz^2_i$ measure the causal impact of the quiz on exam performance. Students that participate in the quiz are likely to have characteristics that would lead to better exam performance than students that did not take the quiz, even if neither group took the quiz. However, our inclusion of the variable measuring the exam results from the end of semester 1 should proxy for these characteristics, which are likely to be time-invariant, since both exams are equally weighted and students therefore have no incentive to prioritise one over the other.

Finally, following Ng et al (2010) and Siriopoulos and Pomonis (2009), we consider the effect of the quiz at different parts of the performance distribution using quantile regression. While OLS will provide an estimate of the effect of the quiz on the average student, quantile regression will allow us to observe whether the quiz had larger effects for particular groups of students.

5. RESULTS

The results presented in tables 5 and 6 extend the simple bivariate analysis between exam outcomes and quiz attempts and develop the model subsequently by introducing more controls from the specifications left to right.

[Table 5 about here]

In table 5, column (1) a simple regression is presented whereby exam outcome is assumed to be solely influenced by the number of quiz attempts. Unsurprisingly, this is not significantly different from zero and is also negative, in line with the explanation that all other things being equal, repeating the quiz will result in diminishing returns. Overall the regression performs badly (an R-squared of less than 1%). In column (2) a squared term is included to take account for any non-linearity that is likely to exist. We see that this too is not significantly different from zero. These findings indicate that the number of times the quiz is carried out appears to be of no significance to exam outcome. Column (3) looks at whether undertaking the quiz at all, as measured by a dummy variable that takes the value of 1 if the student looked at the quiz, matters. This too does not appear to be relevant to the exam outcome.

Specification (4) includes a variable to account for lecture attendance. That is, examination performance is a function of quiz participation and attendance of lectures. This column indicates that attendance has a strong and positive influence on exam results, but we find that quiz participation still has no statistically significant impact. Note the slight increase in R^2. Column (5) includes a range of controls for individual characteristics, such as age, gender and whether the student is from overseas, many of which are statistically significant, but the quiz attempt dummy remains statistically not significant. Estimation (6) reverts to the quiz attempts

specification, including the squared term: neither terms are significant but note the improvement in the explanatory power of the specification when controls for individual characteristics are included. Column (7) estimates the relationship in logs. Whilst the size of the coefficients changes in magnitude, which is unsurprising given the manipulation of the data, the overall direction and significance levels of the variables do not alter.

As discussed above, in the following year, a number of small changes were made to the quiz, principally to the fulsomeness of the feedback. The use of the second year provides another year of data to analyse, but restricts the variables which can be used. Therefore, to include both years, the general form of the specification estimated was.

$$ex_i = \alpha + \beta_1 Quiz\_12_i + \beta_2 Quiz\_13_i + \beta_3 Quiz^2{}_i + \beta_4 CW_i + X_i + t_i + e_i \qquad (2)$$

Results are presented in table 6 which broadly follows the same structure as table 5. Initially, column 1 assumes that exam results are a function of the number of quiz attempts only. The coefficient again is found to be insignificant but negative. This is further supported by the change in sign observed in this variable in specification (2) when a squared term is added, although both terms are still not significantly different from zero. Specification (3) uses a dummy variable measuring participation in the quiz and a dummy variable measuring participation in the quiz in 2013. While the former is positive, the latter is negative although in absolute terms not as large. However, neither variable is a statistically significant determinant of exam performance. This is also the case in column (4) where control variables for individual characteristics are included. In column (6), in which continuous variables are logged, both variables are positive but neither is statistically significant. Column (5) uses the number of attempts and the square of this variable instead of dummy variables to measure quiz participation but, again, neither variable is statistically significant.

[Table 6 about here]

Overall, the findings of insignificance are at first glance disappointing; they tell us that regardless of specification or whether controls for individual characteristics are included, participation in the quiz in either year had no significant impact on exam outcome. Variables that were significant throughout were coursework mark, initial exam mark (measures of aptitude) and whether the student was undertaking a BSc degree as opposed to the BA. In terms of personal characteristics, gender was not significant but age was, suggesting that older students are more likely to achieve higher examination outcomes. All other factors were not consistently significant although, before controls were added, attendance was significant. This indicates that it was proxying for aptitude or other characteristics, rather than mattering *per se*. If we consider the correlations in table 3, note that it is highly positively correlated with exam and coursework outcomes.

Extending the analysis further, our preferred model (equation 4 from table 6) was estimated using quantile regression applied to the pooled data. The results of the coefficient-spread are presented in figure 2 (full results are presented in the appendix). This reveals considerable variation in the effect of all variables, with the exception of coursework marks, over the performance distribution, particularly when the scale on the vertical axes is noted. However, the key result is that regardless of the quantile considered, the quiz dummy did not yield results significantly different from zero. Thus, whilst there might be reason to suspect that an online quiz might be more use for different segments of the performance distribution, our results do not support this.

[Figure 2 about here]

In terms of the other variables, the coursework marks variable is significant throughout the distribution, and being an overseas student had a negative impact throughout, although this was only significant at the lower end of the marks distribution. Being enrolled as a BSc (rather than a BA) student was significant between the 30^{th} and 50^{th} centile. The influence of gender appears to approach zero at the upper end of the distribution. Siriopoulos and Pomonis (2009) analyse results relating to critical thinking of economics graduates separately by gender and find different teaching methods are more beneficial for males compared with females. With a larger dataset, this is something we could explore further. Conversely, being an overseas student appears to have less of an impact at the upper end of the distribution, but has a strong negative effect at the lower end. Most other variables are more erratic over the distribution.

6. CONCLUSIONS AND REFLECTIONS

This paper takes an extensive look at whether the use of an online multiple-choice quiz has a positive effect on exam outcomes and finds little evidence to support this. This casts doubt on the ability of online quizzes delivered through VLEs to improve student performance and suggests that the use of such material needs to be made available judiciously since it may encourage displacement activity.

However, we recognise that further research is required because there are other plausible explanations for our inability to find a statistically significant effect of the quiz on exam performance beyond an inherent inability of such quizzes to improve exam performance. Firstly, it may simply be the case the multiple choice quiz was poorly designed. As stated by, Draper (2009), "[a]s with all educational technology, whether learning benefits are achieved depends not on the technology but on whether an improved teaching method is introduced with it."

Secondly, the computer based learning tool used in this instance was implemented at the end of the course as a revision tool. Elsewhere, similar tools have been used at the beginning of courses in order to establish the level of existing knowledge amongst the students on the course or at regular intervals throughout the course to encourage ongoing engagement with the material. These approaches may be superior to that taken here.

Although we find little statistical support for the introduction of the revision quiz making a difference to final examination results, students may have benefited in other ways. For example, the revision quiz may have reassured students that they understood the material and therefore reduced their stress before the exam. Related to this, it may have increased their satisfaction with the course, even if it did not improve their grades. Although the module evaluation scores were relatively high on the module, it is not possible to attribute this to the quiz. We also hope that the use of the quiz contributed more generally to a 'learning climate' (Gibbs, 1992), although this is also difficult to assess.

NOTES

[1] Notwithstanding the increasing popularity of flexible teaching or classroom 'flipping' (Berrett, 2012), lectures still dominate.

[2] However, if students had achieved 80 credits in other courses, a mark of between 30-39 or 'tolerated fail' would be sufficient to progress to the next year.

[3] Those that did not sit either exam were excluded from the analysis, however, given the coursework accounted for a relatively small proportion of the overall mark, students might choose not to complete this and yet still pass the module. Therefore, a mark of zero in the coursework was not used as a rationale for dropping the datapoint.

[4] Is it therefore a fair criticism of the intervention that the multiple choice test detracts from more constructive revision practices?

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TABLE 1: Raw data description, 2012

	Mean	**Std. Dev.**	**Min**	**Max**	**%**
Resit year (=1)	-	0.30	0	1	10%
Gender (male=1)	-	0.40	0	1	80%
Overseas (=1)	-	0.31	0	1	11%
Disability (=1)	-	0.23	0	1	6%
Age (years)	19.80	1.27	19	28	-
BSc (=1)	-	0.48	0	1	65%
Coursework (%)	62.97	15.34	0	90	-
Exam 1 (%)	53.33	12.85	11	80	-
Exam 2 (%)	52.89	12.07	4	86	-
Lecture attendance (%)	34.89	25.49	0	89	-
Quiz (no of attempts)	2.43	3.30	0	20	-
Quiz (participation=1)	-	0.45	0	1	72%
Number of observations	*138*				

*Note outliers in terms of exam results were excluded

TABLE 2: Raw data description, 2013*

	Mean	**Std. Dev.**	**Min**	**Max**	**%**
Resit year (=1)	-	0.29	0	1	9%
Gender (male=1)	-	0.34	0	1	87%
Overseas (=1)	-	0.48	0	1	34%
Age (years)	19.21	2.06	17	36	-
Disability (=1)	-	0.28	0	1	8%
BSc (=1)	-	0.49	0	1	58%
Coursework (%)	53.39	12.32	13	73	-
Exam mark (%)	50.74	10.98	17	81	-
Quiz (no of attempts)	1.93	3.77	0	29	-
Quiz (participation=1)	-	0.49	0	1	62%
Number of observations	*130*				

*Note, two variables missing for year two - exam1 and lecture attendance.

FIGURE 1: Density of exam mark by quiz participation (pooled data)

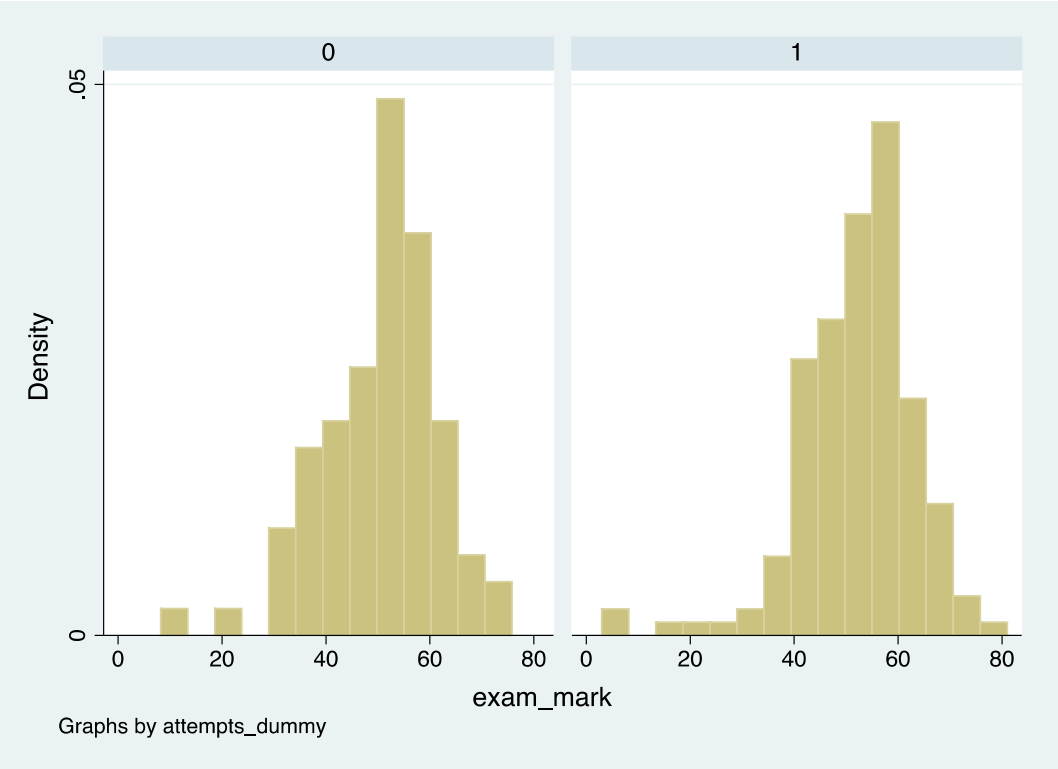


TABLE 3: Correlations of quiz taking with 'performance' measures, 2012

	Repeat year	**Coursework**	**Previous exam**	**Exam mark**	**Gender**	**BSc**	**Age**	**% lectures**	**Quiz times**
Repeat year	1								
Coursework	**0.6068***	1							
Previous exam	**0.8801***	**0.4581***	1						
Exam mark	**0.8675***	**0.3194***	**0.6579***	1					
Gender	0.0813	-0.1186	0.1444	0.072	1				
BSc	0.0158	0.042	-0.1178	0.1142	-0.1174	1			
Age	-0.1605	0.0646	**-0.2027***	-0.1387	-0.0929	-0.0918	1		
% lectures	**0.2663***	**0.2380***	**0.2710***	**0.1764***	-0.0121	0.0815	0.0075	1	
Quiz times	-0.0332	-0.0787	0.0165	0.022	-0.0448	-0.032	0.0852	0.0723	1
Quiz	0.0683	0.0113	0.1115	0.0245	0.0797	0.0088	0.1163	0.1115	**0.4523***

* indicates significance at the 5% level

TABLE 4: Correlation coefficients between variables in the pooled data covering two academic cohorts

	Exam mark	**Attempts (y/n) (2012)**	**Attempt (y/n) (2013)**	**Coursework**	**Age**	**Gender**	**Overseas**	**BSc**	**Econ dept**
Exam mark	1								
Attempts (y/n) (2012)	0.0699	1							
Attempts (y/n) (2013)	0.0857	**0.5372***	1						
Coursewor	**0.5323***	0.073	0.1091	1					
Age	-0.0423	**0.2107***	**0.3689***	-0.057	1				
Gender	-0.0098	0.0553	0.0397	0.0086	**0.1508***	1			
Overseas	**-0.2569***	**0.1898***	**-0.1822***	**-0.3284***	**0.2271***	0.0604	1		
BSc	0.0465	-0.0882	0.0568	-0.106	**-0.1497***	0.0449	**-0.1957***	1	
Econ dept	-0.0948	**-0.1564***	**0.1877***	-0.0551	0.0019	0.0655	**-0.3536***	**0.3870***	1
Resit	-0.0204	-0.0411	0.0192	-0.0733	**0.1573***	**0.2073***	0.0434	**0.1918***	0.0416

TABLE 5: Regression results, Dependent variable: Exam Outcome (2012 data only)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1st exam (%)					**0.328*** **	**0.320*** **	
					(0.090)	**(0.090)**	
Quiz (y=1)			0.939	-0.011	-0.434		0.011
			(2.308)	(2.240)	(1.959)		(0.040)
Coursework %					**0.185*** **	**0.181*** **	
					(0.067)	**(0.068)**	
Attendance				**13.45*** **	4.772	5.068	
				(3.938)	(3.663)	(3.687)	
Age					**1.687** **	**1.597** **	
					(0.709)	**(0.710)**	
Gender (m=1)					0.504	0.408	0.007
					(2.292)	(2.270)	(0.047)
Overseas (=1)					-4.140	-4.250	0.003
					(3.378)	(3.371)	(0.070)
BSc					**4.643** **	**4.452** **	**0.086** **
					(1.872)	**(1.881)**	**(0.039)**
Resit					-1.736	-1.720	0.024
					(2.895)	(2.896)	(0.060)
Quiz attempts	-0.087	0.990				0.592	
	(0.313)	(0.754)				(0.631)	
Quiz squared		-0.077				-0.040	
		(0.049)				(0.041)	
Ln(1st exam%)							**0.389*** **
							(0.080)
ln(attendance)							0.023
							(0.021)
ln(coursework)							0.174
							(0.137)
ln(age)							**0.888*** **
							(0.312)
Constant	53.10***	51.77***	52.21***	48.20***	-13.79	-12.32	-0.993
	(1.281)	(1.533)	(1.964)	(2.226)	(15.70)	(15.73)	(1.072)
Observations	138	138	138	138	138	138	123
R-squared	0.001	0.018	0.001	0.081	0.366	0.370	0.333

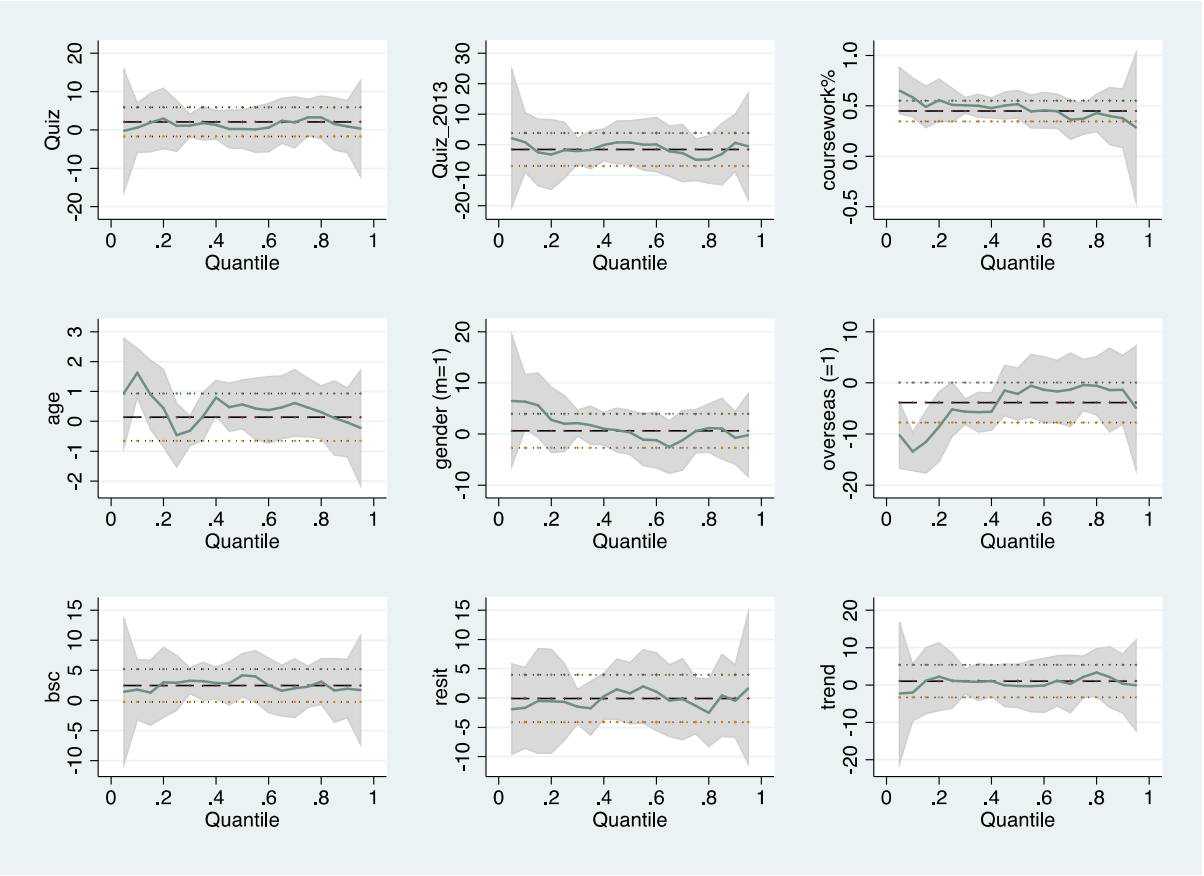
Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

TABLE 6: Regression results, dependent variable: Exam outcome (pooled data, 2012 & 2013)

	(1)	(2)	(3)	(4)	(5)	(6)
Quiz			2.180	2.096		0.016
			(1.662)	(1.933)		(0.051)
Quiz_2013			-1.558	-1.574		0.003
			(1.883)	(2.745)		(0.072)
Coursework %				**0.448*** **	**0.454*** **	
				(0.052)	**(0.052)**	
Age				0.138	0.0741	
				(0.402)	(0.474)	
Gender (m=1)				0.626	0.477	0.028
				(1.686)	(1.666)	(0.044)
Overseas (=1)				**-3.850***	**-3.808***	**-0.096***
				(1.980)	**(1.980)**	**(0.053)**
BSc				**2.477***	**2.562***	**0.068***
				(1.381)	**(1.382)**	**(0.036)**
Resit				-0.066	-0.129	-0.025
				(2.053)	(2.054)	(0.054)
Time trend				1.024	-0.087	0.027
				(2.215)	(1.299)	(0.058)
Quiz attempts	-0.010	0.196			0.245	
	(0.198)	(0.412)			(0.366)	
Quiz_ squared		-0.012			-0.005	
		(0.022)			(0.021)	
ln(coursework)						**0.654*** **
						(0.058)
ln(age)						-0.113
						(0.248)
Constant	51.37***	51.10***	50.23***	21.25**	23.19**	1.580**
	(0.878)	(0.999)	(1.263)	(8.755)	(10.08)	(0.797)
Observations	240	240	240	240	240	239
R-squared	0.000	0.001	0.008	0.307	0.306	0.433

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

FIGURE 2: Coefficient estimates from quantile regression analysis.



Notes: Shaded area indicates 95% confidence interval around the coefficient estimates throughout the quantile regression estimates. Dashed line represents the OLS variable coefficient (and the corresponding confidence interval is highlighted in small dashed lines).

Appendix 1: Quantile Regressions (pooled data)

Quantile	5	10	15	20	25	30	35	40	45	50
Quiz	-0.263	0.578	1.894	3.000	1.050	1.149	1.792	1.309	0.248	0.218
	(3.476)	(3.127)	(3.543)	(3.049)	(2.752)	(2.447)	(2.336)	(2.346)	(2.454)	(2.598)
Quiz_2013	2.044	0.803	-2.532	-3.222	-1.832	-2.114	-1.708	-0.079	0.759	0.704
	(4.936)	(4.440)	(5.031)	(4.330)	(3.908)	(3.475)	(3.317)	(3.331)	(3.485)	(3.689)
Coursework%	**0.649*** **	**0.583*** **	**0.489*** **	**0.556*** **	**0.509*** **	**0.505*** **	**0.500*** **	**0.479*** **	**0.503*** **	**0.517*** **
	(0.094)	**(0.084)**	**(0.096)**	**(0.082)**	**(0.074)**	**(0.066)**	**(0.063)**	**(0.063)**	**(0.066)**	**(0.070)**
Age	0.956	1.628**	0.894	0.444	-0.466	-0.317	0.167	0.794	0.476	0.566
	(0.724)	(0.651)	(0.738)	(0.635)	(0.573)	(0.509)	(0.486)	(0.488)	(0.511)	(0.541)
Gender (m=1)	**6.456****	**6.332****	**5.617***	2.778	2.019	2.153	1.750	1.036	0.780	0.326
	(3.032)	**(2.727)**	**(3.090)**	(2.659)	(2.400)	(2.134)	(2.037)	(2.046)	(2.141)	(2.266)
Overseas (=1)	**-10.28*** **	**-13.43*** **	**-11.57*** **	**-8.556*** **	**-5.199***	**-5.634****	**-5.708****	**-5.630****	-1.517	-2.157
	(3.561)	**(3.203)**	**(3.629)**	**(3.123)**	**(2.819)**	**(2.507)**	**(2.393)**	**(2.403)**	(2.514)	(2.661)
BSc	1.474	1.794	1.298	3.000	2.919	**3.287***	**3.208***	**2.915***	2.829	**4.172****
	(2.483)	(2.234)	(2.531)	(2.178)	(1.966)	**(1.748)**	**(1.669)**	**(1.675)**	(1.753)	**(1.856)**
Resit	-1.912	-1.664	-0.489	-0.556	-0.652	-1.460	-1.750	0.303	1.490	0.825
	(3.692)	(3.321)	(3.763)	(3.238)	(2.923)	(2.599)	(2.481)	(2.491)	(2.606)	(2.759)
Time trend	-2.272	-2.045	1.149	2.222	1.149	0.955	0.792	1.079	-0.077	-0.272
	(3.983)	(3.583)	(4.060)	(3.494)	(3.153)	(2.804)	(2.677)	(2.688)	(2.812)	(2.977)
Constant	-17.10	**-25.45***	-4.766	1.000	**24.79****	**22.56****	13.83	3.794	10.53	8.480
	(15.74)	**(14.16)**	(16.04)	(13.81)	**(12.46)**	**(11.08)**	(10.58)	(10.62)	(11.11)	(11.76)
Observations	240	240	240	240	240	240	240	240	240	240

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Quantile	55	60	65	70	75	80	85	90	95
Quiz	0.112	0.621	2.376	1.984	3.278	3.286	1.551	0.910	0.350
	(2.785)	(2.653)	(2.715)	(2.636)	(2.687)	(2.266)	(3.102)	(2.925)	(3.954)
Quiz_2013	-0.005	0.046	-2.141	-2.761	-4.969	-4.878	-3.076	0.594	-0.552
	(3.954)	(3.768)	(3.855)	(3.743)	(3.816)	(3.217)	(4.405)	(4.153)	(5.615)
Coursework%	**0.444*** **	**0.455*** **	**0.447*** **	**0.362*** **	**0.371*** **	**0.429*** **	**0.398*** **	**0.376*** **	**0.286*** **
	(0.075)	**(0.072)**	**(0.073)**	**(0.071)**	**(0.072)**	**(0.061)**	**(0.084)**	**(0.079)**	**(0.107)**
Age	0.425	0.379	0.471	0.614	0.464	0.306	0.112	-0.0376	-0.218
	(0.580)	(0.552)	(0.565)	(0.549)	(0.559)	(0.472)	(0.646)	(0.609)	(0.823)
Gender (m=1)	-1.094	-1.193	-2.553	-1.207	0.557	1.163	1.052	-0.767	-0.204
	(2.429)	(2.314)	(2.368)	(2.299)	(2.344)	(1.976)	(2.706)	(2.551)	(3.449)
Overseas (=1)	-0.556	-1.365	-1.682	-1.340	-0.412	-0.551	-1.413	-1.353	-4.862
	(2.852)	(2.718)	(2.781)	(2.700)	(2.752)	(2.321)	(3.178)	(2.996)	(4.050)
BSc	**4.005** **	2.532	1.624	2.042	2.289	**3.143***	1.661	1.962	1.721
	(1.989)	(1.895)	(1.939)	(1.883)	(1.919)	**(1.619)**	(2.216)	(2.089)	(2.825)
Resit	1.991	1.090	-0.447	-0.189	-1.340	-2.531	0.456	-0.474	1.630
	(2.957)	(2.818)	(2.883)	(2.799)	(2.854)	(2.406)	(3.295)	(3.106)	(4.199)
Time trend	-0.327	-0.129	1.106	0.260	2.165	3.327	2.099	0.368	-0.086
	(3.191)	(3.040)	(3.111)	(3.020)	(3.079)	(2.596)	(3.555)	(3.351)	(4.531)
Constant	17.27	19.44	18.89	**22.76***	**24.77** **	**25.29** **	**34.67** **	**41.08*** **	**53.79*** **
	(12.61)	(12.02)	(12.29)	**(11.94)**	**(12.17)**	**(10.26)**	**(14.05)**	**(13.24)**	**(17.91)**
Observations	240	240	240	240	240	240	240	240	240

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1